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Brave Smart World: Capabilities and Ecosystems for Innovation

Proceedings of the 32nd IAMOT Conference

Paulo Antônio Zawislak, Breno Nunes, Fernanda Reichert, Kadígia Faccin, Carlai Netto (eds.)

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Brave Smart World: Capabilities and Ecosystems for Innovation
Proceedings of the 32nd IAMOT Conference

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BRAVE SMART WORLD

Capabilities and Ecosystems for Innovation

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PREFACE

The dynamism that defines our world has become apparent with floods of novelty emerging in all areas and resulting in the widespread of innovation. In fact, innovation has become the defining adjective of the 21st century.

We are currently witnessing a number of changes that are giving rise to new business models, being brought about, both, by born-digitals with a DNA of innovation, as well as by the digital transformation of incumbents who previously did not comprehend the power of innovation. The digital revolution has enlighted more than just technological solutions. While the access to new knowledge and a new base of connections have certainly accelerated the development of potential applications for these novelties, the revolution goes far beyond that. The idea of being more creative, efficient, sustainable, collaborative, is making the first decades of the 21st century the cradle of a brave smart world.

Smart technologies, products, businesses, and even cities have taken the challenge of innovation to a whole new level. If you weren't born an innovator, to thrive in this environment, you must become one. You are no longer competing among equals, but rather in a jungle of smart competitors. It is essential to be bold and courageous to succeed.

Immerse yourself in the dynamic world of innovation, as captured in the pages of the "Proceedings of the 32nd IAMOT Conference: Brave Smart World." This volume encapsulates the intellectual richness and collaborative spirit of the international event that took place in Porto Alegre from May 1st to May 4th, 2023.

Diving deep into the realms of capabilities and ecosystems for innovation, this collection of papers unveils a panorama of transformative ideas and insights. With 133 meticulously presented abstracts and full papers, this volume serves as a comprehensive reference for anyone seeking to grasp the pulse of global innovation trends.

The conference was an unparalleled gathering that brought together minds from 17 countries, fostering a cross-pollination of perspectives and expertise. With 144 esteemed reviewers, the academic rigor and quality of the contributions were rigorously upheld, ensuring a well-rounded compilation that mirrors the diverse landscapes of innovation across the world.

Spread across 29 parallel sessions, the conference was a testament to the expansive nature of the discourse on innovation. The conference drew participants from Brazil, Canada, Chile, Colombia, France, Germany, Japan, Mexico, Norway, Peru, Portugal, South Africa, Spain, Sweden, Taiwan, the UK, and the USA. This global representation enriched the conference with a myriad of perspectives, solidifying its status as a melting pot of innovation wisdom.

The "Proceedings of the 32nd IAMOT Conference: Brave Smart World" stand as a testament to the collaborative effort that underpins innovation. Whether you're an academic, a practitioner, or an enthusiast, this volume promises to be a beacon guiding you through the realms of innovation, shaping the way we view and interact with the ever-evolving landscape of ideas.

Dr. Paulo Antônio Zawislak
IAMOT 2023 Chair

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CONFERENCE PROGRAMME

Day 1 – May 1st

8h am – 8h30 am: Registration

8h30 am – 10h am: Official Opening: Brave Smart World
Keynote Speaker: John Bessant (University of Exeter Business School)

10h am – 10h30 am: Coffee-Break

10h30h am – 12h30 am: Parallel Sessions
Innovation Capabilities I, Research and Technology Transfer I, Sectoral Innovation I, Industry 4.0 I, Inclusive and Frugal Innovation I

12h30 pm – 1h30 pm: Lunch

1h30 pm – 3h pm: Editors Panel (Chair: Breno Nunes)
Speakers: Steve Walsh (Technological Forecasting and Social Change), Nicholas Vonortas (Science and Public Policy), Marly Carvalho (Technovation), Ricardo Jordão (The Bottom Line), Leonardo Gomes (Innovation and Management Review), Ivan Garrido (Brazilian Administration Review)

3h pm – 3h10 pm: Pit stop

3h10 pm – 5h pm: Parallel Sessions
Special Topics on MOT I, Innovation Ecosystems I, Digital Innovation I, Innovation in Emerging Economies I, Innovation Evaluation and Impact I, Sustainable Development I

5h30 pm – 8h pm: President's Welcome Reception

CONFERENCE PROGRAMME

Day 2 – May 2nd

8h am – 8h30 am: Registration

8h30 am – 10h am: Panel: Smart Policy (Chair: Nicholas Vonortas)
Keynote Speakers: Fernanda De Negri (IPEA), Marcos Pinto (Ministry of Planning and Budget)

10h am – 10h30 am: Coffee-Break

10h30h am – 12h30 am: Parallel Sessions
Digital Innovation II, Innovation Capabilities II, Innovation Evaluation and Impact II, Sectoral Innovation II, Internal and External Collaboration I

12h30 pm – 1h30 pm: Lunch

1h30 pm – 3h pm: Panel: Smart Business (Chair: Guilherme Camboim)
Keynote Speakers: Pedro Dusso (Aegro), Priscila Lora (Biosens), Celso Kiperman (+A Educação)

3h pm – 3h10 pm: Pit stop

3h10 pm – 5h pm: Parallel Sessions
Special Topics on MOT II, Innovation Ecosystems II, Innovation Capabilities III, Service Innovation I, Sustainable Development II, Strategy and Innovation I

CONFERENCE PROGRAMME

Day 3 – May 3rd

8h am – 8h30 am: Registration

8h30 am – 10h am: Panel: Innovation Ecosystem (Chair: Kadigia Faccin)
Keynote Speakers: Marcel Bogers (Eindhoven University of Technology), Leonardo Gomes (USP)

10h am – 10h30 am: Coffee-Break

10h30h am – 12h30 am: Parallel Sessions
Industry 4.0 II, Smart Cities and Regions I, Strategy and Innovation II, Research and Technology Transfer II, Sectoral Innovation III

12h30 pm – 1h30 pm: Lunch

1h30 pm – 3h pm: Panel: Innovation Capabilities (Chair: Paulo Zawislak)
Keynote Speakers: Annabelle Gawer (Surrey University), André Alves (FGV Innovation Center – FGVIn), John Bessant (University of Exeter Business School), Mauricio Camargo (Université de Lorraine), Nicholas Vonortas (George Washington University)

3h pm – 3h10 pm: Pit stop

3h10 pm – 5h pm: Parallel Sessions
Special Topics on MOT III, Innovation Capabilities IV, Innovation Ecosystems III, Entrepreneurship I, Technological Innovation I

8h pm – 11h pm: Annual Banquet Awards

CONFERENCE PROGRAMME

Day 4 – May 4th

8h30 am – 12h30 pm: Technical Visits

Tecnosinos

São Leopoldo Technology Park - is an important infrastructure to promote and transform innovative ideas into opportunities. With over 20 years of history, it currently hosts 110 companies in diverse sectors such as IT, Semiconductors, Automation, Communication, Health, Renewable Energy, and Socio-Environmental Technologies. These firms together generate an annual revenue of over R$ 2.5 billion. The park is responsible for thousands of jobs, the development of an entrepreneurial culture, and is recognized worldwide, with the presence of companies from six countries and partnerships with global technology parks.

Tecnopuc

Tecnopuc is the PUCRS technology park, located in Porto Alegre, Brazil. With more than 20 years of existence, Tecnopuc has supported almost 200 companies and more than 300 startups during its trajectory, contributing to the creation of thousands of jobs in the region. Aiming to foster innovation and entrepreneurship, Tecnopuc offers a wide range of services, including incubators, accelerators, coworking and research laboratories, as well as support for companies and startups, such as training in business management and access to investors.

Instituto Caldeira

Instituto Caldeira is an innovation hub, located in Porto Alegre, Brazil, which promotes economic and social development through innovation. With a 22,000 m² structure, more than 20 meeting rooms, 4 event spaces and more than 120 coworking positions for members to use, the Institute has stood out as a catalyst for change, enabling companies and entrepreneurs to transform innovative ideas into real opportunities. Connecting more than 400 organizations through matchmakings, internal chat tools and socializing and relationship events, it offers training programs, access to mentors and investors, and technical support for startups and companies, promoting collaboration and connection between different sectors of society, including companies, universities, and government.

UFCSPA

The Federal University of Health Sciences of Porto Alegre (UFCSPA) is a federal higher education institution located in Porto Alegre, Brazil, focused on Health Sciences. Established in 1961, it became a university in 2008 and has a mission to produce and share knowledge while educating professionals in the field of Health Sciences. UFCSPA offers undergraduate and graduate programs, as well as medical residency programs and collaborates with healthcare institutions in the city. According to Times Higher Education rankings, it is among the top 85 universities in Latin America and among the top 550 universities in emerging economies. Additionally, the QS Rankings by Subject placed UFCSPA among the top 550 institutions in Medicine.

PARALLEL SESSIONS

Day 1 – May 1st

10h30h am – 12h30 am

- Innovation Capabilities I
- Research and Technology Transfer I
- Sectoral Innovation I
- Industry 4.0 I
- Inclusive and Frugal Innovation I

3h10 pm – 5h pm

- Special Topics on MOT I
- Innovation Ecosystems I
- Digital Innovation I
- Innovation in Emerging Economies I
- Innovation Evaluation and Impact I
- Sustainable Development I

INNOVATION CAPABILITIES I

May 1st: 10h30 am – 12h30 pm

Chair

Laure Morel (University of Lorraine, France)

Papers

Startups' innovation capabilities: A systematic literature review to depict core elements

Rafaela Cabral Almeida Trizotto, Leandro da Silva Nascimento, Carlai Netto, Thiago Persi Gonçalves

A literature categorization model of individual innovation capabilities

Mariela Martínez Chacón, Laure Morel, Manon Enjorlas, Lorraine

Regional technological capabilities and co-invention networks in the technological diversification process: Evidence from Brazil

Mariane Santos Françoso, Vanessa de Lima Avanci, Alysson Fernandes Mazoni

Startups' innovation capabilities: a systematic literature review to depict core elements

Abstract ID#368

Rafaela Cabral Almeida Trizotto, Leandro da Silva Nascimento, Carlai Netto, Thiago Persi Gonçalves (Federal University of Rio Grande do Sul)

Purpose

Innovation capabilities refer to the set of skills, resources, and routines that lead companies to achieve better innovative results, whether technological or nontechnological (Nascimento et al., 2021). According to Zawislak et al. (2012), every company has four innovation capabilities: Technology Development, Operations, Management, and Transaction. Although previous literature has intensified efforts to analyze and understand the four innovation capabilities of established firms, we lack deep understanding of startups' innovation capabilities. By definition, a startup is a nascent venture, with innovative potential, that operates in an environment of extreme uncertainty (Ries, 2018), i.e., it is temporary and is looking to build resources to become a consolidated company. Therefore, one needs to consider that internal and external factors and elements affect the emergence and survival of startups (Pigola et al., 2022), being these elements related to the innovation capabilities. Therefore, this paper aims to analyze the innovation capabilities of startups from the previous literature, identifying the main elements present in the four capabilities.

Literature Review

A series of studies have been developed to understand entrepreneurial behavior, increased competitiveness, and the characteristics that lead companies to achieve superior, innovative performance (Teece et al., 1997). One of the possibilities to identify such constituent characteristics is through the Innovation Capabilities model (Zawislak et al., 2012), which starts from the key dimensions of companies (i.e., product, process, management, and transaction). This model allows for a deeper understanding of change behavior with a view to innovation. After all, every successful company is a business model involving products that need to be brought to the market according to a specific operating pattern, and that has an efficient allocation of resources that justifies its profitability. However, as the name implies, a startup is in "star-up", that is, starting a journey that will lead it to the level of consolidation. A successful way of dealing with the factors that impact the survival of startups is associated with their dexterity in building capabilities, and thus, managing limited resources in favor of business growth (Pigola et al., 2022). According to Feng et al. (2019), capabilities play a vital role during the evolutionary process of startups, helping to acquire, renew and reconfigure resources so that startups can deal with the challenges of their maturation. In this sense, the various elements involved in the process of constituting the innovation capabilities of startups need to be considered. Therefore, this review analyzes previous studies to depict the elements that help startups develop their innovation capabilities.

Methodological Procedures

We present a brief overview of the interaction between innovation capabilities and startups. We then move on to intertwining the two concepts and emphasize the need to understand better how they have been treated in the literature. A systematic literature review was conducted that identified 86 documents from the Scopus and Web of Science databases. Using the Nvivo software, elements were identified in the articles that are relevant to the study of innovation capabilities in startups, which are assigned into categories in a codebook in order to systematically organize the analysis material.

Findings

Based on the model by Zawislak et al. (2012), the main elements that are part of the context of innovation in startups and that are interconnected to each capability were identified. For Technology Development capability, it is necessary to ensure clear and objective differentiation from the initial stage of product development. Therefore, using knowledge in scientific and technological adaptations of goods and services can help reduce negative environmental externalities. In Transaction Capability, the importance of investigating the market environment is addressed before the first product entry. In search of solid relationships and business survival, interacting with different actors in an innovation ecosystem is a way to gain access to valuable resources. For Operations Capability, using agile methods is a way to react flexibly to changes in the environment, quickly adjusting goods and service offerings. It is also possible to organize the operation into projects, considering the need to develop tasks in a certain period. As for the Management capability, it is necessary to use organizational tools to manage knowledge to achieve better decision-making. Also, the founders' knowledge and previous experiences (entrepreneurial skills) reflect essential elements that impact the startup's innovative activities. From the connection of the four capabilities, It is possible to innovate the business model harmoniously to maximize the startup's performance and manage innovation activities that aim for value creation.

Implications

The theoretical implication lies in the identification of the set of internal and external elements that increase the innovative performance, competitiveness, and survival of startups, but that the previous literature on innovation capabilities does not address. In this way, we advance theorizing regarding innovation capabilities in startups. As managerial implications, such core elements can serve as drivers for resource investment (capital and time) by startups to develop or mature their innovation capabilities and achieve superior performance toward business consolidation.

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Nascimento, L., Camboim, G., & Zawislak, P. (2021). Which Innovation Capabilities are Relevant for Technological and Non-technological Innovation?. XXXI Simpósio de gestão da inovação tecnológica.

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A literature categorization model of individual innovation capabilities

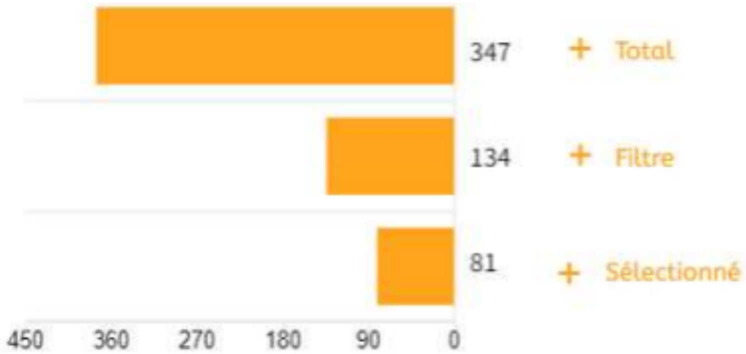
Abstract ID#230

Mariela Martinez, Laure Morel, Manon Enjorlas (Université de Lorraine)

Purpose

The innovation capability includes context and behavioral aspects. The innovative behavioral perspective has been analyzed from different aspects, for example, psychological, professional, behavioral aspects, etc. Based on a literature review of those perspectives, the objective of this paper is to identify the basic and essential categories of variables of individual innovation capability. It means integrating and unifying the essential categories for the personal innovation analysis, adopting: psychological, entrepreneurial, behavioral, and managerial perspectives.

From the total of 347 SCOPUS articles based on the research: ("TITLE-ABS-KEY ("personal innovativeness" OR "personal innovativeness" OR "individual innovativeness" OR "individual innovation" OR "innovative behavior")) W/15 (TITLE-ABS-KEY ("measure" OR "evaluation" OR "evaluation" OR "asess*" OR "model"))", we filtered articles excluding nonopen access articles because we need open access to read and analyze each article, so the nonopen ones are difficult to obtain.



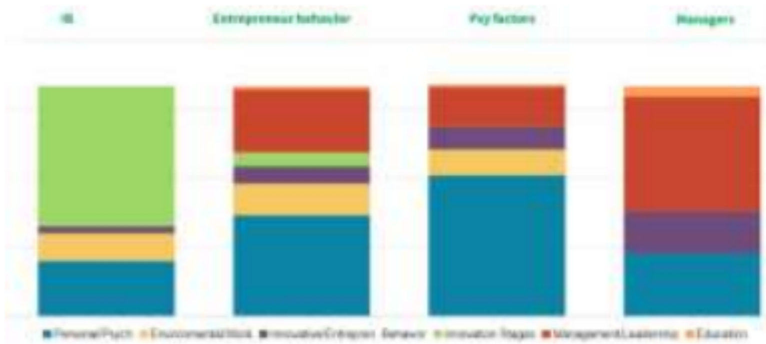
The result of this filtering used was 134 effective papers. Another filtering was used, by excluding those in other languages than the English ones, literature reviews, and topics not related to innovation in the companies or with the person itself. 81 finalist publications were the result. We identify a principal and common concept to call this innovative person behavior, it was: Innovative Behavior or IB. Innovative behavior is defined as "all individual actions directed at the generation, introduction and or application of beneficial novelty at any organizational level" (3). As it was the principal concept used by the authors, our research also used for call this behavior. In the 81-finalist publication, twenty-one models were found that studied IB. To really identify which were the specific variables used to measure the IB, so we could find those principal characteristics of an innovative person, we enlisted all the models and the respective variables.

Methodological Procedures

The objective of this paper is to develop a literature review to identify the basic and indispensable categories of variables of the individual innovation capability, adopting: psychological, entrepreneurial, behavioral, and managerial perspectives. It means integrating and unifying the categories indispensable for the personal innovation analysis. Using the Scopus date-based, qualitative analysis in the literature review, we identified the most common variables in models related to personal perspectives used by the authors to study individual innovation capabilities. We started with an individual search in the Scopus database for each of the models. An analysis of the construct and variables used by the authors in each paper were made. Then, a categorization of those variables in each variable category depending on their frequency. A total of four variable categories were established. Then, we analyzed the average of the most and less used categories in total for the four variables. A model of the basic categories of variables for individual innovation capability was determined.

Findings

The four models: IB, EB, PSY, and Managers Innovation Profile, shared most of the categories for the classification of their variables. At this point, a comparison between the four variables to establish a common pattern of categories of variables is required to understand the differences and analyze possibilities to establish a model to study the innovation profile. The personal/Psychological category variables are in the four variables because this is the base of this study.



Variables comparation

Based on these and other analysis results, we proposed a preliminary integrated model of categories of variables. The preliminary model should include the followings categories:

The analysis of the data found allows us to identify the most used categories of variables in each model, and it clarifies how each variable used the categories, which of them were focused on each one, and on average how the variables used the categories.

Implications

With the results, we determined and synthesized the most important six indispensable categories that should be considered in the analysis and measure of individual innovation capabilities: personal/psychological aspects, management/leadership skills, innovation stages responses, innovative/entrepreneurial behavior, environmental/work/social support and conditions, and education. A potential impact on the innovation management system, at different levels, could include the way to evaluate and measure the innovation capability of the employees and managers, the consideration of the influence of the context and external variables, as well as Figure 2 Variables comparation education category of variables. Also, the inclusion of the rights points to the contextualization of the innovation.

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Regional technological capabilities and co-invention networks in the technological diversification process: Evidence from Brazil

Abstract ID#252

Mariane Santos Françoso, Vanessa de Lima Avanci, Alysson Fernandes Mazoni (Unicamp, BR)

Purpose

This paper investigates the role of the regional endowment of technological capabilities and co-invention network structures in the emergence of new technological specializations in regions. We consider a region specialized in a technology when its share of patents in a given technology is higher than the share in Brazil.

Literature Review

The development of new technologies in regions has been discussed in the literature as a path-dependent process in which new technologies requiring similar technological capabilities as those already present in the region are more likely to be developed (Hidalgo et al., 2007; Neffke et al., 2011). The rationale behind it is that regional diversification is like a branching process in which local knowledge is used to support the development of new technologies cognitively close to those in which the region is already specialized. Many works have explored this argument, emphasizing the endogenous dynamics involved in the regional diversification process. They empirically show that the regional endowment of knowledge and technological capabilities is crucial to developing new economic specializations (Balland et al., 2019; Neffke et al., 2011). At the same time, another stream of literature has extensively pointed out the benefits of inter and intraregional co-invention networks for regional innovation performance (Bathelt et al., 2004). However, the impact these networks' configurations may have on technological diversification has not yet been widely discussed in a branching process context. Recently, some attempts have been made on this matter, especially regarding the role of external linkages (Balland & Boschma, 2021; Whittle et al., 2020). Nevertheless, the role of co-invention network structures at the inter- and intraregional levels is still unclear for distinct kinds of regions.

Methodological Procedures

We used patent data from Brazil (2000 – 2019) and designed two types of networks: one based on interregional and the other based on intraregional co-invention linkages. We then conduct an econometric analysis on the microregional level, focusing on four main variables: centrality degree, betweenness, transitivity, and technology flexibility. Centrality degree is the number of connections a region establishes with others, capturing the region's access to external knowledge. Betweenness shows how well-positioned a region is in the interregional co-invention flows occurring in Brazil, meaning that the region has a control position in the network formation, as it intermediates knowledge flows between other regions. Transitivity shows how well knowledge disseminates inside a region based on the network's cohesiveness. Technology flexibility captures the average cognitive closeness of the regional technological capabilities to the technologies in which the region is not specialized.

Findings

Our results indicate that regional technological endowment and co-invention network structures at the inter- and intraregional levels are essential for technological diversification. We can see that high intraregional transitivity and high betweenness in interregional networks are important in all contexts. At the same time, centrality is only statistically significant and positive when interaction terms regarding the regional development level are included. Our results suggest a substitution mechanism between technology flexibility and betweenness, and GDP per capita and betweenness. This effect also holds when we change betweenness for centrality degree. It means that less developed regions with lower technological endowments benefit from establishing interregional co-invention linkages in general, regardless of control and intermediate positions. Our analysis corroborates with findings from two strands of literature. First, the literature on evolutionary economic geography which has empirically shown that the diversification process is path-dependent and strongly impacted by the relatedness between different sectors, technologies, and products, as the current knowledge and capabilities regionally available will support the development of new ones. Furthermore, this result also corroborates with studies focused on regional innovation networks, in which the flows between physically close and distant agents contribute to enhancing knowledge recombination and production, encouraging learning and innovation.

Implications

Our results add to the debate on regional diversification policies, especially in less developed regions. Designing place-based policies can be especially challenging for these regions because less developed regions have few technological specializations, implying little locally available knowledge and technological capabilities. This thin economic setting provides few insights for policymakers into which technological options are the best to pursue. However, including network-related aspects, the scope of the policy can be broadened by including practices that favor the connection within regions and with external actors.

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RESEARCH AND TECHNOLOGY TRANSFER I

May 1st: 10h30 am – 12h30 pm

Chair

Janaina Ruffoni (Unisinos, Brazil)

Papers

A comparative study of technology transfer office organization for engagement with university intellectual capital

Christle de Beer, Corne Schutte

Post-pandemic: Critical success factors of a technology park

Luiz Stephany Filho

Should universities be smart about innovation? University technology portfolio and licensing strategies

Arman Yalvac Aksoy, Catherine Beaudry, Davide Pulizzotto, Polytchnique Montreal, Canada

International knowledge flows in human health in Brazil

Rosane Becker Flores, Janaina Ruffoni

A comparative study of technology transfer office organization for engagement with university intellectual capital

Abstract ID#140 | Full paper ID#388

Christle de Beer, Corne Schutte (Stellenbosch University)

Abstract: The study of universities in advanced nations often serves as a frame of reference and basis for innovation policy recommendations in emerging economies. In this study, novel primary data gathered from universities in Continental Europe, UK, Brazil, and South Africa was compared based on innovation policy decisions regarding technology transfer office (TTO) organization. Specifically, the following aspects of TTO organization were considered: the autonomy, typology, and mission statement of university TTOs. Furthermore, these TTO organizational aspects were assessed in terms of its impact on engagement with university intellectual capital (IC). Recent research has proven that engagement with university IC impacts the efficiency of university technology transfer. The data shows that the differences between advanced nations and emerging economies in their TTO organization seem to be negligible. On the whole TTOs in emerging economies are not as efficient as their advanced nation counterparts, and have less access to university IC, but it appears that this is shifting with time as maturity grows.
Keywords: Technology transfer, organizational design, intellectual capital, innovation policy, efficiency

Introduction

Due to the longevity of their technology transfer activity, the study of universities in advanced nations often serves as a frame of reference and basis for innovation policy recommendations in emerging economies. In this study, novel primary data gathered from universities in Continental Europe, UK, Brazil, and South Africa will be compared based on innovation policy decisions regarding technology transfer office (TTO) organization. Specifically, this study will focus on the autonomy, typology, and mission statement of university TTOs and its impact on engagement with university intellectual capital (IC). Recent research (Secundo et al., 2016; Fai et al., 2018; de Beer et al., 2017) has proven that engagement with university IC impacts the efficiency of university technology transfer. Some research has been conducted on the typologies of TTOs (Bercovitz & Feldmann, 2001; Schoen et al., 2014; Brescia et al., 2016, Fai et al., 2018) and which type of TTO enables increased access to university IC in advanced nations. Other research in advanced nations (Fitzgerald and Cunningham, 2016; Brescia et al., 2016; Fai et al., 2018) has shown how the mission statement of the university influences the choice of TTO typology and accordingly has an impact on access to university IC. Using a tool created by Secundo et al. (2016) which determines the degree and ease of access to university IC (de Beer et al., 2017), we developed and sent an online questionnaire to 234 universities in Europe and the UK, and 38 universities in South Africa and Brazil. The data will be compared to determine if the findings from research conducted on university TTOs in advanced nations hold true of emerging economies, if there are any significant differences in innovation policy decisions, and if different TTO organizations exists in emerging economies. Most importantly, this study will confirm if TTOs in emerging nations are significantly more inefficient at technology transfer than advanced nations by comparing access to university IC.

Theoretical Background

Innovation policy in advanced nations and emerging economies – Universities in advanced nations first established TTOs in the 1980s and 1990s with a very clear commercial focus and the Bayh-Dole Act was enacted in the USA in 1980 to formalize the intellectual property (IP) rights of universities (Lockett et al., 2015). Given that most TTOs at the time were established with missions to derive economic benefits for the university from technology transfer, this was reflected in their core activities i.e.: IP protection, research, and spin-off support. This is also reflected in the structural dimensions of the TTO typology and autonomy. Technology transfer has changed dramatically since then (Siegel and Wright, 2015). In the UK there is no equivalent legal counterpart to the Bayh-Dole Act. As such, British TTOs were not necessarily established with the same mission in mind as those in the USA, although some universities did see the benefit of a commercial focus. Many TTOs in the UK have an impact focused mission statement because the government uses the Research Excellence Framework (REF) to assess and reward universities that have achieved international scientific excellence. The REF utilises three criteria namely: research output, impact, and environment (Fai et al., 2018). As such, the factors driving innovation policy decisions at universities in the UK are different to those in the EU and USA. Furthermore, not all TTOs have a commercial objective or an impact focus in their mission statement. In line with the third mission of universities, some TTOs, especially those in Europe, have shifted to have a relationship focused mission statement, in which university-industry links are prioritised as a source of research funding and/or contracts (Fai et al., 2018).

Universities in emerging economies have tried to implement the lessons learnt, via innovation policies, from universities successful at commercial technology transfer from predominantly the USA, the UK and Europe. This is motivated by the assumption that the economic growth of knowledge-based economies is primarily led by intangibles (Schiuma, 2012; Bornemann and Wiedenhofer, 2014; Secundo et al., 2015). Therefore, emerging economies are becoming increasingly dependent on technology transfer, IP, and IC from universities, as knowledge producers, (Schiuma and Lerro, 2008; Yasar and Schiuma, 2009) to grow their economies. This has typically led to formalizing the IP rights of universities and the formation of TTOs with little autonomy, an internal typology, and a commercial mission statement (Kloppers et al., 2006). The Brazilian Innovation Law, initially introduced in 2004, aimed to incentivize cooperation between government, universities, and industry with the goal to create commercial offerings. This was followed by the Technological Innovation Law, which saw the establishment of TTOs with a purpose to encourage technology transfer through licensing and/or through the creation of spin-offs (Dos Santos et al., 2013). Similarly, in 2010, the IP Rights Act was introduced in South Africa with the primary purpose to ensure that IP outcomes from publicly financed research and development with the potential to create social and/or economic value are protected and commercialised for the benefit of the people of South Africa (Taylor, 2009). As such, TTOs at universities in emerging economies primarily have a commercial mission statement.

University Intellectual Capital - There are many different types of universities (research, public, private, teaching), and each university has a different managerial approach and policy in terms of the management of innovation, IP, and IC, depending on the country in which the university is based (Secundo et al., 2015). IC in a university is, ultimately, the set of intangible and knowledge assets that drive value creation mechanisms according to the targets defined by stakeholders of the internal and external environment (Redford and Fayolle, 2014). Without a doubt, the tripartite classification of IC is the one that has the widest recognition in the specialized literature, structuring IC in three blocks: Human Capital, Structural Capital or Organisational Capital, and Relational Capital. In the context of universities, the tripartite IC classification would be as follows (Secundo et al., 2015):

- Human Capital (HC) is the knowledge assets derived from the expertise and experiences of researchers, professors, technical staff, Ph.D. students and administrative staff.

- Structural Capital (SC) is the intangible resources found in the organization itself, such as the databases, IP, research projects, research infrastructure, research and education processes and routines, university culture and governance principles.
- Relational capital (RC) is the value asset linked to the university's internal and external relationships, such as networks, collaborations, and commercial partnerships.

In view of their meaning and organisation, HC, RC, and SC can be useful for universities only if they are considered as interconnected and interrelated. This capital dimension, interconnectivity, is thus a fourth dimension to consider, highlighting the fact that in knowledge intensive organizations like universities and research centers, the three IC dimensions are related to and interconnected with each other (Habersam and Piber, 2003).

TTO structure and mission statement - Several TTO typologies have been suggested and reviewed in literature (Schoen et al., 2014; Brescia et al., 2015). Initially, most studies considered TTOs to be centralized and hierarchical structures, embedded at the central level of the university (Link and Siegel, 2005). However, a number of studies have argued that TTOs can take different organizational forms, which have been mainly defined by the degree of autonomy granted to TTOs (Markman et al., 2005), and the mission statement of the TTO (Fitzgerald and Cunningham, 2016). The organization of a TTO depends on the university it serves and its innovation policy, and evolves over time. Consequently, each university must take its specific goals, characteristics, as well as environmental factors, into account when organizing its technology transfer (Schoen et al., 2014). The university plays an important role in defining the mission statement of its TTO, thereby setting the objectives of the TTO, defining the relationships with other university structures, and assigning the funds for TTO activities (Brescia et al., 2016). In the same way, aligning the organization of the TTO and mission statement ensures that the objectives of the innovation policy are met (Fai et al., 2018).

Methodological Procedures

An online survey, based on the tool created by Secundo et al., (2016) was sent to 272 universities in Europe, the UK, South Africa and Brazil. Of these 84 responded, and after removing duplicate responses (from the same institution), incomplete responses, and the responses of those who requested to remain anonymous, the responses from 48 institutions were studied. This study builds upon prior research by Fai et al., (2018). As such frequent reference will be made to the findings of this paper, as the comparison with recent findings is elucidated.

The tool created by Secundo et al., (2016) assesses the degree and ease of access the university IC across the three dimensions of HC, SC, and RC. Specifically, the HC dimension determines if appropriate human resources are available, and if the knowledge and expertise of the researchers in the university are applied towards creating high-quality technology. The SC dimension assesses if the innovation policy, mission statement, and organization of the TTO enables the function of the TTO. Lastly, the RC dimension focusses on networks and university-industry cooperation and if those are being leveraged appropriately. The access to university IC is given as a percentage. Investigating the responses to the SC dimension allows for the determination of the typology and autonomy (organization) of the TTO as well as the mission statement of the university.

According to the initial research in this space by Fai et al., (2018) three TTO typologies can be identified: Internal, External, and Hybrid. An internal TTO is a centralised department or office within the university, but functions independently from other university substructures. This means the TTO is physically and culturally close to all the other resources of the university (legal team, management team) as well as faculties and academic departments, which enables it to build strong internal relationships within the university and to leverage research contracts to create university-industry links. As such, these TTOs generally have greater access to HC and RC. An external TTO, on the other hand, is likely established as a company outside of the university structure, yet wholly owned by it. It is more autonomous and may be more able to take on more risk and seek to engage more pro-actively in developing commercial ventures. As such, these TTOs usually have a commercial mission statement. Finally, a hybrid TTO is, as the name suggests, a combination of the above. In some instances, a hybrid TTO is a centralised office, but supported by decentralized IP scouts who assist in the technology transfer process. Alternatively, the office is supported by external third parties e.g. legal firms, or other intermediaries. There are yet other instances, where a local TTO is established to serve the technology transfer needs of all universities in the region. As such, thee TTOs have great access to HC and RC, and usually a commercial or impact mission statement.

Furthermore, Fai et al., (2018) define the three mission statements of a university TTO as: commercialisation (IP protection, licensing, and spin-off company creation); impact (research outputs, knowledge transfer, and contributions to regional development) and; relationship building (research contracts, consulting to industry, and collaboration for the development of research).

Results

Emulating the analysis in Fai et al., (2018) the following results were obtained and are given in Table 1 below.

Table 1: Findings from 48 survey respondents organized by country. Also captured are the percentage access to university intellectual capital, typology, degree of autonomy given on a 5-point Likert scale, and the mission statement.

Country	% access to university IC	Typology (Internal, External, Hybrid)	Degree of autonomy (scale of 1 – 5)	Mission Statement (Commercial, Impact, Relationship)
Austria	50	Hybrid	4	Commercial
Belgium	62,5	Hybrid	5	Commercial
Belgium	62,5	Hybrid	2	Relationship
Belgium	62,5	Hybrid	5	Relationship
Belgium	50	Internal	1	Commercial
Brazil	75	Hybrid	2	Commercial
Brazil	50	Hybrid	2	Commercial
Brazil	75	Internal	1	Commercial
Brazil	62,5	Internal	1	Commercial
Brazil	50	Internal	1	Commercial
Brazil	50	Internal	1	Commercial
Bulgaria	62,5	External	2	Relationship
Czech Republic	62,5	Hybrid	3	Relationship
Czech Republic	50	Hybrid	4	Relationship
Czech Republic	62,5	Internal	1	Impact
Czech Republic	62,5	Internal	1	Relationship
Czech Republic	50	Internal	1	Relationship
Denmark	62,5	Hybrid	3	Commercial
Estonia	62,5	Hybrid	4	Relationship
France	62,5	Internal	1	Relationship
Germany	50	External	4	Relationship
Germany	37,5	External	3	Relationship
Germany	50	Hybrid	4	Relationship
Greece	50	Hybrid	3	Impact
Italy	50	Hybrid	3	Impact
Netherlands	62,5	Hybrid	4	Commercial

Netherlands	62,5	Hybrid	4	Relationship
Poland	62,5	Internal	1	Relationship
Romania	50	Hybrid	3	Impact
South Africa	62,5	External	3	Commercial
South Africa	50	Hybrid	3	Commercial
South Africa	50	Hybrid	4	Commercial
South Africa	75	Internal	1	Commercial
South Africa	75	Internal	1	Commercial
South Africa	50	Internal	1	Commercial
South Africa	37,5	Internal	1	Commercial
South Africa	37,5	Internal	1	Commercial
Spain	50	Hybrid	3	Commercial
Sweden	75	External	4	Commercial
Switzerland	75	External	2	Commercial
UK	75	External	4	Commercial
UK	75	External	2	Commercial
UK	62,5	External	3	Relationship
UK	62,5	External	3	Relationship
UK	62,5	Hybrid	4	Commercial
UK	50	Hybrid	4	Impact
UK	50	Hybrid	2	Impact
UK	62,5	Hybrid	3	Relationship

When evaluating the most efficient TTOs in the dataset (Table 2 below), as determined by the degree of access to university IC, 8 TTOs score 75%. These are 2 from Brazil, 2 from South Africa, 2 from the UK, and 2 from Europe. All 8 TTOs have a commercial mission statement, but varying degrees of autonomy and different typologies. As such no significant correlations can be drawn.

Table 2: Dataset with 75% access to university intellectual capital

Country	% Access to IC	Typology	Degree of autonomy	Mission Statement
Brazil	75	Hybrid	2	Commercial
Brazil	75	Internal	1	Commercial
South Africa	75	Internal	1	Commercial
South Africa	75	Internal	1	Commercial
Sweden	75	External	4	Commercial
Switzerland	75	External	2	Commercial
UK	75	External	4	Commercial
UK	75	External	2	Commercial

Expanding the dataset under consideration to include all TTOs who have more than 50% access to university IC, we see that 27 TTOs meet this threshold but the distribution is significantly different (Table 3 below). The TTOs are from Brazil (3), South Africa (3), the UK (6) and Europe (15). Here we start to notice some significant correlations. All TTOs who have little autonomy (1 on the 5-point scale) also have an internal typology (8 in the sample). Interestingly most (6 out of 8) TTOs who have an external typology also indicate low levels of autonomy (2 or 3 on the 5-point scale). Even more interestingly, the typology with the most autonomy (4 or 5 on the 5-point scale) seems to be the hybrid (6 out of 11) TTO. This seems to suggest that autonomy is not necessarily a given with an external TTO as one might imagine. In this dataset only 1 TTO has an impact focused mission statement with an internally typology. The remainder are commercial and relationship focused, but neither mission statement seems to favor a typology, as all three are present. Another interesting aspect of this dataset is that all TTOs with a relationship focus have 62% access to IC, while the majority of TTOs with a commercial focus have 75% access to IC.

Table 3: Dataset with more than 50% access to university intellectual capital

Country	**% Access to IC**	**Typology**	**Degree of autonomy**	**Mission Statement**
Sweden	75	External	4	Commercial
Switzerland	75	External	2	Commercial
UK	75	External	4	Commercial
UK	75	External	2	Commercial
South Africa	62,5	External	3	Commercial
Bulgaria	62,5	External	2	Relationship
UK	62,5	External	3	Relationship
UK	62,5	External	3	Relationship
Brazil	75	Hybrid	2	Commercial
Belgium	62,5	Hybrid	5	Commercial
Denmark	62,5	Hybrid	3	Commercial
Netherlands	62,5	Hybrid	4	Commercial
UK	62,5	Hybrid	4	Commercial
Belgium	62,5	Hybrid	2	Relationship
Belgium	62,5	Hybrid	5	Relationship
Czech Republic	62,5	Hybrid	3	Relationship
Estonia	62,5	Hybrid	4	Relationship
Netherlands	62,5	Hybrid	4	Relationship
UK	62,5	Hybrid	3	Relationship
Brazil	75	Internal	1	Commercial
South Africa	75	Internal	1	Commercial
South Africa	75	Internal	1	Commercial
Brazil	62,5	Internal	1	Commercial
Czech Republic	62,5	Internal	1	Impact
Czech Republic	62,5	Internal	1	Relationship
France	62,5	Internal	1	Relationship
Poland	62,5	Internal	1	Relationship

Contrasting this with the remainder of the dataset, i.e all TTOs who have less than 50% access to university IC, brings 21 TTOs under consideration (Table 4 below). The TTOs are from Brazil (3), South Africa (5), the UK (2), and Europe (11). Similar to the dataset above, all TTOs who have little autonomy (1 on the 5-point scale) also have an internal typology (7 in the sample), TTOs with an external typology (2 in the sample) also indicate low levels of autonomy, and TTOs with a hybrid typology indicate the greatest autonomy. Interestingly in this dataset, 5 TTOs had an impact focused mission statement, and all favored the hybrid typology. The remainder had a commercial focus, but favored the internal or hybrid typology, or a relationship focus but with all 3 typologies present. What is also notable in this dataset was that most TTOs with a commercial focus were from Brazil or South Africa (8 out of 11) and that none of these TTOs had an external typology.

Table 4: Dataset with less than 50% access to university intellectual capital

Country	**% Access to IC**	**Typology**	**Degree of autonomy**	**Mission Statement**
Austria	50	Hybrid	4	Commercial
Brazil	50	Hybrid	2	Commercial
South Africa	50	Hybrid	3	Commercial
South Africa	50	Hybrid	4	Commercial
Spain	50	Hybrid	3	Commercial
Belgium	50	Internal	1	Commercial
Brazil	50	Internal	1	Commercial
Brazil	50	Internal	1	Commercial
South Africa	50	Internal	1	Commercial
South Africa	37,5	Internal	1	Commercial
South Africa	37,5	Internal	1	Commercial
Greece	50	Hybrid	3	Impact
Italy	50	Hybrid	3	Impact
Romania	50	Hybrid	3	Impact
UK	50	Hybrid	4	Impact
UK	50	Hybrid	2	Impact
Germany	50	External	4	Relationship
Germany	37,5	External	3	Relationship
Czech Republic	50	Hybrid	4	Relationship
Germany	50	Hybrid	4	Relationship
Czech Republic	50	Internal	1	Relationship

When reflecting on the differences between the high access to IC dataset (Table 3), and the low access to IC dataset (Table 4) as elucidated above other interesting trends emerge. The high access to IC dataset is dominated by the UK and Europe (21) versus 6 from emerging economies. The low access to IC dataset has far less representation by Europe (8) and only 2 from the UK versus 8 from emerging economies. This seems to suggest, on the whole, that TTOs in advanced nations have greater access to IC to enable the TTO function, and are more efficient at technology transfer. This confirms the literature, as reviewed above, given the longevity of their technology transfer activity. When looking at mission statement, despite the fact that there is no legislation driving the commercialization of university research in the UK, and that universities are increasingly assessed on impact, only 2 UK TTOs have an impact focus. Interestingly, only 1 TTO with an impact focus is in the high access to IC dataset, which may indicate that achieving this mission statement has not been so successful.

As can be expected, from the review of literature above, the TTOs in emerging economies all have a commercial mission statement. However, it is about an equal split between the high and low access to IC datasets, which may point to the fact that some TTOs in emerging economies have been successful in achieving this mission. Only one TTO in South Africa has an external typology, the remainder are all internal or hybrid typologies. Indeed, when looking at typology another interesting observation is made. In the low access to IC dataset, only two TTOs have an external typology, while in the high access to IC dataset there are 8 TTOs with this typology. This may suggest that the external typology allows greater access to the IC required for the function of the TTO.

However, no other significant correlations seem to emerge. Both datasets have the similar degrees of autonomy, seemingly unlinked to typology or mission statement, except in the case of an internal typology which has the lowest autonomy in both datasets.

Discussion

The purpose of this paper was to determine if the findings from research conducted on university TTOs in advanced nations hold true of emerging economies, if there are any significant differences in innovation policy decisions, and if different TTO organizations exists in emerging economies. Even though literature suggests a link between an external typology and a commercial mission statement, due to the fact that an external typology is deemed to have greater autonomy, the data does not support this. Similarly, an internal typology does not necessarily support a relationship mission statement to any greater degree than another typology. However, an internal typology does seem to have the least autonomy. The data seems to suggest that the hybrid structure is more favored and enjoys greater autonomy than its counterparts. Furthermore, the data suggests that there are no significant innovation policy differences between the countries that were studied. All three mission statements and TTO organizations were present in all countries.

Conclusions

In conclusion, the differences between advanced nations and emerging economies in terms of preferred typology, autonomy granted by the university, and mission statement seem to be negligible. On the whole TTOs in emerging economies are not as efficient as their advanced nation counterparts, and have less access to university intellectual capital, but it appears that this is shifting with time as maturity grows. Expanding the dataset to include more countries from emerging economies, whose technology transfer activities are still in infancy, may influence this perception. It may well be that in the 10 years or so that have elapsed since Brazil and South Africa have formalized technology transfer great strides have been made towards efficiency and success at achieving their mission.

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Post-pandemic: critical success factors of a technology park

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Abstract: In 2022, there were around 60 Technology Parks (TP) in Brazil, and 35 are under implementation. This Innovation Ecosystem is considered one of the most conducive environments for interaction between the agents of the fifth helix. However, managing a TP is complex, including the need for external subsidies until its maturity (around 15 years after the inauguration). For a TP to succeed, management must consider critical success factors (CSF) cited in the literature and the challenges of a post-pandemic world. Based on these propositions, the study proposes two research questions: How do heads of a Technology Park, considering the CSF, adjust their strategies to grow towards maturity and financial sustainability? What are the new PT CSF in the post-Covid-19 pandemic world? The goals of this research are to understand how the heads of a TP align their development strategies, having as reference the old and new critical success factors in a post-pandemic context. In order to answer the guiding questions, the case study methodology will use document analysis and narrative interview techniques, with which it will expect to obtain relevant data that can contribute to the management practices of Technology Parks.
Keywords: Technology Park; Critical Success Factor; Technology Park challenges; talent training; innovative territories.

Introduction

The phenomenon of the creation of Technology Parks (TP) is growing all over the world. However, no formula determines which innovation ecosystems will reach maturity and which will not yield the expected return.

Although each project is complex and unique, several studies have presented the most common critical success factors (CSF) for TPs that have reached maturity and deliver satisfactory results for their investors or maintainers (Faria & Ribeiro, 2016; Jansz et al., 2020; Kharabsheh, 2012).

In the theoretical framework of this study, the author presents 11 CSF of TP. They are: 1) location; 2) infrastructure and facilities offered; 3) provision of specialized laboratories and services; 4) strong scientific and technological base; 5) qualified management team; 6) governance; 7) culture of innovation; 8) learning network; 9) presence of an anchor company; 10) image and reputation; and 11) government support for residents (Faria et al., 2021).

Due to the unique nature of TPs, we chose to use the Case Study methodology with a perspective from Stake (2016), which does not seek to fit the research findings with a positivist logic of generalization. On the contrary, it focuses on identifying the non-existent conformities and bringing to light the reasons that cause these inconsistencies.

In the results section, the author describes the case study and classifies it as a young park, and in the discussion section, the article presents the identified CSF and the adoption level of each one in the TP. Through the interviews, the author identified a junction between four CSF, which he named the benefits package construct. The other CSF form the construct toward maturity. Finally, the author presents two new CSF: The creation of your talents and innovative territory.

In conclusion, the paper presents management guidelines for professionals working with TP and suggestions for updating the literature on the subject. Therefore, it answers the study's two research questions: How do managers of a Technology Park, considering the critical success factors, adjust their strategies to grow towards maturity and financial sustainability? What are the new critical success factors in the post-pandemic world?

The objective of answering the research questions is to understand how a Technology Park's managers align their development strategies, referencing the old and new CSF in a post pandemic context.

Theoretical Background

One TP's success model cannot be replicated in another; countless variables make each case unique (Yang et al., 2009). However, Faria & Ribeiro (2016), Jansz et al. (2020), and Faria et al. (2021) identified that some management practices are constant in many successful TP and that the adoption of these behaviors can signal the way forward toward maturity. The main critical success factors found are in Table 1.

Frame 1 - Critical Success Factors

CRITICAL SUCCESS FACTORS	1	2	3
Geographic Proximity	x	x	x
Infrastructure and Facilities	x	x	x
Offer Laboratories and specialized services	x		x
The solid scientific and technological base			x
Qualified management team	x		x
Governance	x		x
Innovation and Entrepreneurship Culture			x
Learning Network	x	x	x
Presence of an anchor company	x		x
Image and reputation			x
Government support and funding for residents			x

Sources: (1) Faria & Ribeiro (2016); (2) Jansz et. al (2020); e (3) Faria et al. (2021).

Geographic Proximity

A TP located close to a university is an essential attraction because it places companies close to (or inside) a source of professors, researchers, and students. As a result, the company has easy access to researchers in areas of knowledge of interest and talented students who are quickly recruited and can become employees (Link & Scott, 2018; C. Vedovello, 1997).

Another vital aspect of a geographic location is proximity to the consumer market of resident companies and easy access to different means of transportation. A well-located park becomes an innovation hub that interacts with other agents of the local and regional innovation ecosystem, expanding the possibilities of connections for companies that are part of the TP (Fukugawa, 2006; Guo & Verdini, 2015).

Infrastructure and Facilities

Infrastructure and shared facilities reduce costs, so a TP with adequate infrastructure, with wooded spaces, bathrooms, water, modern facilities, good lighting, accessibility for social inclusion, parking, a place for companies to hold events, computer labs, auditoriums, places of coexistence, and facilities such as count-food, security, easy access to public transport, ATMs, bank branches, pharmacies, gyms, and convenience stores, offering value added services, among others (Vedovello et al., 2006).

Offer laboratories and specialized services

The cost of a high-tech laboratory, which involves expensive and state-of-the-art equipment, often makes it unfeasible for companies to develop RD&I within their facilities. On the other hand, universities with these environments do not have a continuous demand for use, and the equipment is idle most of the time (Smirnova et al., 2019).

In addition to offering this equipment, it is also attractive when the TP offers services shared with residents, which would be expensive if hired individually if the company is not a member of the TP. Some examples of services offered: are consulting activities with traditional and emerging themes, participation in forums, conferences, symposiums, discussions, training, mentoring, coaching, and the creation of clubs and informal associations (Smirnova et al., 2019).

The solid scientific and technological base

There must be a tradition in the TP or the linked University in the generation of knowledge. A history of development projects, patents granted, and awards won by researchers. These historical assets are an essential attraction for new projects and companies seeking solutions to their problems or making their ideas viable(Henriques et al., 2018).

However, the TP should look to more than just the past. It must be aware of future technological trends and implement new initiatives, such as new laboratories. Nonetheless, the lack of access to cutting-edge technology is a competitive disadvantage for countries in the southern hemisphere. For example, while Norway has a TP focused on studies of 6G technology, Brazil is still starting to install 5G (Makhdoom et al., 2022).

Qualified Management Team

The TP needs to be managed as an independent business unit to make strategic decisions happen quickly. Therefore, it is necessary to have a management structure similar to any other company, with well-defined processes, functions, and responsibilities. The more dependent the ecosystem is on the supporting institutions, the longer it will take to reach maturity. For example, talent hiring must be guided by each established managerial function's notorious knowledge and skills (Parry & Russell, 2000).

Governance

For Sampaio Filho and Nascimento-Santos (2017), the governance of TP could be one with three theories:

a) Agency theory: Various actors, such as the board of directors, managers, shareholders, and other stakeholders, are given the rights and responsibility to manage an organization. This equity is to reconcile conflicts of interest between interested parties.

b) Stakeholder theory: The organization is a set of multilateral arrangements and agreements between the company, shareholders, and interested parties. It aims to guarantee the generation of value for the business and its distribution to the interested parties.

c) Stewardship theory: oriented to generate value for the organization and not just for shareholders. Managers can act as an intermediary or direction (managers, executives, and CEO) and constantly look for the best for the organization and themselves, with the conciliation of individual and collective interests.

The criteria determining which governance orientation prevails in each TP depends on the legal nature of the Maintainer, the links that the TP has with public or private universities, with investors, with the government, or with other social stakeholders in general (Cumming et al., 2019).

Innovation and Entrepreneur Culture

Innovation requires the acceptance of a culture of risk, which rarely exists in Universities or Government Institutions. The rectory usually does not understand when the researcher states "They are not sure that the resources invested will guarantee good results" (Kharabsheh, 2012, p. 61). However, when specialized people structure a research and innovation area and they start a generalized awareness work supported by the direction of the institution, in a few years, the consistency of this inculturation brings consistent results such as the generation of patents, the receipt of royalties and financial sustainability (Kharabsheh, 2012).

Learning Network

Putting different companies to live together in the same spaces encourages knowledge to be shared. One agent's skills may be another actor's needed gap in the local innovation ecosystem. However, the TP's role in supporting resident companies in developing their ability to absorb knowledge is fundamental. The TP must have as an operational activity and must occur through the organization of events that bring together the interested parties through the close relationship with the residents to understand the demands of each one (Balle et al., 2019; Hansson et al., 2005).

It is noteworthy that the learning network occurs both in formal and informal organizations. Therefore, the TP must facilitate events that bring people together in the TP's spaces. The transmission of knowledge happens through the interaction of people who share affinities, such as language, common codes of communication, conventions, and standards that the same institutional environment has fostered, also by personal knowledge of each other based on a success story, collaboration, or informal interaction (Mattar et al., 2022).

Presence of an anchor company

An anchor company consolidated in the market that wants to surround itself with Startups and satellite companies, which can be current strategic suppliers. In addition, the presence of anchors acts as an element of attraction for other companies that operate in the same business segment. Some examples are Sophia Antipolis™ with Amadeus™ and Shannon Free Zone™ with Vistaken™ (Ozols & Avotins, 2021).

Image and Reputation

When TP builds a successful image or benefits from the linked University's reputation, it is easy to attract residents and talented people. Creating an image and reputation is crucial for the TP to reach maturity (over 15 years old). The construction work consists of keeping the success stories of the resident companies in evidence in the media, such as the implementation of intellectual property, the growth of sales of innovative products, IPO, and others (Ferguson & Olofsson, 2004; Maltseva, 2015).

The presence of award-winning researchers who stand out in their respective areas of knowledge contributes to building TP's reputation. Participation in professional associations and international entities, partnerships with other international researchers, and quality of research publications also increase the image and reputation. However, it is necessary to make these achievements public through dissemination work in the media (Maltseva, 2015).

Government Support and Funding for Residents

Most government funding programs require the participation of a research and innovation entity, such as a University. So, for a company, being within an innovation hub increases the likelihood of access to public and private investment funds(National Research Council, 2009). For example, in Brazil, there are two laws.

1) The information technology law, which guarantees tax discounts for computer component manufacturers who carry out research and innovation in the national territory;
2) The innovation law grants financial contributions to companies that invest together with the Institutes of Science and Technology - ICTs (BRASIL, 2004, 2019).

Methodological Procedures

Most scientific publications on TP have a qualitative approach and single case studies. This work also uses the case study methodology. Two propositions explain the predominance of this type of method: 1) There are not many TPs in operation in the world (Faria et al., 2021), and 2) These innovation poles are so complex that their management practices cannot simply be copied from one to another (Yang et al., 2009).

When analyzing other case studies on parks, a theoretical character of the variance is perceived; that is, only is sought the validation of empirical data, the discovery of new factors for the adoption of tools, and the comparison between cases to find patterns and generalization (Eisenhardt, 1989). This paper adopts the theoretical character of the process, therefore, seeks to understand in depth the phenomenon studied, also analyzing the trajectory (Langley, 1999).

The proposal adopted in this study seeks to break with the positivist logic of creating models or predictive formulas and avoids closing in on a watertight methodology (case study).

Therefore, it invests in a methodological approach that tries to deal with the complexity of the object of study, aiming to deepen the understanding of the studied phenomenon and not treat it superficially, tell a good story and not build suitable constructs (Dyer Jr & Wilkins, 1991; Stake, 2008).

The requirements of a Brazilian promotion notice for TP were the initial stimulus in the search and analysis of documents; later, the author applied the document analysis technique (FINEP, 2021). The documents also served as a guide for elaborating the questions used in the narrative interviews.

Document Analysis (Pimentel, 2001)

The author had access to the archives of projects carried out between quintuple helix's agents, to the patents granted in cooperation and the laboratories of the University/TP, to the collection of information on the website of the Maintainer/TP, and the documents transferred between the administrative sectors of the University and the TP.

Afterward, the documents were analyzed and extracted the information that shed light on the construction of the TP's historical lapse. The documentary research was also a guideline for choosing subjects participating in the narrative interviews. As a result, the people selected participated in the history and development of TP.

Narrative interviews (Jovchelovitch & Bauer, 2002)

The interview in qualitative research is considered an art, according to which, regardless of the method used, those who use it consider the interview "an adequate means to get a person to say what he thinks, to describe what he lived or what he did. " was a witness" (Poupart, 2008, p. 227). Accordingly, these were the purposes of the interviews; lead the interviewee to:

1) Say what they think about their experiences in research and innovation at the University/TP, and

2) Reconstruct the historical lapse of his career in the research and innovation department.

The subjects selected for the interviews participated in the history and development of TP. The author conducted nine narrative interviews with different stakeholders. The acronyms formed with the letter "i" and a sequential number identify the interviewees: (i1) Intellectual Property Manager, (i2) Innovation Advisor, (i3) Ethics Committee Advisor, (i4) Research Advisor, (i5) Researcher in the Technology Area, and (i6) a Health Researcher. All these six people with more than ten years of experience at the University. In addition to them, TP recently hired: (i7) an Innovation Coordinator, (i8) a Technological Park Coordinator, and (i9) a Project Coordinator.

The interview begins with demographic questions and the question: "Tell me your story within the University?" Then, the interviewee told his story when he started to work with research and innovation; The author introduces the second and third questions: "Why did you accept to be transferred to the research and innovation sector?" "What did you feel when you started working at TP?" "How has your work been after the pandemic?"

All interviews were recorded and uploaded to ATLAS.ti. In the software, the interviews were analyzed and coded. Finally, the codes were submitted to Density and Magnitude Tests, confirming the critical success factors presented in the theoretical framework. In addition, the analysis suggests two other CSF.

Results: the case of study: a young Brazilian technology park

The Embryos of TP's Creation

The foundation's vocation for research and innovation that maintains the YBTP dates to the beginning of the century. For example, in 2002, the University developed a research project called artificial saliva. The General Hospital of Fortaleza-HGF was a partner in this project. The product promoted the quality of life of patients with cancer in the head region.

The second invention developed by the team of researchers at the University was the firefighter robot in 2004, known as SACI. This invention won some awards. Subsequently, the project partner company sold the equipment to several customers using the fire control device since January 2005.

The success of research projects in the field of health sciences culminated in the opening of the Nucleus of Experimental Biology (NUBEX), which brings together projects from a multidisciplinary perspective. In the area of technology-based innovation, one of the Foundation's first initiatives was the agreement between the University and IBM to install an artificial intelligence study laboratory.

In 2010, the University inaugurated a business incubator - EDETEC. With the inauguration of the Technological Park in 2017, NUBEX and EDETEC became part of the YBTP infrastructure.

Currently, the incubator can incubate up to 30 companies simultaneously. The success rate of the incubator in the last five years is 85%, with seven companies graduating and nine incubated and pre-incubated.

The effects of the Covid-19 pandemic on the TP

The onset of the pandemic in 2020 accelerated the adoption of the home-office work model, mainly in the ICT area. Sector employees quickly adapted to this new modality, which led companies to reduce the need for offices (Nagel, 2020). As a result of TP, two large companies terminated the contract, and even in the post-covid period, the difficulty in finding new residents for TP is in the affirmation of the need to expand the physical spaces of companies (i8).

Interviewee 7 believes that this phenomenon will be temporary because for companies to be able to develop innovations, the collision between people is a crucial variable. Without this coexistence and exchange of experiences, the different types of knowledge do not intersect and do not generate innovations.

Current TP Infrastructure

The TP has around 5,640 m² divided into three floors, two of which are available for the installation of companies with their RDI (Research, Development, and Innovation) sectors, a business incubator (EDETEC) with 240m2, an external lounge, a decompression, the YBTP administration room, in addition to the laboratories:

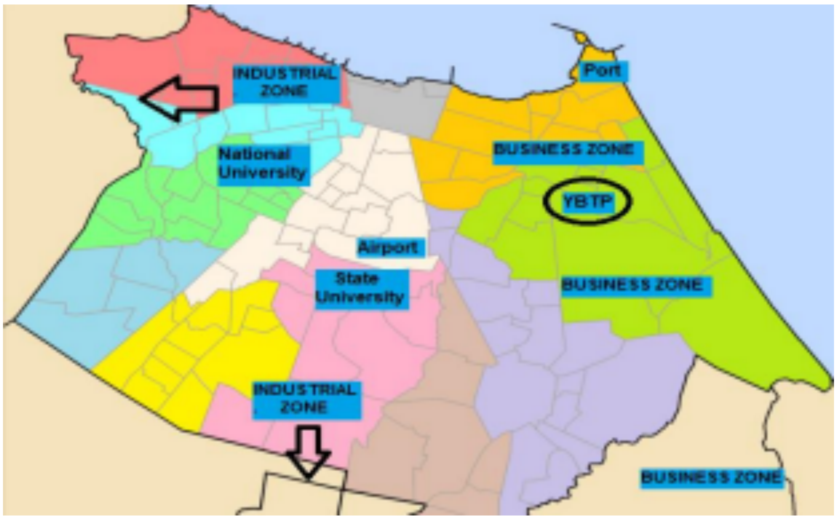
- Data Science and Artificial Intelligence Laboratory
- Knowledge Engineering Laboratory
- City Research and Innovation Laboratory
- Innovation Management Laboratory
- Renew Energy Laboratory
- Biology Laboratory

Environment that contributes to the advancement of research and knowledge about management, organization, and governance processes of RD&I in companies, government, and S & T institutions in Brazil and other emerging countries, with emphasis on its relationship with competitive strategies, growth, and globalization.

Discussion

The YBTP occupies a block within the University, located in one of the prominent neighborhoods of Fortaleza, Ceará, called Edson Queiroz, on Washington Soares Avenue, which connects different business areas in the city and is close to the Port and the International Airport of Fortaleza.

Figure 1 - Map of the City



Source: Adapted from Iplanfor

The proximity of YBTP to the business zones of the city corroborates the statement by Guo & Verdini (2015) that being in the same geographic area as where the wealth generating market is, creates countless possibilities for connections for resident companies (i7).

Critical Success Factors: Benefits Package

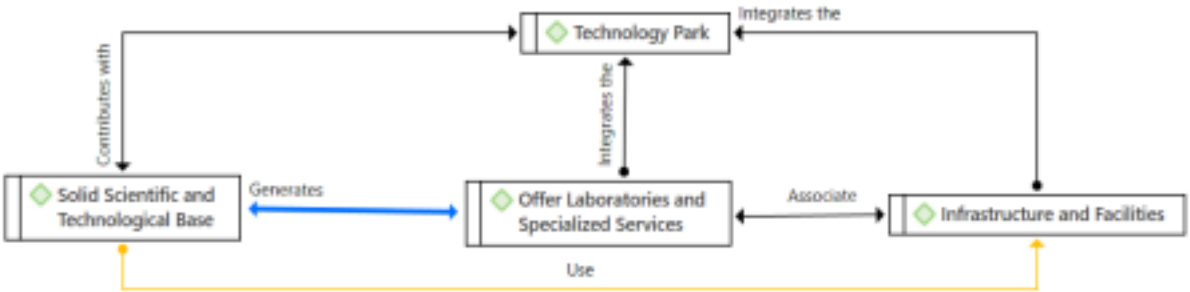
Regarding infrastructure, people from resident companies have access to different public transport lines and parking lots for those who opt for their transport. The campus/YBTP has squares and gardens that contribute to the well-being of residents. The YBTP has wide corridors, clean and spacious restrooms, drinking fountains, and elevators. Next to the workplace, there are two restaurants, five cafeterias, a pharmacy, and a bank branch, in addition to snack kiosks spread across the campus (i8). This infrastructure increases the interest of companies and human talent in staying in the TP (Roldan et al., 2020).

YBTP offers various facilities, but currently, resident companies have a low membership fee. For example, while workers in established companies can enroll in University continuing education courses at a discounted rate, workers currently do not seek this benefit. The same happens with specialized laboratories and services (i4). Only a few companies enjoy these benefits. Therefore, renting companies must know all the laboratories or researchers they may have access to conceive new projects or innovations.

For the YBTP board, the conclusion is that these four factors presented are correlated (figure 1). Even the literature findings point in this direction (Dabrowska, 2016; National Research Council, 2009; Parry & Russell, 2000). For the i7, "The excellent location, the infrastructure, the facilities, and the set of specialized laboratories form a package of benefits. Thus, it will be made known to future residents.".

This benefit package also helps retain high-impact researchers in YBTP laboratories. The YBTP research coordinator states that "there is equipment available in the laboratories for researchers that are unique in Brazil, which increases the impact of our publications. Several of our publications are in journals with a high impact factor".

Figure 2 - Correlation between four CSF.



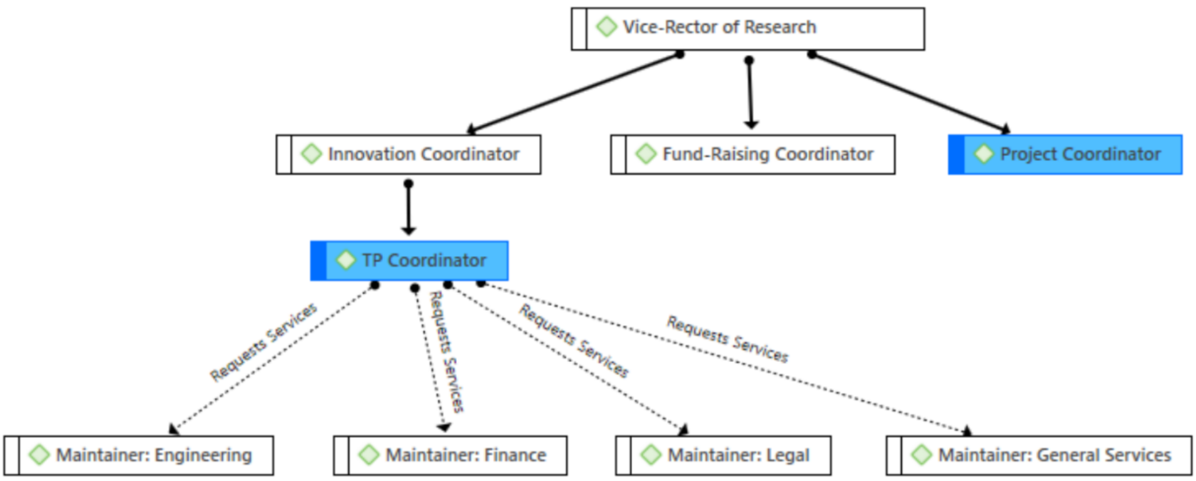
Source: Author, ATLAS.ti

However, more than just having a suitable package of services is needed to contribute to the success of PT; It is necessary for residents to use these spaces and to be the driving force behind the creation and maintenance of learning networks (Roldan et al., 2020). On the part of the park's Administration, there needs to be greater dissemination of this equipment to residents and progress in compliance with the second block of CSF, which we named towards maturity.

Critical Success Factors: Towards to maturity

In response to the first research question, after the pandemic, one of the first steps taken by the Maintainer was to professionalize management. Although this rearrangement is motivated by the need for the University to improve its scientific production indicators compared to other regional competitors (i4), this decision provided greater autonomy and organization of the YBTP's processes. As a result, the new management hopes to start a new cycle of attracting companies.

Figure 3 - New Hierarchical Structure of YBTP



Source: Author, ATLAS.ti

The second block of critical factors characterizes the change in the maturity of a YBTP. The (i1) points out that "a TP that presents only the characteristics of a benefits package is similar to a real estate development, which is not our future objective." The i8 adds: "To make it a place that generates innovation, we need to make progress in improving processes linked to critical governance factors.

As it is part of the University, the YBTP is subject to the norms and rules of its Maintainer (i2). Therefore, the YBTP board acts more as an intermediary between the Maintainer's interests and the YBTP resident companies, which brings the current governance stage closer to the Stewardship Theory

(Sampaio Filho & Nascimento-Santos, 2017). Furthermore, with the future growth of the YBTP, the need to implement councils, committees, and other governance mechanisms will arise (i8).

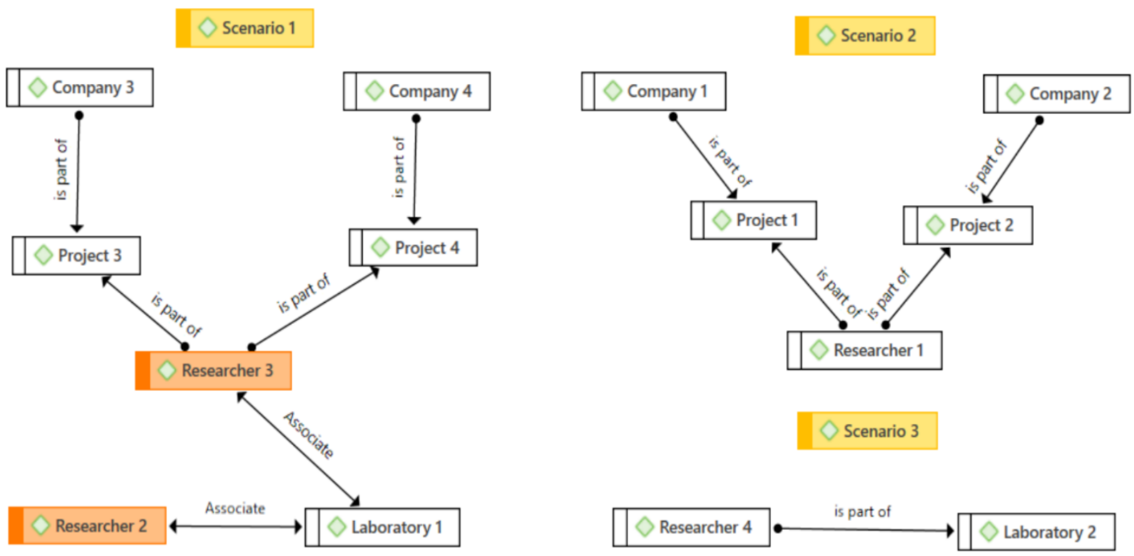
Regarding the innovation and entrepreneurship culture, the organizational culture of the Maintainer is still predominantly traditional, with many controls and risk aversion. However, the culture is changing, and many actions exist to disseminate innovation. For example, the coordinator of the management laboratory states, "I see traces of an ambidextrous organization in the institution" (O Reilly & Tushman, 2004). While the core of the business, teaching, has a traditional structure, the research division has a structure focused on innovation". The YBTP board believes that the success of these initiatives will reverberate throughout the University environment and that the innovative culture will spread.

As for the learning network, the YBTP still works with a star topology when the best model is a network in which the nodes do not need a central element to initiate new connections, new learning, and develop new projects or products (Castells, 2011). In YBTP, there is a strong dependence on its Maintainer. There is even a risk of saying that the YBTP 's anchor company is the University itself, as there are still no inter-company connections in the YBTP.

Another evidence of the fragmentation of the YBTP learning network is the still isolation of different laboratories and researchers. In the interviews with researchers (i5) and (i6), they could not to mention other services offered by other laboratories. Instead, there was an overlapping of events and a repetition of themes. The elaboration of a unified calendar would solve the problem.

Below are the existing network types and the YBTP's desired scenario. In scenario 1, the laboratory has several researchers, but the projects are concentrated on one researcher, while others are without projects with companies. In scenario 2, the researcher is not part of any laboratory and develops his projects in isolation. Finally, in scenario 3, researchers use laboratories to develop pure science research without the intention of making the discovery viable as an economically viable product (i9).

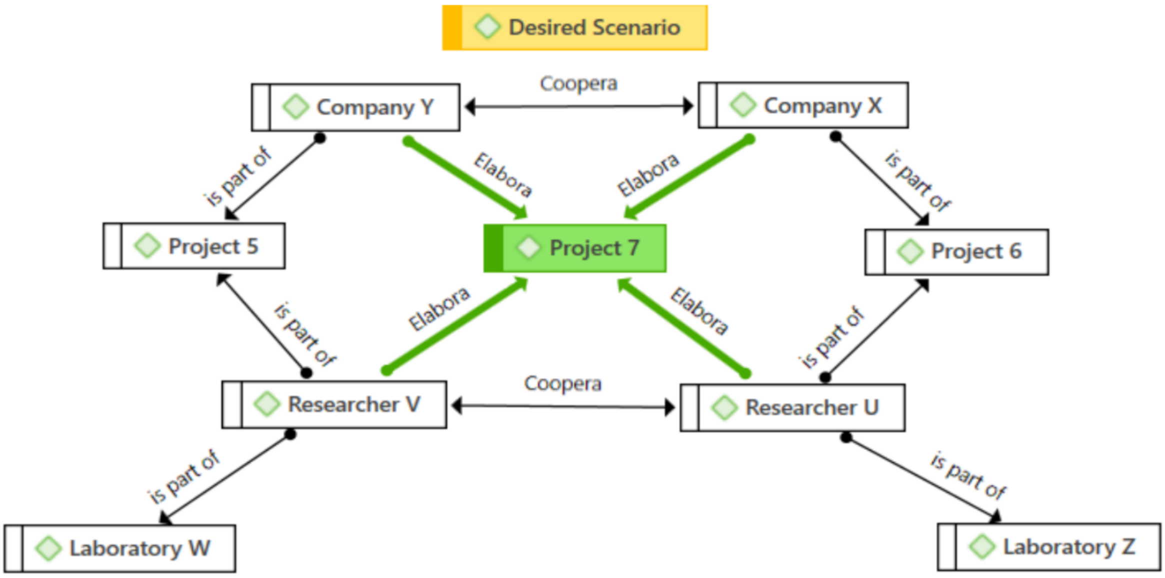
Figure 4 - Recent scenarios of Laboratories x Researchers x Companies.



Source: Author, ATLAS.ti

The need for an anchor company in the YBTP aggravates this centralization. Despite the existence of large resident companies, they still need to act as stimulating elements to attract new companies. Each organization develops its projects with a laboratory or a researcher and does not have joint projects with the other installed companies. Therefore, the YBTP needs to capture companies that are willing to share knowledge with other companies and manage to develop projects based on the desired scenario (i8).

Figure 5 - Desired Scenario



Source: Author, ATLAS.ti

To alleviate problems, Maltseva (2015) proposes using marketing tools to shape an institution's image and reputation. However, it is also necessary to keep the formal and informal information network functioning in the daily life of the TP (Mattar et al., 2022). Furthermore, the University researchers also need to be integrated into this knowledge network so that they can propose research and innovation projects and take on the role of capturing new initiatives (i4).

Of all the factors presented, the most critical is related to the image and reputation of the YBTP because the effort to publicize the YBTP in the local business community was negligible (i8)(i9).

The perception that entrepreneurs have is what Fukugawa (2006) highlights; businesspeople see, most of the time, TP as a real estate development that has cheap spaces for rent. Therefore, it is necessary to constantly reinforce to the stakeholders of the innovation ecosystem that the main objective of the TP is to create favorable conditions for the development of innovation projects (Fukugawa, 2006).

To help with this change in the perception of stakeholders, the dissemination of public funding notices, the holding of events that publicize the laws to encourage business, and the frequent publication of information in the media will help the YBTP to become famous. Moreover, more importantly, the regional quintuple helix community recognizes the YBTP as a catalyst for innovation (i7; i8).

As a summary of this section, an adaptation of Table 1 shows with the inclusion of another column: critical success factors that the YBTP's managers present as advantages.

Frame 2 - Critical Success Factors of the YBTP

CRITICAL SUCCESS FACTORS	STATUS
Geographic Proximity	✓
Infrastructure and Facilities	✓
Offer Laboratories and specialized services	✓
The solid scientific and technological base	✓
Qualified management team	✓
Governance	✗
Innovation and Entrepreneurship Culture	Needs dissemination to the Maintainer.
Learning Network	Needs to transform the star topology into a network topology.
Presence of an anchor company	No anchor company.
Image and reputation	Marketing depends on the Maintainer.
Government support and funding for residents	Companies are unaware of subsidies.

Source: Author

New Critical Success Factors

The creation of your talents

One of the primary growth reducers for companies is the need for more talent in the job market. In addition, there is a need for more people with experience and knowledge to plan and execute new projects. (Blažek et al., 2013).

In the discourse found in the interviews, the statement that a technology park needs to anticipate and create the workforce required by residents was recurrent. Therefore, one suggestion is to create a training program focused on the talent needs of resident companies.

Innovative territories

A TP cannot limit itself to developing actions within its geographic limits or focusing only on its core activity. TPs need to integrate and assume a prominent role within the ecosystem. For example, TP can spread the culture of innovation in schools, associations, class entities, and others (Tanguy, 2018).

Conclusion

Considering the critical success factors discussed, the work presents a managerial contribution to the alert so that the TP board does not succumb to reaching a quick financial balance, becoming just a real estate enterprise. Instead, management must resist and persevere so that the PT maintains its objective of creating a qualified knowledge network with actors interacting to create value.

Being a vanguard environment must be the main element of attractiveness for companies and talents. The TP must be a place of technological excellence influencing the innovation ecosystem. Technological pioneering should be the magnet to attract companies to the park.

Additionally, the future of Technology Parks, especially those based on technology, is challenging. Professionals in the ICT area resist returning to face-to-face work. This absence can negatively impact the innovative environment, given that one of the main assumptions of this type of ecosystem is to promote interaction and exchange of tacit knowledge between people.

The study proposes two new critical success factors as a theoretical contribution to overcoming this challenge. First, the creation of its talents; that is, the TP must be prepared to train people with the profile needed by the resident companies. Second, the TP must become an innovative territory; it must expand its products and services to potential customers outside the limited geographical areas of the TP.

As a suggestion for future studies, the author proposes the use of quantitative methods to confirm the formation of the service package (4 CFS) and toward maturity (7 CFS) factors, in addition to validating the other two factors proposed in this study: the creation of your talents and innovative territory.

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Should universities be Smart about innovation? University technology portfolio and licensing strategies

Abstract ID#366

Arman Yalvac Aksoy, Catherine Beaudry, Davide Pulizzotto (Polytechnique Montreal)

Background and rationale

The Smart Specialisation Strategy was first adopted by the European Commission in 2009. The concept quickly grew in popularity, and today, the strategy is emulated by other nations around the globe.

The place-based approach is characterised by the identification of local competitive advantages to bolster through targeted policies. It aims at developing local economies and coordinating innovation ecosystem actors around common development goals. Policymakers in North America have shown interest in the strategy and Canada has even launched a smart-specialisation-inspired initiative called the Global Innovation Clusters.

However, previous studies have shown that diversification essential for innovation. Thus, smart specialisation could have unforeseen effects on university research commercialisation by reducing the university's and local actors' research diversity.

We study the effect of university-industry research coordination on university research commercialisation at North American universities. The aim is to provide empirical evidence of the effect smart-specialisation type policies could have on research commercialisation. The study focuses on the relationship between research coordination and licensing to incumbent companies versus launching startups.

Methods

We used patent and licensing data to analyse how the university and province/state patent portfolios affect university licensing behaviour in Canada and the United States. Patent data was collected from the United States Patent and Trademark Office (USPTO). Licensing data was obtained from the association of university technology manager's (AUTM) database.

We used panel regressions to measure the relationship between university/state patent portfolios characteristics and the number of licenses generating income and university startups. Our dependent variables are the number of licenses generating income and the number of startups created. These two variables represent the strategies that universities can use to license their technology, either generate income with an existing company or create a new company to commercialise the technology.

Our independent variables include the technological diversification of the university and the state, the technological proximity between the university and the state, and the national expertise of the university. We use two different indexes on patent portfolios to calculate the university and state technological diversification and compare the results: the entropy index and the Herfindahl-Hirschman index. These indicators are supplemented with the technological proximity indicator which is the cosine similarity between the university and state patent portfolios. Finally, the university national expertise is a location quotient of the university patent portfolio. We selected the highest location quotient as it represents the expertise field of the university compared to the nation.

Results

Technological diversification is associated with more licenses generating income and more startups being created. However, the effect of proximity is moderated by technological diversification. For diversified universities, technological proximity has a positive association with the number of startups created and a negative association with the number of licenses generating income. For none diversified universities the relationship is inverted, proximity is associated with more licenses generating income and fewer startups.

More specifically, results show that universities can be divided into four (4) profiles alongside technological diversity and technological proximity to the local patent holders. Hence, our four profiles are: high technological diversification and proximity, low technological diversification and proximity, low technological diversification and high technological proximity, and high technological diversification and low technological proximity.

High technological diversification and proximity are associated with more startups and fewer licenses generating income. This profile shows the highest number of startups created amongst all four (4) profiles. This hints at the importance of local absorptive capacities and spillovers. Companies can not or do not want to integrate every innovation the university can come up with due to cost issues. However, these innovations can still have an economic value which encourages entrepreneurs to launch startups.

Low technological diversification and proximity are associated with fewer licenses generating income and more startups. This profile exhibits the lowest number of licenses generating income. This is coherent with results from previous studies on regional innovation which highlighted the negative association between local absorptive capacities and startup creation. In the absence of local incumbents with sufficient absorptive capacities to integrate the innovation, the only way to commercialise becomes the launch of a startup. However, none diversified universities launch fewer startups than their diversified counterparts which demonstrates the importance of knowledge diversification for innovation.

Low technological diversification and high technological proximity have the fewest number of startups. These universities grant more licenses generating income than their low-proximity counterparts but are still far behind diversified universities in that regard. We believe that this is due to these universities preferring to work with local incumbent firms to innovate and license instead of launching startups. However, low diversification hinders their innovativeness.

High technological diversification and low technological proximity are characterised by the highest number of licenses generating income. This profile is also associated with fewer startups than their high proximity counterparts. High diversification is leading to more innovation. However, low proximity to local patent holders ensures that, first, the innovation cannot be easily absorbed without the aid of the university researcher. Second, low technological proximity also ensures that the university technology is not in competition with existing similar technologies and does not threaten sunk costs.

Significance

This is the first study to look at the relationship between university technology portfolios and licensing. Our results confirm the importance of technological diversification for innovation and highlight its moderating effect between technological proximity and licensing strategy.

These findings can help universities and policymakers in setting up the right R&D programs and incentive structures. These can be aimed to either push the university towards more collaboration with local incumbents to improve existing industries and bolster local R&D efforts, or towards more startups to create new industries and open up new R&D avenues. This is even more important considering the growing literature on smart-specialisation-type policies aimed at coordinating local economic growth and innovation efforts. The results provide insight into how such policies would impact university research commercialisation. Smart-specialisation could in fact hinder innovation by reducing technological diversification. At the same time, proximity to local patent holders can either help or hinder commercialisation efforts depending on the university's technological diversification.

International knowledge flows in human health in Brazil

Abstract ID#326

Rosane Becker Flores, Janaina Ruffoni (Unisinos University)

Purpose, context, research question and objectives

Knowledge is an essential asset for the generation of scientific and technological progress. According to the neo-Schumpeterian discussion of innovation systems, knowledge and innovation are generated by multiple actors in a dynamic process. Considering this, the focus of the research is the analysis of the characteristics (direction, main partners, geographic distribution, objectives, and others) of the knowledge flows between research groups from universities,and international partners in human health area. The relevance of this study lies in answering: “what are the main characteristics of the knowledge flows established in human health field by Brazilian academic actors in two different periods?” This research was conducted through an exploratory method and the database of the Directory of Research Groups (DGP) of the National Council for Scientific and Technological Development (CNPq) was analysed.

Literature review

The neo-Schumpeterian approach of innovation systems highlights the relevance of the interaction between actors with different functions in the process of generating and disseminating scientific and technological knowledge. An important element of innovation systems are the knowledge flows. For Gui, Liu and Du (2018) international flows of knowledge are becoming more and more frequent, and the analysis of knowledge flows is a current topic in economic geography. Chen and Guan (2016) address the existence of a core-periphery structure in the international diffusion of knowledge. Therefore, most flows occur in the center, while peripheral flows are scarce and weak. Furthermore, actors (universities, firms, and others), regions and countries can play different roles in knowledge flows. However, the positions of countries and regions in the flows are not constant, thus highlighting the relevance of observing the flows over time. Gui, Liu and Du (2018) highlight the effects of social and technological actors’ proximity on flows. Over time, the effects of geographic and cultural proximity tend to decrease, while the effects of social and technological proximity increase. Garcia et. al. (2020) also highlights the role of stimuli for the establishment of knowledge flows. The authors emphasize that, in the case of developing countries, policies to encourage collaboration between academic researchers and industry can represent an important tool for advancing innovation. According to Chen and Guan (2016), in the relations between the Global North and the Global South, the North concentrates the most technological and innovative countries in the world, while in the South there is a predominance of developing economies, which seek to match the countries from North. Yet, the Global South’s States still have a long way to develop technologically, and the deepening of partnerships is relevant to this process.

Methodological Procedures

Secondary data were used from the Census of the Directory of Research Groups in Brazil (DGP), from the National Council for Scientific and Technological Development (CNPq) from the last available year (2016), in addition to the Current Base in 2022, to present up-to-date data. Descriptive statistics about the two periods analyzed were used. In the analysis of the types of relationships, interactions typology was used, based on the types applied in the DGP-CNPq, proposed, and elaborated by Schaeffer (2017). For the collection of data in the Current Base, a program was developed in JavaScript language.

Findings

The 216 Census presented a volume of 2046 groups in the health area, of these 382 showed international interactions (18.7%). Thereby, in total, 4.851 interactions in the health area were identified, 660 with international partners (12.4%). The main partners of these interactions were the universities. The main health areas of the research groups were Public Health and Medicine. In the analysis of the types of relationships, the typology of Schaeffer (2017) was used, and most of the relationships found were scientific research without and with consideration of the immediate use of the results and training of the group's personnel by the partner and of the partner by the group. In terms of remuneration, the interactions aimed for partnerships without transferring resources. Most of the Brazilian research groups that interacted with international actors were universities in the Southeast and South regions of the country. Most of the partnerships were with actors from North America and Europe. The results for 2022 also show that most international partners are public universities located in Northern countries. The number of Brazilian research groups increased, reaching 410 that carried out 775 international interactions. Again, most of the groups belong to universities in the southeastern and southern regions of the country. Regarding the health area, types of relationship and remuneration, the results were similar to 2016, with a predominance of the areas of Medicine and Public Health, scientific research without and with considerations of immediate use of results and partnerships without the transfer of resources.

Implications

The results of the study can be useful for the generation of public policies that encourage interactions between Brazilian universities and foreign actors, aiming to expand opportunities to access knowledge. And, in terms of database, the use of the Current Database of DGP is relevant for more up-to-date data, even though it requires detailed definition of criteria for searching and selecting data, as well as using artificial intelligence for data collection in the public database of DGP/CNPq.

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SECTORAL INNOVATION I

May 1st: 10h30 am – 12h30 pm

Chair

Anthon Botha (University of Pretoria, South Africa)

Papers

Leadership 4.0 - Exploring the relevance of executive functions in the South African process manufacturing industry

Palesa Mankoe, Anthon Botha

Emerging innovation in the brazilian truck industry: The e-delivery project

Marcela Sayumi de Souza Ito, Marcelo Gonçalves do Amaral

Brazilian pharmaceutical industry: Recent development and future perspectives

Lia Hasenclever, Julia Paranhos, Fernanda Perin, Caroline Miranda

Leadership 4.0 – Exploring the relevance of executive functions in the South African process manufacturing industry

Abstract ID#156 | Full paper ID#377

Palesa Mankoe, Anthon P Botha (University of Pretoria)

Abstract: The adoption and integration of technologies coupled with expanding globalisation has steered global manufacturing industries towards the fourth industrial revolution (4IR), to better fulfil customer demands for quality and value-added products. Consequently, this era of intelligent factories has introduced complexities in the tasks of leading and managing businesses due to the growing human-machine interaction in the workplace. To investigate the role of leadership in this era in the South African process manufacturing industry, a comprehensive literature review and primary research assisted in compiling a technology management framework which integrates the relevant factors and considerations in the process manufacturing industry and the cognitive skills, or executive functions, required by leaders. The work conducted for this research built on the literature on leadership, as well as recent studies on leadership in 4IR (Leadership 4.0), by exploring how executive functions in individuals may assist with the increasingly complex task of leadership in the age of smart manufacturing. Metacognition, related to the acquisition of knowledge emerged as the most important cognitive skill, followed by sense-making, related to pattern recognition and understanding, attentional control in which the individual manages their focus, and problem solving relating to the ability of resolve challenges both creatively and analytically.
Keywords: Fourth Industrial Revolution (4IR), Manufacturing, Leadership 4.0, Executive Functions, Cognitive Skills

Introduction

The term "Industrie 4.0" (I4.0) surfaced in 2011 at the Hannover fair in Germany, as a manufacturing initiative promoted by the German government, in partnership with industrial and scientific organisations (Baldassarre, Ricciardi & Campo, 2017). This was broadened to the notion of the fourth industrial revolution (4IR) which builds on the digital revolution beyond smart connected systems but includes innovation and the fusion of various kinds of emergent and sophisticated technologies which blur the boundaries between digital, physical, and biological domains. This includes the use of cyber-physical systems (CPS), internet of things (IoT), and cloud computing (Zhong, Xu, Klotz & Newman, 2017), to realise autonomous production resources driven by networks of spatially distributed intelligent systems, the foundation of which would be sensors, robotics, and knowledge (Wilkesmann & Wilkesmann, 2018). This fourth industrial wave with its new technologies, coupled with the continuously expanding degree of globalisation has changed the role of nations within the competitiveness framework and has seen business competitiveness become increasingly fierce both nationally and internationally (Chikán, 2008). Consequently, the concept of 4IR moved manufacturing industries around the world in the direction of embracing the adoption and integration of various technologies to better fulfil customer demands for quality and value-added products (Mikulic & Stefanic, 2018). This era of intelligent factories has, however, introduced complexities in the tasks of leading and managing businesses due to the growing humanmachine interaction both within and outside of the workplace, termed "socio-technical systems". Socio-technical systems are described as systems which comprise of a convoluted interaction between humans, machines and the environment of working systems (Emery, Thorsrud & Trist, 2013), and are the incremental reality for most enterprises today (Zavareh, Sadaune, Siedler, Aurich, Zink & Eigner, 2018). According to Bawany (2017), this evolving work environment demands new techniques and tools for effective leadership. Leadership in 4IR has mostly been a focus for developed countries such as Germany in particular

(Dory & Waldbuesser, 2015). In recent times however, there has been an increasing need for leaders around the world to have an understanding and vision of how digitalisation and the integration of technologies associated with 4IR may affect their organisations, as they have the difficult task of successfully navigating themselves and their organisations through the emergent disruption of 4IR and acceleration of globalisation. As a result, disciplines such as Technology Management (TM), have become popular in the business community (Cetindamar, Phaal & Probert, 2010). TM is a combination of science, engineering and management disciplines assembled with the purpose of planning, developing and implementing technological capabilities intended to assist organisations to reach their strategic and operational objectives (Kaya, Erol & Ozbilgin, 2017). Thus, the popular TM framework was developed as a generic framework to support both practical and theoretical understanding associated with the management of technological capabilities (Phaal, Farrukh & Probert, 2004). The generic nature of the framework provides the advantage of applicability to firms across various industries, regardless of their size (Cetindamar et al., 2010).

The work conducted for this research attempted to build on the literature on leadership, as well as recent studies on leadership in 4IR, by exploring how executive functions in individuals may assist with the increasingly complex task of leadership in the age of smart manufacturing. Scallan (2003) defines executive functions in individuals as the cognitive abilities that enable effective management of attention, therefore facilitating performance in scenarios where individuals must think, act and adapt quickly. The research questions were:

Research question 1: Are leaders in the South African process manufacturing industry familiar with concepts and tools for managing 4IR proposed by 4IR literature, (e.g. future thinking, TM and complexity theory) and are they recognised and being applied in South Africa's process manufacturing industry?

Research question 2: Which executive functions of leaders in process manufacturing organisations are deemed critical in successfully carrying out the functions of leadership in the South African 4IR process manufacturing environment?

Theoretical Background

The 4IR has been a major topic in the context of "smart" manufacturing, however, the question of whether the previous methods of manufacturing were not "smart" is posed by (Wuest, 2019). The major difference is that the "intelligence" element in the pre-4IR environment was associated with the human operators and planners (human experts), and not within the system itself. Therefore, at the heart of smart manufacturing, is reproducing the human intelligence by putting systems in place to collect and analyse data to draw conclusions while ultimately providing valuable insights for decision support for humans. Dory & Waldbuesser (2015), propose that the future of traditional work in production will be enriched and humanised, meaning that simple manual tasks will disappear, and workers will serve as coordinators who ensure continuous production through the well-being of the smart production line. The result being a workplace of human interaction mixed with complex machinery, and a diverse workforce. Dory & Waldbuesser (2015) further proposed that the change in workforce and work environment would place higher demands in terms of managing complexity, selforganisation, and problem-solving, further allowing for flexibility in shifts and employee work preferences. Shvetsova & Kuzmina, (2018) foresee the transformation to 4IR bringing challenges for different employees, and processes such as strategic planning, research, and development. Leaders, especially, are being faced with the challenging task of finding ways to exploit new, innovative business opportunities brought forth by 4IR, while maintaining the task of running core business on a daily basis, in an era where the importance of new technical skills is on the rise, specifically in the case of mechanical working processes in production, logistics, and purchasing (Dory & Waldbuesser, 2015). The literature also suggests that humans will still be needed to perform jobs which require critical and innovative thinking, as well as emotional intelligence (Hyacinth, 2017). The same author further emphasizes how artificial intelligence (AI), for the foreseeable future, will not be able to match the emotion and human aspects of the workplace. Uhl-Bien (2021), identifies the need for adaptive and responsive leadership brought to light by the corona virus 2019 (COVID-19) pandemic, as safety measures such as social distancing, health management, and sourcing of Personal Protective Equipment (PPE) and technologies to support work paradigms demanded adaptive response from leadership in organisations.

Frameworks and Theories Relevant to Leadership in 4IR

The TM Framework: The field of Technology Management (TM) is aimed at planning, controlling, directing, and coordinating the development and implementation of technological capabilities intended for assisting firms to accomplish their strategic and operational objectives (NRC, 1987). Cetindamar, Phaal & Probert (2009), point out that this definition of TM does not distinctively distinguish between the technical and managerial issues of TM, and therefore suggests approaching TM through the dynamic capabilities theory (Teece, Pisano & Shuen 2008). They define dynamic capabilities as the ability to reconfigure, channel, transform, shape and integrate existing core competencies using external, strategic and complementary resources to navigate through the challenges of volatile times in business. Therefore, through the dynamic capabilities theory, the focus of TM is not only on fixed assets, but rather elaborates on how organisations allocate resources for innovation, how existing resources are utilised, and where and how new resources are obtained. Therefore, the purpose of TM becomes a quest of the activities which will enable leaders to build technological capabilities (Cetindamar et al., 2009). Cetindamar, et al. (2010) consider TM as a professional task and introduces the TM framework, with the advantage that it can be applied to any firm regardless of the size. The TM framework lists three business processes - strategy, innovation, and operations, as the core business competencies of the organisation which further provide guidance for the six generic TM activities – acquisition, exploitation, identification, learning, protection, and selection necessary for TM at all organisational levels (Cetindamar et al., 2010). De Wet (1996), identifies effective integration of technological considerations into organisations' business strategy as a key aspect of business planning. The premise being that the business strategy should not be developed independently from the technology strategy, rather that technological resources be regarded as vital to business planning.

4IR Maturity Models: Cetindamar & Kilitcioglu (2013), present a study conducted to measure competitiveness at firm level and emphasise the role of technology in competitiveness, and base this on three pillars, namely, outcome indicators, resources, as well as managerial processes and capabilities. To meet the challenges brought forth by 4IR, manufacturing organisations of the future need to be able to manage their entire value chain in a swift responsive manner. Organisations will need both virtual and physical structures which facilitate close cooperation and rapid adaption throughout the lifecycle of the systems from innovation, production, and distribution (Gligor & Holcomb, 2012). In a study by Schumacher, Erol & Sihn (2016), it is stated that the proposed maturity of an industrial system includes the integration of 4IR concepts and technologies in manufacturing systems and organisations with the digital integration of engineering throughout the value chain. In determining 4IR readiness levels, Schumacher et al. (2016) propose a model based on nine company dimensions -strategy, leadership, customers, products, operations, culture, people, governance and technology. This model determines how leaders have implemented initiatives which support the implementation of 4IR technologies within their organisations to support the success of the nine dimensions.

Future Thinking: This is a concept founded in systems thinking, which takes a holistic approach in identifying the influences which shape the future. The aim of future thinking includes strategic visioning, where back-casting methodologies are used to determine strategic interventions to be taken in the present, to manage the future from the present (Botha & Pretorius, 2017). A triangular model of the future thinking space encompassed by the three factors that shape the direction of the future is presented by Botha (2018). These factors include:

- Technology: Identifying the relevant and recognisable technologies of the future which are at least in the research and development phase.
- Behaviour: Recognition of the behaviour of people within the organisation and the market.
- Events: Awareness of both the predictable and unpredictable events which include geopolitics, economics, social developments, and natural events.

Complexity framework: The Cynefin Framework was developed by Snowden and Kurtz between 1999 and 2003 based on studies initiated by Boisot and Cilleris (Fierro, Putino & Tirone, 2017). Snowden & Boone (2007) explain that leaders do not always achieve the results they desire when faced with scenarios that demand a variety of decisions and responses, and attributes this to common leadership practices which are usually successful in singular circumstances. The purpose of the Cynefin framework is to develop a model which interprets the different levels of complexity in which systems can exist, ranging from order to unorder, through the simple, complicated, complex, chaotic, and disordered domains. The framework aids leaders in identifying the context in which their decisions should be taken and proposes the appropriate courses of action and logic to be applied (Fierro et al., 2017).

Cognitive Readiness Competencies: Cognitive readiness is described as one of the advanced thinking skills, which gives leaders the ability to confront any complex problems they may face. In practice, this concept is the mental preparation which leaders develop in order to prepare themselves, as well as their teams for dynamic, disruptive, or unpredictable challenges in the volatile, unpredictable, complex, and ambiguous (VUCA) business environment (Bawany, 2017). Executive functions are defined as a set of mental processes which require subprocesses and past experiences to achieve a goal in the present life (Elliott, 2003). Executive functions make it possible to think before acting, meet unfamiliar and unexpected challenges, express flexibility in cognitive function, use memory, and give the ability to see things from different perspectives (Diamond, 2013). The seven key cognitive skills are summarised in Table 1.

Table 1: *Summary of the seven executive functions*

Executive Function	**Definition**
Metacognition	The mental action or process of acquiring knowledge and understanding through thought, experience, and the senses.
Attentional control	The ability to manage and focus attention.
Sense making	Allows an individual to recognise patterns and see the bigger picture.
Intuition	The brain process that gives people the ability to make decisions without requiring analytical reasoning. This ability also requires one to be aware of intuitive feelings.
Problem solving	Enables an individual to resolve challenges both analytically and creatively.
Adaptability	Refers to an individual's willingness to change in dynamic conditions.
Communication	Refers to the ability to create and utilise fluid communication pathways.

Complexity theorists have been saying since the 1990s, that “complexity in the world is continuously increasing” (Uhl-Bien, 2021). Organisations will continue to face complex landscapes driven by globalisation and technological revolutions in a global economy where knowledge and innovation are increasingly critical for organisational survival (Bettis & Hitt, 1995). More importantly, the COVID-19 pandemic revealed the need for flexibility in manufacturing, to replace rigid and static operating models, a task which requires more than just technology, to meet the demands of markets through volatility (Czifra & Molnar, 2020). As such, the frameworks and theories discussed in the literature review provide a solid foundation of theory and tools to assist in understanding how the technological wave has shaped the world, and the available resources, tools, and frameworks which can be applied to assist the various functions of leadership in ensuring that their organisations are able to, not only adapt, but identify emergent markets which could impact or benefit their organisations.

Conceptual model for Leadership 4.0

The conceptual model presented in Figure 1 was intended to build on the generic TM framework of Phaal et al. (2004) and Cetindamar et al. (2010) and includes considerations applicable to the South African process manufacturing industry, given that the reviewed literature confirmed that TM had become an integral part of the role of leadership in the 4IR environment. Therefore, the conceptual research model was developed using the five main considerations from the TM framework as the organisational model considerations to relate to a recognised foundation, but to add aspects of importance for leadership in 4IR. The five main considerations in the TM framework are: the technological perspective, the organisational perspective, the commercial perspective, the core business competencies, and the environment consideration. The TM literature reviewed lists strategy, innovation, and operations as the core competencies for all businesses, and elaborates on the TM activities (identification, selection, acquisition, exploitation, protection, and learning). The conceptual model integrates the considerations and dimensions extracted from the generic TM framework to identify the gaps for the additional dimensions requiring guidance and input from leaders and from the literature. Figure 1 depicts the topics and frameworks obtained from the literature review and integrates them into a conceptual model to address the remaining main TM considerations for the organisational perspective, the commercial perspective, and the environment. The dimensions were categorised based on which organisational perspective they represented. Figure 1 further indicates how the dimensions from the topics of relevance in 4IR research, manufacturing industry structures, and leadership models were integrated and allocated into the generic TM framework main considerations. Human management factors were allocated to the organisational perspective, technology management factors were allocated to the technological perspective, strategy management factors were allocated to the core business competencies consideration, consumer management factors were allocated to the commercial perspective, and the market environmental management factors were allocated to the environmental consideration.

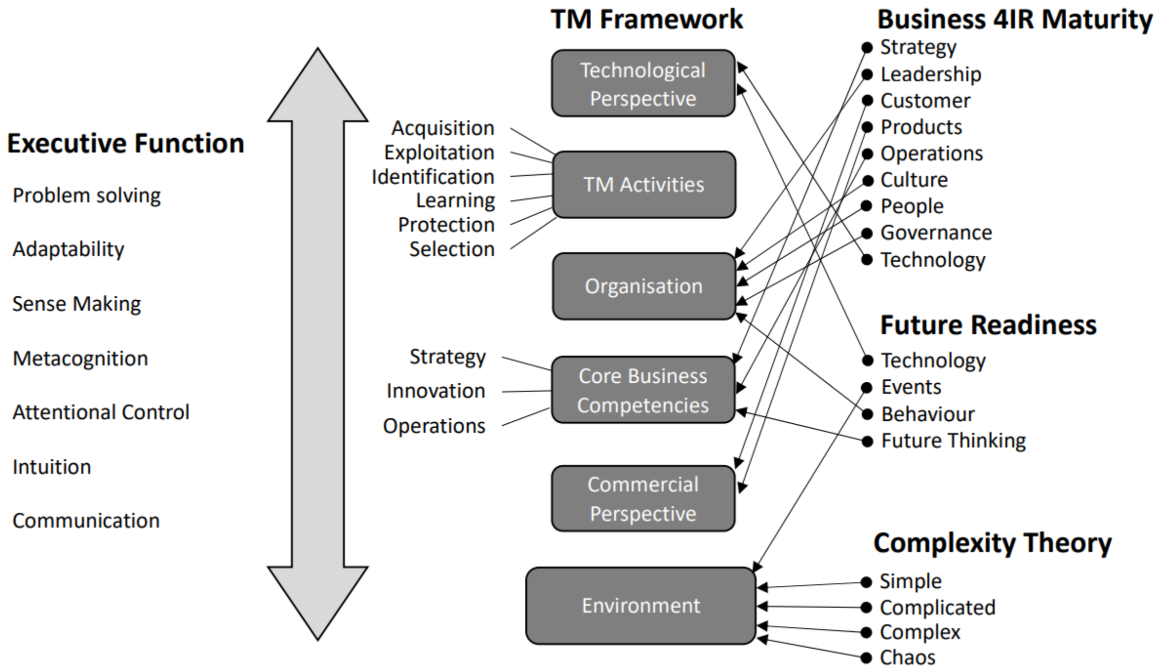

Figure 1: *Topics and frameworks included into the conceptual model*

Finally, the conceptual model integrates the seven executive functions obtained from the literature review, across all the selected considerations and dimensions, to determine the role of the mental processes presented in the literature on executive functions in fulfilling the required leadership competencies in the implementation of TM to meet organisational outcomes in the face of complexity. This integration of the executive functions and the modified generic TM model is a new theoretical proposition from this research reported upon. This is to be tested together with the familiarity leaders have of TM tools and applications for the South African process manufacturing industry. Figure 2 shows the holistic TM framework used in this research.

	Holistic TM Framework																			
	Core Business Competencies				**Organisation**					Technological Perspective							Commercial Perspective		Environment	
Executive Function (Paragon 7)	Strategy	Innovation	Operations	Future Thinking	Leadership	People	Governance	Behaviour	Culture	Technology	Acquisition	Exploitation	Identification	Learning	Protection	Selection	Customer	Products	Events	Complexity
Metacognition																				
Attentional Control																				
Sense Making																				
Intuition																				
Problem Solving																				
Adaptability																				
Communication																				

Figure 2: *The holistic TM framework used in this research*

As directed by the literature on TM, the holistic model encompasses the managerial issues as well as the technical issues related with TM in the organisation. The generic TM framework did not provide dimensions to address the managerial issues which form part of the technological capability considerations of organisations as discussed in the dynamic capabilities concept proposed by Cetindamar et al. (2009). The 4IR maturity model proposed by Schumacher et al. (2016), provided the conceptual model with nine business dimensions relevant to the manufacturing industry which can be used to determine or monitor the growth of 4IR technology adoption across the organisation. These nine dimensions could be grouped under the commercial and organisational perspective considerations of the conceptual model. In some cases, the dimensions overlapped, such as strategy, operations, and technology, however, this was to be expected as the research articles were developed in isolation from each other, to address different 4IR concerns. The literature on future thinking contributed to the core competencies consideration of the framework through the growing requirement for leaders to have foresight through the volatile fourth technological wave.

Methodological Procedures

The research project was part of a mini-dissertation for a master's degree in Engineering Management and made use of mixed research methods to explore the extent to which TM theory and tools are applied in South African process manufacturing organisations, and the perceived level of executive function required by individuals in leadership roles in conducting TM. An extensive literature survey was conducted to identify existing theory and knowledge on the research on leadership in the fourth industrial revolution, gaps that may exist and to extract a framework for the primary research. The secondary research was not structured to be a systematic literature review. The secondary research led to the development of the holistic TM model where the broadly referenced generic model of TM framework of Cetindamar et al. (2010) was used as basis. This was combined with the 4IR maturity model proposed by Schumacher et al. (2016), providing the nine business dimensions relevant to the manufacturing industry. Complexity and future thinking related to major events (risks or opportunities) were added to the generic model. The model then integrates the seven executive functions obtained from the literature review, as outlined above. Qualitative research design methodology was adopted for the primary research to form the proposed holistic TM framework. To answer the research questions, the primary portion of the research study required input through factual questionnaires from a sample of research participants. A clear definition of the research population was drawn up by creating eligibility requirements, which assisted in identifying the individuals of interest, for the research data collection sample. The following requirements were drawn up as the eligibility factors for the research population of interest.

- The participants had to be previously or currently employed by a South African process manufacturing organisation.
- The participants had previously been or were currently employed as either leaders or managers or both by a South African process manufacturing organisation.

The selection of the sample was conducted through non-probability purposive sampling since statistical inferences were not made in relation to the wider population (Yin, 2003). Purposive sampling is a method of sampling where the prospective participants are required to meet a defined set of criteria in order be to be included in the research sample (Easterby-Smith et al., 2018). The study further made use of snowball sampling, where prospective participants were asked to use their network to refer the researcher to other potential participants who can contribute to the study (Noy, 2008). The issue of determining sample sizes when employing non-probability sampling methods such as purposive sampling and snowball sampling is ambiguous and should therefore be guided by the research questions and objectives. Saunders et al. (2012) recommend 12-30 individuals as the minimum sample size for non-probability sampling in the consideration of a heterogenous population. In this study, N=30 was considered within the recommended range.

The research data collection method selected was a structured self-administered webbased questionnaire. This method of data collection allowed the inclusion of images of the frameworks used, as well as background insight into the topics extracted from the literature review and the related concepts. Furthermore, this information was aimed at assisting the participants in relating the theoretical concepts presented in the research to their professional responsibilities, to identify the application of these tools within the context of their organisations.

The first section of the survey was designed to collect data regarding the professional background of the participants to create a professional experience profile of the study sample. Section two of the research survey was designed to determine whether the participants were familiar with the concepts included in the research and if the concepts had been applied by the participants in their professional careers with the South African manufacturing industry. The final section of the survey was designed to determine the participants' perceived relevance of executive functions in carrying out the responsibilities of leadership/management in using the theoretical tools presented in the context of the South African manufacturing organisations in which they had gained experience.

Prior to the circulation of a research survey, it was vetted by a university ethics committee to ensure that the research does not infringe on any ethical concerns or request any sensitive information that could be harmful for any of the parties involved. One organisation was used as a case study. Permission was gained from the organisation employing the prospective participants. To obtain this permission, a detailed background of the research project, as well as the data collection survey needed to be submitted.

Research data processing and analysis were aided by the online-survey software that was set to exclusively include responses to completed surveys only in the research questionnaire results report. Since the data collected was quantitative in nature, the software was able generate visual representations in the form of pie charts, bar/line charts, breakdown bars, and tables to present the data. This report was be exported to Microsoft Excel. Visual charts and tables were the selected method of data representation as these tools provided simplistic break down of the variables being measured for both the nominal and ordinal scale response data.

Results

The research questionnaire was circulated to 65 invitees via either email or sharing an anonymous link. The results presented were based on 30 completed surveys. This was considered as adequate in a single company purposive case study and within the target as discussed in Section 3. The first section of the research questionnaire collected data regarding the professional backgrounds of the participants. This information was relevant in verifying that each participant met the eligibility requirements set in the research design, as well as in creating a general professional profile of the managers and leaders included in the research study.

Professional background of respondents

The results obtained in the section on professional background of the respondents in the web-based self-administered questionnaire, are summarised and shown in Figure 3.

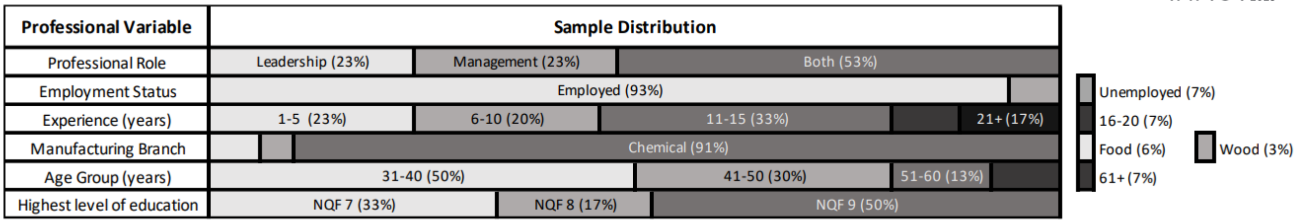

Figure 3: *Distribution of professional profile of the research participants*

The research sample of respondents was noted to be significantly skewed in favour of representing individuals with experience in the South African chemical processing manufacturing industry, as well as the representation of individuals who were employed during the data collection timeframe. Half of the sampled individuals fell within the 31 - 40 years age group, and half of the respondents' highest level of education was NQF level 9 (master's degree). The sample of respondents' extent of experience was fairly distributed over the total time interval from 1 to 21+ years, with the majority (10 respondents) falling within the 11 to 15 years of experience category.

Familiarity and application of TM concepts and tools

These results address research question 1. The section of the research questionnaire that was aimed at determining whether the respondents were familiar with the theoretical concepts used to develop the holistic TM model in the context of the South African process manufacturing industry yielded results that indicated that a majority of the research respondents were familiar with the research topics included in the project: 4IR (83%), I4.0 (73%), TM (67%), and future thinking (67%). Conversely, a minority of the research respondents indicated that they had attended formal training in the form of either a postgraduate qualification, a short training course, or industry lectures, on the topics included in the research, 4IR (23%), I4.0 (20%), TM (40%), and future thinking (33%). The results further showed that 20% of the research participants had first-hand experience in developing TM strategies, 13% had first-hand experience in developing innovation management strategies, and 43% had employed future thinking methodologies in the development of a corporate strategy. All the Professional Variable Professional Role Employment Status Experience (years) Manufacturing Branch Age Group (years) Highestlevel of education NQF 8 (17%) Sample Distribution 61+ (7%) Unemployed (7%) 16-20 (7%) Food (6%) Wood (3%) Leadership (23%) Management (23%) 31-40 (50%) 41-50 (30%) Both (53%) NQF 9 (50%) 1-5 (23%) 6-10 (20%) 11-15 (33%) 21+ (17%) Chemical (91%) 51-60 (13%) NQF 7 (33%) Employed (93%) research respondents indicated they were or had been involved with performing TM activities in their professional careers.

Critical executive functions

These results address research question 2. The research participants were requested to rank the importance of each executive function in performing or navigating the proposed holistic TM framework aspects based on their professional training and experience, the complexity of the process manufacturing organisations they had worked in, and the current environment. The results were used to rank each of the cognitive skills in each of the dimensions of the holistic TM framework, with number 1 representing the cognitive skill scored the highest and perceived as the most important for TM in the given dimension, and number 7 indicating the lowest scored cognitive skill, perceived as the least important.

The colour coding of the different rankings was applied in the same manner, with the intense colours for the high rankings items and the colour intensity fading with the lower ranked items as indicated in Figure 4.

	Holistic TM Framework																			
	Core Business Competencies				Organisational Perspective					Technological Perspective							Commercial Perspective		Environment	
Executive Functions	Strategy	Innovation	Operations	Future Thinking	Leadership	People	Tech. Governance	Behaviour	Culture	Technology	Acquisition	Exploitation	Identification	Learning	Protection	Selection	Customer	Products	Events	Complexity in the organisation
Metacognition	1	1	2	1	1	4	1	1	2	1	1	1	1	1	1	1	3	1	1	1
Attentional Control	7	5	3	6	4	2	2	4	5	2	3	3	3	2	2	4	3	4	3	3
Sense Making	2	3	5	2	3	4	4	3	3	3	4	2	2	4	3	2	2	2	2	2
Intuition	6	7	7	4	5	3	6	2	4	7	6	6	6	6	5	6	7	7	5	5
Problem Solving	3	3	1	5	6	7	5	7	7	5	2	4	4	5	6	3	5	5	7	4
Adaptability	4	2	6	3	7	6	3	5	6	4	5	4	5	7	7	5	6	2	4	7
Communication	5	6	4	7	2	1	7	5	1	6	7	6	7	3	4	7	1	6	6	6

Figure 4: *The results from the holistic TM model ranking the seven executive functions*

In the holistic TM framework considerations in which skills, tools, and knowledge related to the management of technical capabilities are implicit, the dominant executive function abilities required are metacognition and sense-making. This includes the majority of the TM activities (Technological Perspective), future thinking, and developing corporate strategies (Core Business Competencies) as well as events and complexity (Environment) considerations. This could be because the participants view these considerations requiring a leader with strong technical knowledge and comprehension. There is also a consistent low ranking of intuition in all these dimensions, adding to the perception that the dimensions require cognitive skills for obtaining and applying technical knowledge. For the considerations in which the skills related to leading and managing people, such as leadership, influencing organisational culture, people, (Organisational Perspective), operations (Core Business Competencies), learning or knowledge management (Technological Perspective), and customer management (Commercial Perspective), communication was consistently ranked within the top four most important cognitive skills. The overall scores and ranking of the holistic TM framework considerations are shown in Figure 5.

Cognitive Skills	Overall Scores & Ranking	
Metacognition	73	1st
Sense Making	62	2nd
Attentional Control	59	3rd
Problem Solving	55	4th
Communication	51	5th
Adaptability	50	6th
Intuition	50	6th

Figure 5: *Rankings for the perceived relevance of the executive functions for Leadership 4.0*

Overall, based on the total average score calculated across all the dimensions of the holistic TM framework, metacognition was perceived as the most important cognitive skill for Leadership 4.0

in the context of the South African process manufacturing industry. The second highest ranked cognitive skill in the role of leadership across the dimensions of the holistic TM framework was sense making. Attentional control ranked in third place, followed by problem solving in the fourth rank. Communication was ranked in the fifth position, and the two lowest ranking cognitive skills adaptability intuition, both ranking in the sixth position.

The observable trend is that the cognitive skills tied to technical abilities were consistently ranked as the most important. This could be due to the technical nature and complexity of the process manufacturing industry, and therefore the research participants consistently ranked metacognition, linked to knowledge acquisition; sense making, linked to pattern recognition and understanding; as well as attentional control which manages focus. This could further be influenced by the observed high education level of the participants.

Discussion

The research project was able to address the two research questions dealing with the knowledge and familiarity of using TM tools and to understand executive functions leaders need in context with an enhanced holistic TM framework to operate in the 4IR era in the South African process manufacturing industry. The research further indicated a significantly low appreciation for TM training in leadership within the South African process manufacturing industry, however, the participants unanimously validated the need for TM capabilities within their organisations and leadership capabilities. An extension to the well-founded generic TM framework is proposed that introduces elements of future readiness, 4IR business maturity, future events and complexity. These were then mapped against the executive functions that are critical for leadership in 4IR and the executive functions were prioritised for the South African process manufacturing industry. The limitation of a low sample size and restriction to a single company for a case study related to master's study should be borne in mind when the work is considered. Testing this model among more companies in the same industry or broadening it to other manufacturing industries will be required before definitive conclusions are to be made. Furthermore, given the dynamic workplace paradigms facilitated by the COVID-19 pandemic (during which this research was conducted), research on the adoption of TM and TM training growth trends in the industry could be explored based on the Leadership 4.0 capabilities identified in this work.

Conclusions

The additional dimensions and concepts included into the generic TM framework to develop the proposed holistic TM framework were identified and selected through a comprehensive literature review and gap analysis (secondary research) and the validity of the inclusion of these dimensions and concepts was confirmed by the primary research. A model of the TM framework which embodied the characteristics and considerations of organisations in the South African process manufacturing industry was developed and confirmed by the research respondents. The cognitive skills tied to technical abilities were consistently ranked as the most important as perceived by leaders in the South African process manufacturing industry. Metacognition, related to the acquisition of knowledge, was perceived as the most important cognitive skill, followed by sense-making, related to pattern recognition and understanding, attentional control in which the individuals manage their focus, and problem solving relating to the ability to resolve challenges both creatively and analytically. The research project was able to create a profile of the relevance of executive functions for 4IR leaders for one South African processing manufacturing company. This should be expanded to the broader industry to establish a representative trend.

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Emerging innovation in the brazilian truck industry: The e-delivery project

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Abstract: The object of research is the e-Delivery Project of Volkswagen Trucks and Buses, located in Resende, in the State of Rio de Janeiro. It is important to deal with an agenda of innovation, development and competitiveness of the automotive sector installed in that region. It isanalyzed from the theoretical framework of the GVC and the Triple Helix (3H) model, whichhelps to understand the development process from the university – industry - government relashionship. From the viewpoint of GVC, a reconfiguration of the Modular Consortium to produce electric cargo vehicles is identified, with the entry of partners with specific skills, without changing the central characteristic of a chain driven by the producer. From 3H's pointof view, e-Delivery does not present any relationship between the university and industry in research activities. The government appears as a partner through tax incentives and funding. Therefore, it was verified that a new modular consortium was organized to develop and producethe electric bus without significantly altering the previous relationships. The company VWTB continues to lead and induce internal partners and external interaction with government and university actors remains limited.
Keywords: automotive industry; e-Delivery Project; Volkswagen Trucks and Buses; electric vehicles; electric trucks.

Introduction

Concerns about climate change and the search for sustainable energy sources make countries like China, England, Sweden, and Germany, among others, change their legislation and force the motor vehicle industry to adapt to the new regulations. As a result, in addition to the electrification of motor vehicles, new business models are emerging, such as the leasing of electric motor vehicles (EVs) through applications and subscription transport, a movement called Mobility as a System (MaaS). As a result, electrification is cited by automakers as the focus for the coming years.

However, the transition to electromobility, in the search for sustainable economic and social development requires efforts on the part of several actors (government, industry, university, and civil society). However, electric mobility and sustainable development are not just about producing electric cars but the generation of a whole new value chain of traditional companies and new entrants, in addition to structural, institutional, and consumer changes.

The e-Delivery Project of Volkswagen Trucks and Buses (VWTB), a company located in Resende, a municipality located in the south of the State of Rio de Janeiro, was identified as of central importance to address an agenda of innovation, development and competitiveness of the automotive sector installed in that region, as well as an effort to increase value capture and insertion in the Global Value Chain (GVC) (Sturgeon et al., 2017).

This work aims to present the aforementioned Project and analyze it from the theoretical framework of the GVC and models such as the Triple Helix (3H) (Etzkowitz & Leydesdorff, 2000) and its derivations. These approaches help to understand the development process from the relationship between the industry (VWTB), the government (City Hall of Resende, State Department of Development and Federal Government), the university, and society. The initiative has as an essence to contribute to regional economic development by stimulating the creation of entities resulting from university-business-government interaction, such as incubators and science and technology parks (Amaral et al., 2011). Therefore, it is a vital approximation to determine the regional insertion of VWTB and the cooperation and knowledge sharing between it and the regional universities (Etzkowitz & Leydesdorff, 2000). Therefore, it is expected to analyze the degree of influence of public policies such as

Inovar-Auto and Rota 2030 in stimulating VWTB's modernization process and to analyze the impact of e-Delivery on regional development, as well as the sharing of knowledge between the automaker and universities. And thus, to determine whether VWTB, through the project e- Delivery, produced positive externalities on the part of the automotive sector in the South Fluminense region.

Theoretical Background

The Global Value Chain

The theory of GVC describes how the physical production process that connects countries through an organized chain takes place based on a governance structure (Bair & Gereffi, 2001). According to Bair & Gereffi (2001), the term GVC is used to locate the set of inputs and transformations that lead to the production of a final consumer good. That, is, the GVC generates value by producing a final product. Therefore, it is of paramount importance to understand its structure and functioning.

The original concept of Productive Chains (commodity chains) was developed by Hopkins and Wallerstein (1977, 1986 apud Sturgeon, 2011) who highlighted the power of the State to shape global production systems, primarily through tariffs and quality standards. Gereffi takes up this concept but orients it towards the strategies and actions of companies, relatively subject to the limitations imposed on States in the context of trade opening and market liberalization. That, is, the author replaced the State as a promoter of development by corporations. Four factors influence chains: input-output, geography, governance and institutions. However, the governance factor has aroused the most significant interest of researchers (Gereffi & Korzeniewicz, 1994).

The concept of governance captures variations in how companies "organize their cross- border production networks" (Sturgeon, 2011, p. 16). Therefore, the "Analytic Framework of Production Chains" defines buyers and suppliers as the two types of leading companies that are responsible for stimulating global chains. Gereffi presents producers and buyers as the companies that drive global chains (Gereffi & Korzeniewicz, 1994).

Producer-driven chains originate from "internal and external networks" created by large manufacturing companies such as Volkswagen. Therefore, they are "capital-intensive industries such as electronics and automobiles." Buyer-driven chains, on the other hand, are concentrated in "powerful market actors," such as large retail chains (Walmart, for example) and international brands (Nike, Zara, and Benetton) that "influence global markets and production and distribution networks" such as "labor-intensive industries" (textiles, for example). Therefore, in buyer-driven chains, "innovation is based on product design and marketing rather than technology or machinery for production, making it easy for leading companies to outsource manufacturing." Therefore, they are "manufacturers without factories, as they do not own the factories, they exercise a lot of power over their suppliers given the high volume of their orders" (Sturgeon, 2011, p. 17).

Thus, the VWTB factory in Resende-RJ fits the type of GVC driven by the producer and can also be classified as a modular governance structure, presented by Gereffi & Korzeniewicz (1994; Sturgeon, 2011). The modular governance structure is represented by more complex transactions, but the "coding level" is simple. In this model, "suppliers usually produce according to the customer's specifications and assume full responsibility for production, which allows them to have a wide range of customers." In this case, "information technology and information transmission standards are the keys to the functioning of modular- type governance" (Cabo, 2018).

A Triple Helix

The Triple Helix approach seeks to interpret the ability of "macro investments" to cause change regionally and relate to public institutions and universities. Therefore, 3H's main objective is to collaborate for regional economic development, mainly by encouraging the creation of mechanisms for creating, appropriating, and disseminating scientific and technological knowledge, such as incubators and science and technology parks (Amaral et al., 2011).

Simply put, the 3H can be explained as a model that analyzes the degree of intensity of the link between universities and research and development centers (knowledge producers), industry or the productive sector of goods and services (knowledge user), and the government (economic and social regulator). And how these relationships are critical factors in improving the circumstances that favor innovation and the consequent socioeconomic development. In this way, the university, with its ability to promote teaching and research, would be competent to play an entrepreneurial role, and thus include socioeconomic development in its academic goals (Etzkowitz, 2008).

The 3H presents three different link configurations between the helices or spheres Universities (U), Industries (I), and Governments (G), or academia, productive sector and government as some authors name the helices (Amaral et al., 2017), being:

3H1 – The U and I are both dominated by the G sphere concerning strategies and decision-making processes;

3H2 - Each actor (U - I - G) plays its role independently (laissez-faire), with well-defined limits and low interaction;

3H3 - There is an overlap between each sphere; interrelationships deepen in quantity, quality and complexity, creating consensus spaces and even hybrid organizations based on these interfaces.

According to Etzkowitz (2008), one of the ways to analyze innovation efforts is to study the networks created. Thus, the 3H approach indicates that the intensity of the links between knowledge producers (Universities and R&D Centers [U]), knowledge users (Industry [I]), and regulatory instances of economic and social activities (Government [G]) are critical to improving the conditions that favor innovation. In the 3H framework, academia is elevated to a position similar to that of industry and government as a "triad of institutional spheres" with similar and overlapping activities. Thus, the academy takes on a new role due to the growing need to create new knowledge in the so-called knowledge economy of the 21st century and brings a new mission to the U ("the second academic revolution"). Therefore, the 3H is a critical concept to explain and promote regional development through the analysis of production factors, but also the analysis of the relationships between these actors (Amaral et al., 2011) within the helices ("intrahelix") and between helices ("interhelix"). Therefore, the use of 3H is relevant for this research, as it will allow understanding if there is and how the exchange of knowledge ("scientific cooperation") between universities in the South Fluminense region and VWTB regarding the production of electric vehicles takes place. As well as the role of the government and its relationship with VWTB concerning to regional development.

Recent public policies to encourage the automotive sector

In Brazil, throughout history, the presence of the State in encouraging the country's economic development through regulation and/or direct investment has been verified. In January 2013, the Incentive Program for Technological Innovation and Increased Density of the Motor Vehicle

Production Chain (Inovar-Auto) was launched, based on Provisional Measure nº. 563/2012, transformed into Law nº. 12,715/12, intending to strengthen Brazilian automotive production and impose the nationalization of component production. Thus, generating jobs and boosting Brazilian automotive production, setting the nationalization of component production and thus creating jobs. From Inovar-Auto, a policy of presumed credit in percentage points comes into force following the increase in national content in production. However, the program ended in 2017, and its results are uncertain (Leão & Goulart, 2013).

Thus, having as main guidelines the stimulus to the production of new technologies and innovations; the increase in investments in research, R&D, and energy efficiency, the Federal Government created the Rota 2030 Program, which is part of the strategy for the development of the automotive sector, whose content includes, according to the Ministry of Economy, Industry, Foreign Trade and Services: "(...) market regulations, the automotive regime that succeeded the Inovar-Auto Program, which ended on December 31, 2017, and a special tax regime for importing auto parts without equivalent domestic production" (Brasil, 2020).

Therefore, the program aims to progressively increase the "global insertion" of the Brazilian automotive industry through the export of vehicles and auto parts and, thus, enabling the country to be fully inserted in the "state of the arts" of production of global automotive vehicles. However, the program seeks to increase productivity through cost reduction and technological differentiation. In this way, Rota 2030 was planned as a long-term public policy, more specifically fifteen years, divided into three five-year cycles, in which, for each cycle, the goals and instruments will be reviewed and reoriented.

The Ministry of Economy and the Ministry of Science, Technology, Innovation and Communication officially launched, in September 2019, the Route 2030 Priority Programs, with the support of the National Association of Motor Vehicle Manufacturers (Anfavea) and of the National Union of the Automotive Vehicle Components Industry (Sindipeças). The program determines the "allocation of resources from the 2% Import Tax on auto parts without similar national products." In this way, "six priority programs were accredited by the Management Council, composed of members of the Federal Government, academia, unions and representatives of the private sector." These aim to "promote research, development, and innovation, as well as solutions to productivity and competitiveness issues. The source of funding is the counterpart to the Non-Produced Auto Parts Regime (Chap. III, of Law 13.755/2018)" (ANFAVEA, 2019).

According to art. 8 of Law n. 13.775 / 2018, the Rota 2030 Program - Mobility and Logistics presents the following guidelines:

I - increase in energy efficiency, structural performance, and the availability of assistive technologies for driving vehicles sold in the country;
II - increase in investments in research, development and innovation in the country;
III – a stimulus to the production of new technologies and innovations following global technological trends;
IV - increase in the productivity of industries for mobility and logistics;
V - promotion of the use of biofuels and alternative forms of propulsion and enhancement ofthe Brazilian energy matrix;
VI – a guarantee of technical training and professional qualification in the mobility and logistics sector; and
VII – a guarantee of expansion or maintenance of employment in the mobility and logistics sector.

The program is structured around three pillars (ABGI, 2022): (I) Mandatory requirements, which deal with the conditions for selling new vehicles in the country; (II) Rota 2030, which deals with the reduction of Corporate Income Tax (IRPJ) and Social Contribution on Net Income (CSLL) for companies that invest in R&D; and (III) Tax regime for non- produced auto parts, which deals with a tax exemption for the acquisition of parts. By the end of 2019, there were a total of 56 companies qualified in the Rota 2030 Program, of which 11 companies qualified in the automobile manufacturer modality (of which 6 produce heavy vehicles) and 45 qualified in the auto parts manufacturer modality (Rota 2030 Program Monitoring Group - Mobility and Logistics, 2021).

Methodological Procedures

This work is part of a broader effort by research groups based in the region to understand the development of the Southern Fluminense Automotive Cluster (CASF). It is, therefore, applied research with a descriptive, exploratory, and inductive nature. It is applied because it uses tools, models, and theories to understand the region. It is descriptive because it assumes the role of documenting the activities of the studied phenomenon, which is a function of the university and contributes to understanding the industrial and socioeconomic phenomenon in the region. It is exploratory because it seeks to understand cause and effect relationships between actors and their positions, strategies, and decisions. Finally, it is inductive in the sense of feeding the discussion of public policies and trying, from an example, to extrapolate considerations on a national scale.

The research project prioritizes the combination of qualitative and quantitative methodologies and, through the latter, seeks to build a bank of information regarding innovation in the automotive sector in Brazil, especially at VWTB and CASF companies.

From a theoretical point of view, it seeks texts and articles that bring the debate on the Theory of GVCs and the 3H approach. Such as the use of academic platforms Web of Science (WOS), Scielo, Scopus, and Spell as tools to search for articles with the following themes: innovation; electric vehicles; mobility; sustainability; autonomous vehicle and hybrid vehicle. As for information on the industrial sector, this research uses secondary data from communication sources about the market and technological innovations related to the automotive industry. Among these vehicles are Jornal Valor Econômico; Quatro Rodas Magazine; Automotive Business Magazine; Auto Industry Magazine. In addition to seeking up-to-date information on the automotive sector in statistical yearbooks and historical lines of truck production in the country. The data was taken from specialized channels, such as

ANFAVEA, the National Federation of Motor Vehicle Distribution (FENABRAVE), the Brazilian Association of Importers and Manufacturers of Motor Vehicles (ABIEFA), and the International Organization of Motor Vehicle Manufacturers (OICA).

The research also looks for statistical indicators of innovation and incentives for the production of electric vehicles in Brazil through the websites of the Brazilian Agency for Industrial Development (ABDI), the Brazilian Association of Automotive Engineering (AEA), the International Federation of Engineering Societies (FISITA) and the Brazilian Electric Vehicle Association (ABVE).

In this sense, the theoretical course of this article is a cut of the broader research work

- collection and organization of information - complemented by a case study, built from the collection of data with the company through official and non-official documents. officials, observation during technical visits, and informal testimonials from employees and other stakeholders.

Case presentation

The company

Volkswagen Trucks and Buses LTD was inaugurated in November 1996 as an independent truck and bus manufacturing plant of the Volkswagen group, as production was previously carried out at an Autolatina plant owned by Ford Motors of Brazil LTD (a plant whose production ended in 2019). VWTB was integrated into the MAN Latin America group in 2008, following the acquisition by MAN SE (parent company of the MAN Group). VWTB is the largest truck manufacturer and the second largest bus manufacturer in South America, with a total production capacity of 80,000 vehicles per year and great model flexibility. In 2018, the group was reorganized under the Traton SE brand, a subsidiary of the German Volkswagen AG group, which encompasses the MAN, Scania, Volkswagen Trucks and Buses, and RIO brands. Information on production and exports since 1992 is presented in Table 1.

The Resende plant uses an innovative production system, the Modular Consortium, in which seven partner companies (modulists) are coordinated by VWTB. Through this configuration, the Volkswagen Trucks and Buses Modular Consortium (VWTBMC) establishes a cluster relationship between the parent company and its modular suppliers. This type of productive arrangement linked to external actors has positive consequences for development, especially in emerging countries, especially places that are more dependent on a given sector. Among the partner suppliers are Maxion (chassis assembly), Arvin Meritor (axles and suspension), Remon (wheels and tires), Powertrain (engines), AKC (cab frame), Carese (paint), and Continental (body finish). Quality control is the responsibility of MAN Latin America (Trintini et al., 2020).

The MC seeks to reduce production costs, investments, inventories, and time and, above all, seeks greater agility in producing differentiated vehicles. Thus, it makes the assembly process more efficient and flexible and increases productivity (Trintini et al., 2020). In this way, the company can focus on other esssential points such as marketing strategies, logistics, customer service and developing new products such as e-Delivery.

In the relationship between production and sales, Trintini et al. (2020) observe that there was a stock formation in the years 2005, 2007, 2008, 2009, 2010, 2011, and 2013, while there was a decrease in stock in 2006, 2012 and 2014, with no detailed information for the last five years. After the creation of Traton SE, the data were no longer released on a consolidated basis. The company is limited and headquartered outside Brazil. Regarding exports of trucks, it is observed that the volume of exports over total production fluctuated at different times, reaching 30% of production in 2005 and 2006. However, since 2010 this level has been around 15 %.

Table 1: VWTB production, registration and export table (1992 – 2021).

Year	Production			Registration	Exports
	Trucks	Buses	Total		
1992	3.124	217	3.341	3.054	615
1993	6.212	1.471	7.683	6.212	719
1994	8.642	1.218	9.860	9.670	608
1995	14.353	2.008	16.361	12.188	1.982
1996	10.461	1.190	11.651	8.737	1.138
1997	6.697	2.042	8.739	10.638	1.735
1998	9.833	2.783	12.616	11.221	1.066
1999	10.641	1.741	12.382	11.333	1.072
2000	14.631	3.951	18.582	17.111	1.316
2001	18.989	4.639	23.628	21.829	766
2002	18.570	5.051	23.621	21.867	710
2003	22.649	6.370	29.019	24.648	1.917
2004	29.271	4.984	34.255	28.148	4.142
2005	32.781	5.680	38.461	26.695	7.141
2006	28.632	6.751	35.383	27.295	7.777
2007	39.328	7.889	47.217	35.326	9.578
2008	46.029	9.969	55.998	44.457	6.964
2009	36.994	7.859	44.853	39.522	3.954
2010	57.442	10.625	68.067	52.804	6.401
2011	69.275	13.831	83.106	61.963	7.660
2012	36.845	11.072	47.917	49.459	6.527
2013	50.923	10.545	61.468	49.857	6.020
2014	38.111	6.808	44.919	42.638	4.161
2015	18.816	4.472	23.288	23.196	n.a.*
2016	14.923	4.437	19.360	15.484	n.a.*
2017	n.a.*	n.a.*	n.a.*	16.383	n.a.*
2018	n.a.*	n.a.*	n.a.*	24.971	n.a.*
2019	n.a.*	n.a.*	n.a.*	35.746	n.a.*
2020	n.a.*	n.a.*	n.a.*	33.213	n.a.*
2021	n.a.*	n.a.*	n.a.*	44.702	n.a.*

Source: Own elaboration based on Trintini et al. (2020) and ANFAVEA (2022, p. 101)
* n.a.: not available. Note that the sum between licensing and exports is greater for some yearsthan production due to inventories. The import has existed for a few years but is irrelevant.

The project

The e-Delivery Project is part of a significant development project that has been carried out at the VWTBMC plant. The electric mobility project involves developing and producing a 100% electric truck prototype using Brazilian technology.

The truck is the first electric vehicle model developed by VWTB and produced in Brazil. To enable and divide the investment in this Project, the automaker brought together suppliers through the e-Consortium business model, in the form of a "Modular Consortium." VWTB determines a cluster relationship with its suppliers and workers for the supply of items and participation in the assembly of trucks. In this way, the company is active in developing the “ecosystem” that ranges from assembly to the charging infrastructure and lifecycle management of the electric truck battery, thus boosting and generating the engagement of the entire supply chain in an integrated manner. (VWTB, 2019).

The e-Consortium has ten companies working together: Bosch (supplier of the truck's electronic management), CATL (Chinese battery manufacturer), Moura, Semcon, Siemens (supplier of the entire energy infrastructure for recharging batteries), Weg (producer of electric propellers and responsible for the production of the AL 160 electric motor), Meritor, Eletra (specialized in pure electric buses, hybrids and trolleybuses), ABB. More recently, Brasol joined the e-Consortium as a new partner to reinforce the brand's "tailor-made" concept (Automotive Bussiness, 2019; VWTBPress, 2023).

The new phase of the e-Mobility business plan received an investment of BRL 110.8 million from VWTB, in addition to own resources from the "investment cycle" of BRL 1.5 billion, considered the largest ever made by VWTB in Brazil (Diário do Transporte, 2016). The National Bank for Economic and Social Development (BNDES) will finance part of this investment.

The e-Delivery brings a new concept for electric trucks, as it aims to make its production more flexible and freer up more space for batteries through more flexible engineering, making it possible to modify the composition of each module. By creating different arrangements, it allows the combination of different modules and from a "base vehicle", it is possible to develop new electric models (both trucks and buses). In this way, "(...) the modular packages are independent, making the use of different components and concepts simple and flexible, enabling the widest synergies between the Group companies and partners" (VWTB Institutional, 2019).

The electric truck was officially launched in 2021 and the Ambev brewery was the first company in Brazil to test the prototype. The company entered a strategic partnership with VWTB to purchase 1,600 electric trucks to be delivered by 2023. The e-Delivery has a range of up to 200 kilometers. It is sold in 11-tonne and 14-tonne models, equipped with six or three battery modules. At the end of 2022, VWTB began testing the largest electric truck manufactured in Brazil, a 17-tonne model. Thus, e-Delivery trucks became the biggest in their segments. Since its official launch, VWTB has produced more than 350 e-Delivery units and, in 2022, began its export plan for the electric truck, starting with Mexico.

Discussion

From the point of view of GVC theory, what is seen in the Project is a reconfiguration of the Modular Consortium to produce electric cargo vehicles (trucks and buses), with the entry of partners with specific skills, without changing its central characteristic of a chain driven by producers.

Such reconfiguration generates opportunities but also threats for current modularists, mainly in areas where the necessary knowledge is different. It is understood that the new e- Delivery modules act on a truck very similar to the one currently produced, with only a different propulsion. Also, this reconfiguration may expand the market for the companies currently in the consortium, except for Powertrain. It is thought that the company will produce both vehicles for about a decade. In this sense, the modular supplier that manages to produce for both configurations will be able to position itself more strategically. Table 2 compares both consortia.

Table 2: Members of the Modular Consortium and the e-Delivery Project

<table>
<tr><th colspan="2">Members of the Modular Consortium</th><th colspan="2">Members of the e-Consortium</th></tr>
<tr><th>Company</th><th>Occupation</th><th>Company</th><th>Occupation</th></tr>
<tr><td>Maxion</td><td>chassis assembly</td><td>Bosch</td><td rowspan="3">supply of components (electronic truck management, electric thrusters, etc.)</td></tr>
<tr><td>Arvin Meritor</td><td>axles and suspension</td><td>WEG</td></tr>
<tr><td>Remon</td><td>wheels and tires</td><td>Meritor</td></tr>
<tr><td>Powertrain</td><td>engines</td><td>CATL (chinese battery manufacturer)</td><td rowspan="2">Supply, management, distribution, maintenance and final disposal of batteries</td></tr>
<tr><td rowspan="2">Aethra Sistemas Automotivos AKC</td><td rowspan="2">cabin frame</td><td>Moura</td></tr>
<tr><td>Semcon</td><td>provision of engineering services</td></tr>
<tr><td>Carese</td><td>painting</td><td>Siemens</td><td rowspan="2">provision of infrastructure and chargers</td></tr>
<tr><td rowspan="2">Continental</td><td rowspan="2">cabin finish</td><td>ABB</td></tr>
<tr><td>Brasol</td><td>clean energy supply</td></tr>
<tr><td>WVCO</td><td>quality control (integration)</td><td>Eletra (specializing in pure electric buses, hybrids and trolleybuses)</td><td>strategic partnership</td></tr>
</table>

Source: Prepared by the authors

In 2022, VWTB launched the first "in-company" graduate course in electric, autonomous and connected vehicles in Brazil in partnership with the Federal University of Santa Catarina (UFSC). This initiative aims to develop professionals from VWTB's global development center for the new technological trends in the market.

It is important to note that the beginning of development based on small trucks results from the company's competence in this type of product and the demanding customer, who already uses it for deliveries over short distances (the so-called last mile). The technical success of the product can generate a wide entry into the market: with the increase in scale, production costs should be reduced and possibly the price, expanding the competitive advantage. The issue of recharging is not seen as problematic at the current stage, since if companies change their fleets, they will have garages and spaces for recharging. In addition, the idea of using concessionaires as a charging point favors the perception that such companies will move from product sellers to companies with a range of mobility services.

From 3H's point of view, despite the company's initiative to create an in-company postgraduate course in partnership with the UFSC, the e-Delivery Project does not present a relationship between the university and industry in research activities. Also, no direct connection was found between the universities in the southern region of Rio de Janeiro and VWTB for the Project on screen.

The connection between the university and companies in the automotive sector is limited to training human resources. Basically, engineers for the central production areas and administrators for the finance and human resources areas. On the one hand, the region's universities do not have a research agenda or laboratory capacity to meet the needs and interests of VWTBMC companies. On the other hand, the parent company either solves the technological issues alone, consulting other companies in the group, or "pushes" the problem to the module-suppliers and they solve it with internal engineering.

It is important to remember that, of the companies installed in the CASF, VWTB is the only one that develops its products. And this is probably due to the factory configuration (which is unique in the Volkswagen group) and the lower complexity of making trucks and buses compared to other vehicles (Trintini et al., 2020). Issues such as excessive bureaucracy, cultural differences and lack of communication channels are additional barriers to university-company interaction (Ferreira et al., 2013).

The CASF itself could function as an agent of rapprochement and dialogue. Still, it, does not act as a cluster in the original sense, sticking to defending the interests of large automakers with the public authorities (such as good road infrastructure, energy supply, and availability of labor and training). In this way, it does not perform such an approximation function, either within the cluster itself or with external entities (Lima & Paiva, 2020).

Other actors such as FIRJAN, SENAI and SEBRAE also have a limited role. In the relationship between VWTB and the government, there are tax incentives in use, during the Rota 2030 Program and reimbursable financing from the BNDES, which is part of the company's investment in the country. In this sense, it can be said that the relationship has a 3H2. There is a low relationship between the actors and little influence of these relationships on the regional socioeconomic development, which is a missed opportunity for the actors to build and use knowledge and create an advantageous competitive position for the long term.

Conclusions

This article aimed to study the e-Delivery Project of VWTB. Theoretical frameworks such as the GVC and the 3H were used to carry out the study. What was verified is that a new modular consortium was organized for developing and producing the electric truck without significantly altering the previous relationships. The company continues to lead and induce internal partners and external interaction, with government and university actors, remains limited.

Many external variables directly or indirectly affect the automotive industry and, more specifically, its innovation and electrification projects, as in the case of VWTB's e-Delivery. It is also understood that the current global economic crisis makes the whole scenario more unstable and uncertain. Therefore, how the economy will recover and the consequences and transformations that this will cause in the entire value chain and society need to be further studied.

The automotive sector's future lies in the electrification of motor vehicles along with automation and connectivity. And the Brazilian automotive industry will face major challenges involving bureaucracy, competitiveness, infrastructure and tax issues to keep up with all the transformations that are taking place in the global automotive chain. In this way, some issues must be deepened regarding to e-Delivery and an agenda for innovation, development, and competitiveness of the automotive sector in the South of Rio de Janeiro.

As for a future research agenda, it can be designed based on the limitations of this initial study. First, the deepening of the study of the e-Delivery Project with interviews and the monitoring market results. A second way of deepening the research is to compare the case of VWTB with other automotive companies that have already advanced in developing electric vehicles, such as BYD or Tesla. Still, this research is more complex and costly because it involves international actors. One path is also to understand the requirements for vehicle electrification and study whether Brazil's production chain can meet such needs. This study can be directed to the CASF. Finally, there is the issue of public policy. Analyzing Rota 2030 and other programs and suggesting, recommending or proposing adjustments to these policies; to support the electrification process of the national fleet, is a study that can have a significant impact on sustainable development.

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Brazilian pharmaceutical industry: Recent development and future perspectives

Abstract ID#247

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Purpose

The motivation of the research is to investigate the recent development of the Brazilian pharmaceutical industry, a technology-intensive sector composed of national companies, public laboratories and in the past dominated by multinational companies located in the Brazilian territory. In 2017, the 214 pharmaceutical companies operating in the Brazilian market earned USD 13.9 billion in revenues (BRL 70 billion) and sold more than 6,500 products in the Brazilian market in 458 therapeutic subclasses (Anvisa, 2018). The research question is to what extent has the national pharmaceutical industry been able to overcome the dominance of multinational companies in Brazil and evolve in the value chain beyond the formulation and commercialization of medicines? The objectives of the paper are to characterize the performance of two main groups of actors in the Brazilian pharmaceutical industry – national and multinational companies –, their innovation capacity-building efforts, and to analyze the institutional framework changes and the industrial and technological policies implemented from 1990 to 2020 that could act as both obstacles and incentives to the development of these companies.

Literature Review

The literature on the subject identifies the difficulties of technologyintensive sectors in emerging territories to catch up with the leading countries. According to Katz (1974), in the 1970s, two evolutionary stages of the pharmaceutical industry could be identified. The most advanced stage corresponded to the countries that historically led the world chemical market, such as Germany, and the less advanced stage presented significant distances from the developed nations, such as Brazil. The remarkable difference between the two stages was the dependence on the production of active pharmaceutical ingredients (APIs) and technology, as well as the dominance of multinational companies. In this sense, a series of more recent works on the pharmaceutical industry analyze its evolution. At the beginning of the 2000s, only one national company was among the 10 largest in the Brazilian market, there was a strong dependence on foreign technology and the import of inputs (Hasenclever et al., 2010). Nonetheless, in recent decades, national companies have gained prominence in terms of production capacity, in part, thanks to changes in the sector's institutional framework (Hasenclever et al., 2016). In addition, national companies responded positively to institutional changes through development and investment strategies. Examples are the internationalization movement of national companies (Perin & Paranhos, 2022) and the strengthening of their innovative strategies in the last two decades (Paranhos et al., 2020). However, none of these works discusses whether the current evolution of the Brazilian pharmaceutical industry has moved to a new stage of development and what are its biggest challenges to reduce its distance from the leading countries.

Methodological Procedures

The methodology is exploratory and based on a literature review, document analysis and secondary statistical data published by the Brazilian Institute of Geography and Statistics (IBGE), business associations and other available sources.

Findings

From the data analysis, the evolution of the Brazilian pharmaceutical industry in the last twenty years can be seen through two stylized facts. The first is the evolution of the national companies' participation among the twenty largest in the Brazilian market. In the early 2000s, only one company with national capital was among the 10 largest. According to IQVIA, formerly Quintiles and IMF Healthy, an American multinational company that produces data on the pharmaceutical sector, in the last twelve months to May 2022, the ranking of the 20 largest pharmaceutical companies in Brazil in unit sales brings together 17 manufacturers of national origin. Furthermore, the ranking of the 20 largest in terms of revenue includes 15 genuinely Brazilian laboratories and only five multinationals. The second stylized fact is the evolution of investments in R&D by pharmaceutical companies operating in Brazil. In 2000, these investments were about 0.8% of net sales revenue. In 2017, the pharmaceutical industry spent 2.7% of net sales revenue on R&D. When considering only companies with more than 500 employees, national companies spent 5% of their net sales revenue in R&D, and multinationals spent 1.3%, representing a superior investment strategy by national companies. The analysis of these stylized facts shows an intensification of competition between national and multinational companies in the Brazilian domestic market. The intensification of this competition seems to reside in the fact that national companies are not satisfied with the generic drug market and are evolving to launch incremental innovations. The observed tensions are reflected in the discussion on the extension of patents and on the regulation of innovative medicines. To what extent this evolution may or may not overcome the dependence on the production of inputs and foreign technology observed in the 1970s is not yet clear, but it indeed denotes a different development framework.

Implications

The study brings relevant contributions to formulating a public-private strategy capable of overcoming the development challenges of the pharmaceutical industry. Future research could interview the main actors of the industry and policymakers to deepen the diagnosis.

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INDUSTRY 4.0 I

May 1st: 10h30 am – 12h30 pm

Chair

Marthinus Pretorius (University of Pretoria, South Africa)

Papers

Managing the paradox between the industry 4.0 and human work: A smart working view

Jessica de Assis Dornelles, Alejandro Germán Frank

Digital waste in the industry 4.0 context: Characterization, typology and solutions

Arthur Henrique Gomes Rossi, Giovanna Bueno Marcondes, Paulo Leitão, Joseane Pontes

Adopting circular economy practices through industry 4.0 technologies

Isla Maria Cavalcante Nogueira Araujo, Cláudia Fabiana Gohr, Sandra Naomi Morioka

Sustainable project management and industry 4.0: Data quality in the use of cognitive computing and AI

Marco Aurélio Mazzei, Eder Alberto Diegues, Margarete Diegues, Mauro Luiz Martens, Arnaldo Luiz Ryngelblum

Startup-industry collaboration in the context of industry 4.0: Identification of the main benefits and challenges

Rodrigo Rodrigues Borges de Faria, Arthur Henrique Gomes Rossi, Joseane Pontes, Fernanda Tavares Treinta

Managing the paradox between the industry 4.0 and human work: a smart working view

Abstract ID#257

Jessica de Assis Dornelles, Alejandro Germán Frank (Federal University of Rio Grande do Sul, BR)

Considering the contradictory demands arising from Industry 4.0 (I4.0), companies are faced with paradoxes demanding that strategies be created to deal with different emerging tensions (Smith & Lewis, 2011). Among the paradoxical elements that companies need to deal with in this context, human work and the implementation of I4.0 technologies stand out since the highest level of I4.0 provides for an autonomous system centered on technology (Schuh et al., 2020) while the system depends on the skills of workers so that the implementation of technologies reaches its maximum potential (Fantini et al., 2020). For companies to be able to deal with the tensions emerging from these paradoxical elements, management strategies must be guided by a concept that encompasses the benefits of implementing I4.0 technologies and human work. A concept that stands out in this sense is the Smart Working (SW) of I4.0, which refers to how technologies support workers in their productive activities, contributing to their productivity, flexibility, and improvement of working conditions (Frank et al., 2019).

Thus, this study was based on the paradox theory (Smith & Lewis, 2011) to identify the tensions between human work and implementing I4.0 technologies and propose strategies to manage these tensions based on a SW view of I4.0. Thus, we sought to answer the following research questions: (i) What are the existing tensions between human work and implementing I4.0 technologies? (ii) How can a Smart Working vision help the company to manage these tensions with a view to its long-term sustainability?

According to Smith & Lewis (2011), a paradox occurs when contrary elements (duality) must coexist in favor of a unified whole. However, this coexistence gives rise to paradoxical tensions that can be categorized as belonging (identity/interpersonal relationships), learning (knowledge), organizing (processes), and performing (objectives). Although there is a consensus on the need to implement technologies for the sustainability of factories while workers need to be at the center of the implementation process (Dornelles et al., 2022), there is still a gap in the literature about the tensions related to this paradox, as well as the ways to manage it, enabling the sustainability of the factories in the long term.

For this, a longitudinal case study was carried out in a high-end furniture manufacturing industry that started its 4.0 journey at the same time that it has, in its essence, the DNA of human work. Thus, 66 hours of observations and participating meetings were recorded for structuring the company's I4.0 Roadmap and 26 interviews with managers, coordinators, leaders, operators, and technology providers over one year. A content analysis was carried out to obtain the results, and the tensions were categorized according to the theory. After this, was carried out a literature search of ways of managing tensions related to the SW vision and validated by specialists in I4.0. According to these steps, nine paradoxical tensions and 11 SW strategies were identified for tension management according to the literature and experts in I4.0.

According to the categorizations, five tensions are related to Organizing, four tensions to Learning, three to Belonging, and two to Performing (considering that one tension can be related to more than one category). Regarding the identified SW strategies, to deal with the same tension, it is possible to implement more than one strategy at the same time, as the same strategy can help to deal with different tensions.

The study shows that most of the paradoxical tensions identified come from organizational issues, such as transparency about how the digital transformation process will occur, which technologies will be implemented, and how this will affect the performance of workers' activities. Tensions over learning are also evident in this paradox, as through the implementation of technologies, workers will need to develop new digital and analytical skills and learn to use technologies. In addition, tensions related to belonging are characteristic of this paradox, as when implementing I4.0 technologies in an environment with human work DNA, it is essential that there is a cultural change and that all individuals in the organization understand their roles in this complex process of transformation. As the company analyzed by the study is in the process of putting Roadmap 4.0 into practice, performance tensions are not yet very well defined, although some do appear.

Finally, the results suggest that it is possible to manage the paradox between human work and implementing I4.0 technologies through a SW view. SW strategies aim to create a new work environment in which the organization's individuals participate in the technology adoption process, have clarity about their activities and roles, and develop new skills and multiple production objectives. Although, managers must develop the company's cultural change with a focus on digital transformation and develop a strategic plan aligned with the values and performance expected with this transformation. The article contributes to the Theory of Paradox by investigating the imminent paradox between human work and I4.0 technologies. It also contributes to strengthening the SW concept in digital transformation, opening a frontier for the construction of new theories. To the practice, it presents strategies for managing these tensions, enabling managers to prepare for implementation considering the role of workers for the sustainability of organizations.

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Digital waste in the industry 4.0 context: Characterization, typology and solutions

Abstract ID#285

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Paulo Leitão (Polytechnic Institute of Bragança, PT)

Purpose

This article aims to identify the types of digital waste and the possible solutions to avoid digital waste existing in the literature.

Literature Review

There are several definitions of digital waste (ALIEVA & HAARTMAN 2020), (ALIEVA & POWELL 2021), (DOUSSOU & TORREGROSSA & MARTINEZ 2022) but for this paper, digital waste is all kinds of waste and excess arising from poor implementation, operation, non-addition of value by 4.0 processes and disposal of digital technologies in an industry 4.0. This interpretation allows us to address a larger issue of how digital waste acts in organizations and in people's lives, even if indirectly they are not part of organizations 4.0. One of the easiest ways to identify digital waste is by the amount of stagnant and poorly treated data in organizations (ALIEVA & POWELL 2021). Any kind of data that is generated in service operations but not processed and transmitted to a section of the process is potentially wasteful of a digital nature. There is also digital waste that impacts workers as a result of layoffs and loss of human skills. Generating leadership problems, resistance to change and discomfort (ALIEVA & POWELL 2022), this happens when an organization goes through digitization in an accelerated way and in the search to reduce the costs arising from it, organizations fire their workers. This process can be mitigated according to (ALIEVA & POWELL 2022), via Lean transformations and assisted by consultancies and, if necessary, hire trained workers to be responsible for the digitization process involving the entire organization, trying as much as possible to fire or reduce sectors. It is also necessary to prevent inefficient processes from being digitized as this generates digital waste linked to the misuse of 4.0 technologies [4]. An example of this is operations and processes made by workers that do not generate value, if the process is not optimized, digital technologies only reproduced that task in a non-digitally optimized way (ROMERO et, al. 2018).

Methodological Procedures

It was carried out a bibliographic review using the PRISMA methodology, followed by content analysis that will be performed with the help of the QSR-NVIVO version 10 software. Overall, it was identified from the databases Scopus, Web of science and IEEE explore a final portfolio of 17 articles from a total of 84 records.

Findings

It was noticed that digital waste has a different characteristic depending on how its impact on organizations is evaluated: data, production and technologies. In this way, digital waste was characterized and it was concluded that the main points of intersection between them are that they impact on three different factors: people, environment and operation technological solutions were also identified that seek to avoid or reduce digital waste, starting initially from investing in a 4.0 culture, simplifying activities through Lean Thinking and searching for less complex learning technologies.

Implications

From the social contributions of the article, we highlight the need to be careful about how workers are affected by digitalization and its negative impacts, in addition to their concerns about job maintenance and ethical well-being in the industry. From the economic contributions this article shows that digital waste is something present in 4.0 industries and in those that are in the process of becoming digital, therefore, caution and integration with Lean 4.0 are necessary to consolidate these processes. From the environmental contributions, this article highlights the need to be cautious with digital waste because there is a problem of technological lag and of processing uses and excess digital machines when immersed in high amounts of digital waste, mainly by data. This generates an increase in electricity consumption, internet bandwidth, and increasingly intense disposal of electronic products in the search for better and faster technology. As technologies increasingly seek to be fast and accurate, the disposal of outdated technology is also fast, but sometimes it is not accurate or sustainable.

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Adopting circular economy practices through industry 4.0 technologies

Abstract ID#297| Full Paper ID#517

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(Federal University of Paraíba)

Abstract: The implementation of the Circular Economy (CE) requires changes in business models and society. In this context, new technological solutions based on information and communication from Industry 4.0 (I4.0) can facilitate the introduction of CE practices. However, while academics identify a possible synergy between these two topics, little is known about this in practice. Therefore, how can I4.0 technologies contribute to the implementation of CE practices? Thus, this paper aims to analyze which technologies are better for adopting CE and how I4.0 technologies can facilitate the implementation of CE practices. The primary method applied was an expert opinion by applying a structured questionnaire with open and closed questions through interviews. Data were analyzed using content analysis. The results show that BDA, CPS, IoT, AM, and Simulation are the most used technologies to facilitate CE practices, especially recycling, reusing, reducing, and remanufacturing. The article presents some contributions. First, the paper is one of the first attempts to integrate I4.0 technologies with CE practices and discusses the mutually beneficial relationship between them. Second, it allows managers to determine which I4.0 technologies are best suited to implement in their CE business model.

Keywords: Circular Economy; Industry 4.0; Experts interview; Integration

Introduction

In the past several years, the circular economy (CE) has played an essential role in industrial production, promoting practices such as recycling and minimizing the use of materials and energy to benefit the economy, environment, and society, and achieve balance and harmony among them (Silva & Sehnem, 2022). A challenging problem in this domain is that the transformation from a linear to a circular economy requires radical changes in the development of processes and products (Bag & Pretorius, 2020), business models, and society (Cwiklicki & Wojnarowska, 2020).

In this context, Industry 4.0 (I4.0) technologies can be CE enablers since they assist companies in achieving circularity and improving performance (Ada et al., 2021). The new technological solutions based on I4.0 meet the purpose of the 3Rs, that is, reduce, reuse, and recycle to seek CE and maintain the use value of the product, materials, and components for an extended period (Rajput & Singh, 2021).

However, while academics identify a possible synergy between these two themes, little is known in practice. Massaro et al. (2021) consider that despite the development of theories about I4.0 and CE, the link between them seems relatively recent. Chauhan et al. (2021) also affirm that despite the vast potential for integrating CE principles with the perspective of I4.0, few studies have analyzed this dimension. Agrawal et al. (2021) add that more studies are needed that contribute to the application of I4.0 technologies in CE.

To overcome these gaps, this paper aims to identify which technologies are better and how effective they are in CE adoption, as suggested by Dongfang et al. (2022).

Therefore, the following research questions emerge (i) how can I4.0 technologies contribute to implementing CE practices? The aims of this paper are: (ii) how can I4.0 technologies facilitate the implementation of CE practices?

The development of this paper is relevant both theoretically and in practice. Firstly, we mention the interrelationships between the two theoretical fields. For managers, this paper can assist in making more proactive and consistent decisions regarding the implementation of I4.0 technologies and CE approaches.

This paper is organized as follows: Section 2 presents the theoretical background. Section 3 describes the methodological procedures used for data collection and measurement, while section 4 details the results. Section 5 discusses the findings. Finally, Section 6 concludes the study.

Theoretical Background

Commonly agreed upon definition of the circular economy is those proposed by the Ellen MacArthur Foundation (2015, p.5): "a circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles". The CE offers new opportunities to move away from the linear economy of take-make-use-discard and balance supply and demand in resource management (Rajput & Singh, 2020). However, only in the last few years have environmental and social concerns forced organizations to transition from linear to circular processes to prevent the unproductive disposal of consumer or end-of life products (Kumar et al., 2021). The basic CE practices include the 3Rs – reduce, reuse, and recycle – which have been expanded to at least 6Rs (Bai et al., 2022). Reduce refers to minimizing inputs of raw materials and resources that enter a production and consumption system. Reuse refers to the process in order of maintaining the product value as long as possible. Recycling refers to outputs intended to recycle waste and end-of-life products (Bai et al., 2022).

Industry 4.0 is widely recognized as the Fourth Industrial Revolution. Its concept is based on advanced technologies and aims to combine many technologies for the common good to achieve responsiveness and improve the quality of a production system (Awan et al., 2021). I4.0 gained momentum due to advances in disruptive technologies through the Internet of Things (IoT), Big Data Analytics (BDA), Cloud Computing (CC), and cyber-physical systems (CPS) (Rajput & Singh, 2021). However, the diverse set of I4.0 tools prevents a clear indication of how to use them at the industry level (Cwiklicki & Wojnarowska, 2020). Bag & Pretorius (2020) divides I4.0 technologies into front-end (smart manufacturing, smart products, smart supply chain, and smart work) and core technologies (internet of things, cloud services, big data, and analytics).

Industry 4.0 technologies combined with circular economy practices can help organizations to progress towards sustainable societies, from the improvement of the design of product-service systems focused on preventing and reducing the waste of materials, energy, and ecosystems (Agrawal et al., 2021). In this context, I4.0 technologies can also be used to redesign products systematically, business models, and supply chains targeting CE (Bressanelli et al., 2022). However, as I4.0 and CE are two emerging innovation ideas, these topics have not been widely explored in the literature, which has only presented conceptual or theoretical frameworks (Atif et al., 2021). The literature has not yet shown an integration capable of achieving CE at a systematic level considering I4.0 technologies (Massaro et al., 2021). When analyzing the literature on the integration of these two concepts, several technologies were identified that can be used to implement CE practices and principles (Table 1 – Section 4).

Methodological Procedures

The research reported in this paper was developed following the steps presented in Figure 1.

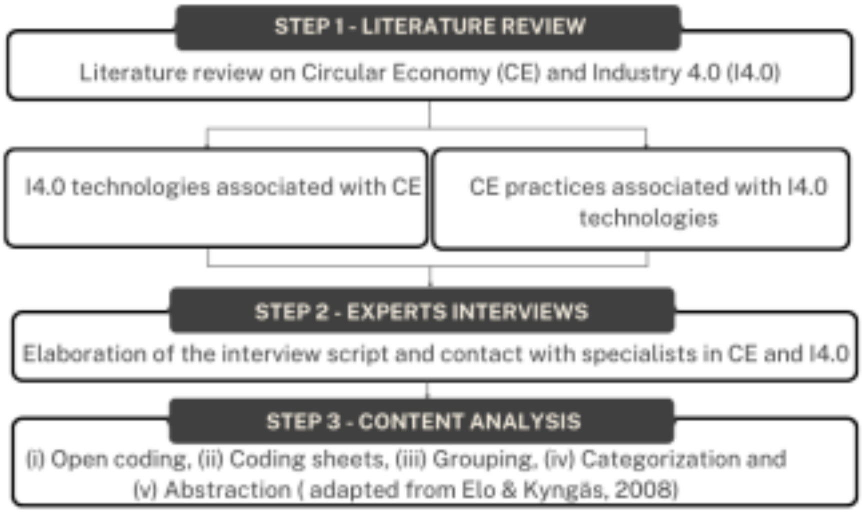

Fig 1. Research Methodology

The first step (Figure 1) is to describe the criteria used for searching and selecting papers. As a reference for the literature review, we used (Tranfield et al., 2003) "Towards a methodology for developing evidence-informed management knowledge by means of systematic review*". The search criteria defined for the research question were "circular economy and Industry 4.0", with search strings: "Circular Economy" or "Circular Business" or "Circularity" or "Circle Economy" or "Closed Loop" AND "Industry 4.0" or "4th Industrial Revolution" or "I 4.0" or "I4.0" or "Fourth industrial revolution" or "Smart Manufacturing" or "Smart Factor*". During the review, only formal literature (scientific publications, academic papers, and reviews) was considered. The queries were made in the Web of Science (WoS) database. The search was conducted considering only documents written in English and published until July 2021. In the eligibility stage, we filtered by the paper structure, citations, and methodology, and the result was 35 papers.

This first step assisted in elaborating the theoretical background and identifying CE practices and I4.0 technologies related to each other and how I4.0 could impact the implementation of CE practices, as shown in Figure 2. This information was the basis to propose Table 1 as presented in the previous Section (2).

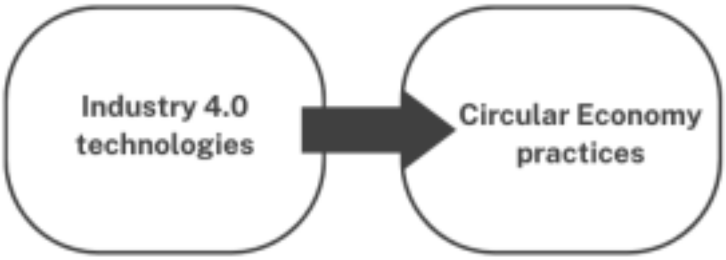

Fig 2. The relation between I4.0 and CE

In the second step, we selected four experts. A summary of their information is presented in Figure 3. For confidentiality reasons, the experts were identified by the following codes: E1, E2, E3, and E4. A semi-structured interview script was developed, validated by two specialists, and an interview/pilot test was carried out with a third specialist. The questionnaire included such questions as "Does Internet of Things technology contribute to recycling? Additive Manufacturing contributes to the reuse?" The experts' opinions were captured and measured on a five-point Likert scale (1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree).

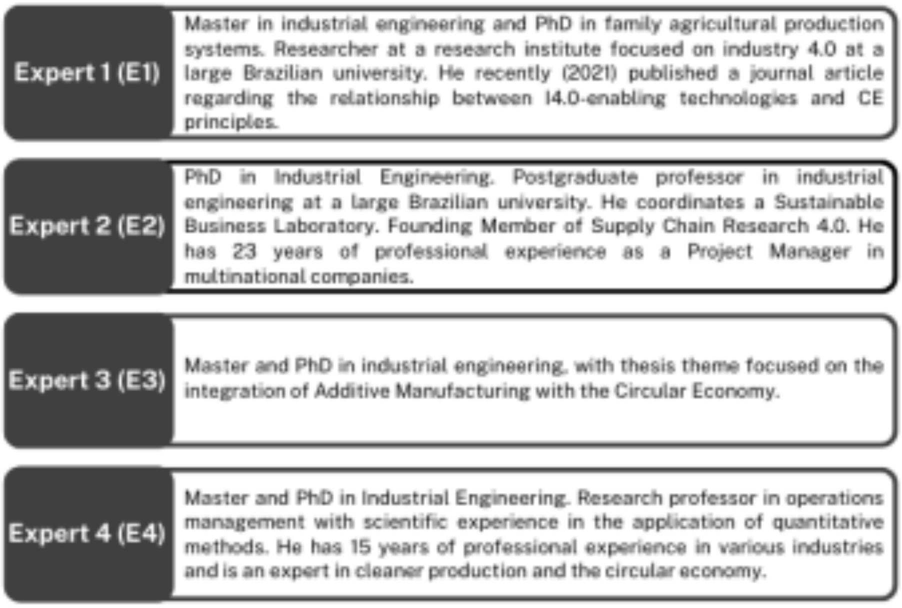

Fig 3. Experts' resume

This qualitative exploratory study was carried out based on the expert's opinions and aimed to seek the experts' perception of the contributions of I4.0 to CE. Exploratory research aims to explore what is happening and ask questions about it. It is especially useful when little is known about a given phenomenon (Gray, 2011), as in the present research. Seidman (2006) also states that the primary way a researcher can investigate a phenomenon is through the experience of individual people. This investigation is carried out mainly through interviews, one of the data collection strategies that can be used either quantitative or qualitative methods (Martins et al., 2014).

Finally, the step 3, the content analysis technique was used. The content analysis consists of a systematic and rigorous approach to analyzing documents obtained or generated during the research (White & Marsh, 2006). This paper used the phases: (i) open coding, (ii) coding sheets, (iii) grouping, (iv) categorization, and (v) abstraction (Elo & Kyngäs, 2008).

Open coding (i) was performed after reading the transcripts, at which time notes were taken on the research constructs and the associations between them. In (ii) coding, the clipping of each stage of the interview was carried out. In (iii) grouping, the information from the interviews was grouped to find meaning, identify convergences and divergences of opinions, emergence or not of new constructs, etc. From the grouping, the (iv) categorization and the (v) abstraction were performed, especially on the insights into how this I4.0-EC relationship could occur in practice.

Results

An overview of the literature considers that I4.0 technologies can be a vast opportunity to support companies in improving their circular performance through adopting digital technologies.

Upon analyzing Table 1, it appears that the Internet of Things (IoT), Big Data Analytics, Additive Manufacturing, Cyber-Physical Systems (CPS), Simulation, and Modeling, were identified as the top I4.0-based technologies related to CE. As for CE practices and principles, Recycle, Remanufacture, Reuse, and Reduce were the ones that stood out the most due to this intersection. Table 2 shows the main contributions of I4.0 technologies to CE practices, according to specialists and literature review.

Figure 4 shows the average, according to expert opinion, of the degree of contribution of each technology to the CE practices.

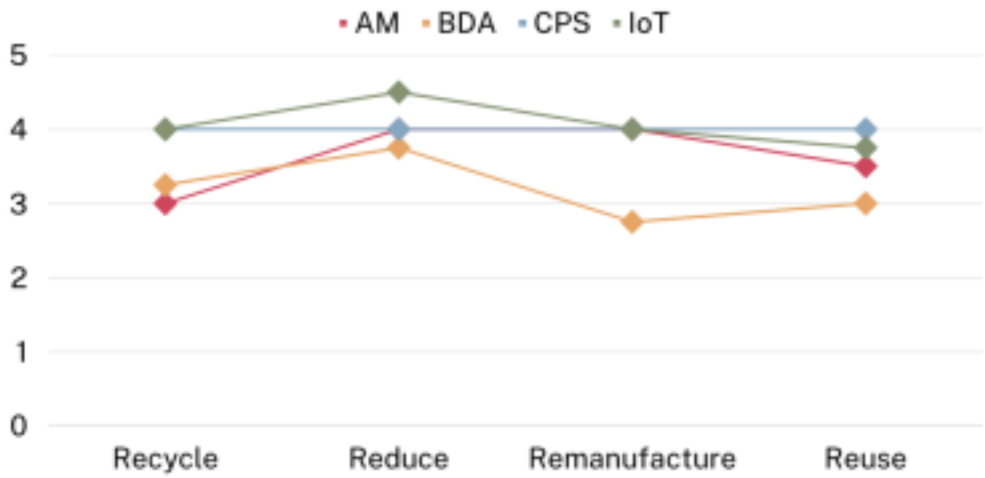

Fig. 4. Degree of the contribution of such technologies to CE, according to experts.

From Figure 4, it is possible to verify that experts had a high degree of agreement regarding the contribution of each technology to each CE practice. The IoT technology deserves to be highlighted, which had greater relevance, which can be confirmed by the literature, for its ability to provide a clearer view of how products are used and track disposal patterns to nurture future projects for a truly circular economy (Cheah et al., 2022). Another highlight should be given to the reduced practice, which significantly benefits from I4.0 since these technologies allow, for example, changing the design of products.

Discussion

Based on the expert's opinion and corroborating to the literature, Cyber-Physical Systems (CPS), IoT, big data and analytics (BDA), additive manufacturing (AM), and simulation were identified as the leading related I4.0-based technologies to the CE (Rosa et al., 2020). As for CE practices, which are summarized in the R-strategies, especially the 3Rs, as pointed out by Bai et al. (2022), provide valuable guidance to integrate I4.0 technologies into practice. In addition to the 3R, remanufacturing, thus forming 4R, is an increasingly essential element of CE, making high-quality products with new quality at low prices with reduced environmental impacts (Agrawal et al., 2021).

CE \ I4.0	Additive Manufacturing (AM)	Big Data Analytics (BDA)	Blockchain	Cloud Manufacturing (MaaS)	Cyber-Physical Systems (CPS)	Internet of Things (IoT)	Simulation and modeling	TOTAL
Recycle	[1]; [3]; [5]; [9]; [10]; [11]	[1]; [5]; [9]; [10]; [35]	[4]; [9]	[5]; [11]	[5]; [10]; [11]	[5]; [6]; [7];[9]; [10]; [11]; [35]	[1]; [10]	27
Reduce	[2]; [5]; [9];	[2];[5]; [9]	[9]	[2]; [5]	[5]	[2]; [5]; [6]; [9]		14
Refurbish	[10]	[10]			[10]	[6]; [7]; [10]	[10]	7
Remanufacturing	[1]; [2]; [10]; [11];	[1]; [9]; [10]; [35]	[4]; [9]	[11]	[1]; [10]; [11]	[1]; [2]; [6]; [7]; [9]; [10];[11]; [35]	[1]; [10]	24
Rethink	[10]	[10]			[10]	[10]	[10]	5
Reuse	[1]; [3]; [5]; [8]; [9]; [10]	[5]; [9]; [10]; [35]	[9]	[5]	[5]; [10]	[5]; [7]; [8]; [9]; [10]; [35]	[10]	21
TOTAL	21	18	6	6	11	29	7	

Note – [1]: (Rosa et al., 2020); [2]: (Spaltini et al., 2021); [3]: (Gupta et al., 2021); [4]: (Khan et al., 2021); [5]: (Cwiklicki & Wojnarowska, 2020); [6]: (Awan et al., 2021); [7]: (Agrawal et al., 2021); [8]: (Hoosain et al., 2020); [9]: (Bressanelli et al., 2022); [10]: (Belhadi et al., 2022); [11]: (Dev et al., 2020); [12]:(Lu et al., 2022).

Table 1. I4.0 technologies versus CE practices

CE / I4.0	Recycle	Reduce	Remanufacture	Reuse
Additive Manufacturing (AM)	- Design of products (E2)	- Low waste in building layer upon layer (E3); - Reuse of materials (E4); - Avoids the need to process raw materials before traditional manufacturing methods (Chauhan et al., 2021); - Design flexibility, waste minimization, and increased production capacity (Dahmani et al., 2021).	- Ability to build parts (E3); - Simulation and AM fit better with new remanufacturing processes (Rosa et al., 2019).	- Design of products (E1); - Separation of materials (E2); - Additive manufacturing, in the context of EC business models, would help with product reuse and redesign (Chauhan et al., 2021); - AM can keep materials in use and design the product, minimizing waste and pollution (Dahmani et al., 2021).
Big Data Analytics (BDA)	- Lifecycle onitoring (E1); - Product traceability (E4); - BDA to nvestigate waste reduction and recycling opportunities (Belhadi et al., 2022).	- Reduces the number of materials in manufacturing (E3); - Production of products (E4).		- Reverse logistics (E2).
Cyber-Physical Systems (CPS)	-System to ontrol the product life cycle (E1).	- Selection of raw materials (E1); - CPS and IoT can facilitate decision-making through the availability of real-time data and improve the optimal use of resources. This will also help reduce waste by identifying and mitigating potential failures (Chauhan et al., 2021).	- Logistic (E1).	- Logistic (E1).
Internet of Things (IoT)	- Control and monitoring of processes (E3).	- Reducing the amount of material in product development and how the process will look with this reduction (E3); - Internal logistics (E4).	- IoT for planning the warranty and maintenance stages of remanufactured items (Bag & Pretorius, 2020); - IoT to help a remanufacturer provide important information in real-time for timely decision-making and meet customer demands efficiently (Bag et al., 2020).	- Internal logistics aiming at the reuse of a component (E4); - IoT can provide real-time waste identification tracking. Connected devices allow the tracking of products, components and materials, and this promotes efficiency in the recovery and reuse of waste (Fatimah et al., 2020).
Simulation	- BDA, IoT and Simulation to improve supply chain coordination and transparency; and for intelligent ecological design (Belhadi et al., 2022).	- Simulation for the adoption of the product as a service and sharing platforms (Belhadi et al., 2022).		

Table 2. Main contributions of I4.0 technologies to CE practices, according to experts and literature

To summarize the previously presented findings, I4.0 technologies were significant enablers for CE implementation. No technology prevailed in isolation, and its implementation would affect not only a CE practice but even the entire life cycle. The information in Table 2 and Figure 4 above confirmed that AM, BDA, CPS, IoT, and Simulation are currently the most used technologies in circularity. Chauhan et al. (2021) considered that when I4.0 technologies are absent, the circularity of materials, sustainable production, and energy utilization are ineffective. The experts also stated that adopting I4.0 technologies and CE practices does not make organizations 4.0 and circular, respectively. Therefore, it is necessary to change the culture and have a strong leadership willing to update itself, survive the evolution of the market, and contribute to a more sustainable society, especially in underdeveloped countries.

Conclusions

The main objective of this article was to analyze which technologies are better suited for adopting CE and how I4.0 technologies can facilitate the implementation of CE practices through the literature and interviews with experts. The results show that AM, BDA, CPS, IoT, and simulation are the leading technologies addressed when referring to CE, and when used in combination, they bring excellent contributions. The article presents several contributions. Firstly, the paper is one of the first attempts to integrate I4.0 technologies with CE practices and discusses the mutually beneficial relationship between them. Secondly, it enables managers to determine which I4.0 technologies are best suited for implementation in their CE business model.

The article also presents some limitations that can be transformed into opportunities for further studies, such as the number of experts who participated in the research. Thus, future studies could conduct surveys to generalize the results of this paper. Exploratory analysis through case studies can also help understand how and why I4.0 technologies are facilitating (or not) the implementation of CE practices. Finally, future studies may focus on I4.0 technologies and CE practices not covered in this paper but deserve further investigation.

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Sustainable project management and industry 4.0: data quality in the use of cognitive computing and AI

Abstract ID#310

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Purpose

Carry out a detailed survey of the clusters of articles and authors proposing the use of AI and Cognitive Computing technologies in TBL + G or ESG contexts and, based on their considerations about the quality and representativeness of the data necessary for the training of the algorithms, identify the factors considered relevant for achieving the implementation objectives of these algorithms in the context of Industry 4.0. The results obtained from the analysis of what they cite and what they say about the quality and representativeness of the data will be used to support the development of a theoretical model highlighting the main gaps and trends in the studied literature.

Literature Review

The development of smart products, using technologies guided by the circular economy paradigm, can provide significant advances towards achieving the sustainability goals of the 2030 agenda. But these advances are dependent on overcoming the risks associated with the use of these technologies (Weidinger et al., 2021). Several studies have already reported problems arising from this use: sample selection bias (Challen et al., 2019), inadequacy of established objectives (Osterrieder et al., 2020) and lack of representativeness of data (Gianfrancesco et al., 2018).

Artificial Intelligence and Cognitive Computing algorithms share some important characteristics, such as the massive use of data obtained from Big Data projects in organizations (Fosso Wamba et al., 2015; Gupta et al., 2018), for training and defining the objectives to be achieved with the development and implementation of algorithms to use these data. There are several techniques for using this data in training processes, which can be supervised, unsupervised or hybrid, with one stage being supervised and the other not. The distinctions arise from the purposes of AI and Cognitive Computing algorithms.

Artificial Intelligence algorithms aim to automate decision-making processes based on occurrences of recognized patterns, reducing the action time in the face of any occurrence (Dwivedi et al., 2021; Terziyan et al., 2018).

On the other hand, Cognitive Computing algorithms aim at creating assistants, capable of interacting with decision-makers using natural language processing and considering the context conditions of their use that may involve thousands of factors or variables considered. in simultaneity. The main objective is to expand the coverage of these variables in the decision making process, consequently expanding the reach of decisions made by individuals and organizations (Chen et al., 2018; Gupta et al., 2018; Zhang et al., 2019).

Methodological Procedures

Systematic review of the literature with research in the Scopus base to register the state of the art in the production on the subject, from articles oriented to the application of Cognitive Computing and Artificial Intelligence technologies in the management of projects associated with Industry 4.0 and guided by the requirements of the socio-environmental, economic and governance sustainability, combining the results of bibliometric research with network and content analysis. The mapping of correlations and networks of authors and terms will be carried out using the VosViewer software

Findings

A total of 145 articles were selected which, with the restriction to the areas of Business, Management, Accounting or Engineering, selected 26 articles matching the search criteria. The analysis of the articles is guiding the construction of a theoretical model about the quality and relevance of the data to be considered in the implementation of the technologies.

Implications

The theoretical gaps and the model under development allow the advancement of the discussion of the human factors involved with the implementation of AI and Cognitive Computing systems in Industry 4.0 contexts to support the sustainable development objectives of TBL + G or ESG

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Startup-industry collaboration in the context of industry 4.0: partnership motivations and challenges

Abstract ID#311| Full Paper ID#520

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Abstract: Industry 4.0 has led to profound transformations in the industrial sector, bringing challenges for organizations, mostly related to new technology integration and how to establish relationship with disruptive companies, such as Startups. This article proposes to identify how Industry 4.0 has been acting as a driver for consolidated companies to engage in a startup industry collaboration, along with the challenges of such partnership. To achieve the objective, a Systematic Literature Review was carried out based on the PRIMSA Method, resulting in a 20-article portfolio. (i) Bibliometric Analysis to characterize the portfolio and (ii) Content Analysis using the MaxQDA software to identify drivers and challenges of the startup industry partnership within the Industry 4.0 scenario. As a result of the work, the main drivers that encouraged large companies to engage in a partnership with a start-up were identified and organized into two main groups, namely: the need for innovation as an organizational strategy and the need to adapt to the demands of digital transformation. Finally, among the challenges encountered in the relationship between startups and industries, the following stand out: cultural rigidity, control methods, limitations due to external factors and limitations due to time horizon.
Keywords: Industry 4.0; Open Innovation; Startups; Cocreation

Introduction

Industry 4.0 emerges as a strategic concept of the German government to define the possibilities of the fourth industrial revolution, marked by a cyber-physical production network involving disruptive technologies such as the Internet of Things, cloud computing and sensors that use RFID (Radio Frequency Identification) technology, among others, which allow the integration of the production chain (Lasi, Fettke, Kemper, Feld & Hoffmann, 2014). With the advent of these technologies, the search for innovation and digitization, applied in the most diverse industrial sectors, have gained a new importance. Emerging technologies not only change the way a product is designed, but also how to consume it. The demand also shows its performance as a manufacturing force, and new consumption patterns require greater customization, customization and co-creation by industries (Ferrás-Hernández, Armisen Morell, Sabata-Alberich, Tarrats-Pons, & Arimany-Serrat, 2019).

The impact of industry 4.0 goes beyond efficiency and profit maximization, and industries that implement new technologies globally to their business demonstrate higher success rates in the market, leaving their competitors behind (Deloitte, 2020). The application of digitalization impacts not only the R&D sectors but, according to Enkel & Sagmeister (2020), also promotes cultural changes and expands the perception of new market opportunities, as it enables a more accurate analysis of the environment. However, the adoption of new technologies that disrupt the established processes also involve risks, therefore requiring a solid strategy, effective leadership, and intensive training within the company (Yildirim & Tuncalp, 2021).

Within this scenario, innovation has been as a key factor to respond to the Industry 4.0 needs, as it enables new forms of interaction within the market, being one of these the partnership between startups and consolidated companies from various sectors. Companies that are at a high level of business maturity, and therefore, the term "large company" will be adopted as a nomenclature for these consolidated companies. The startup-industry relationship allows companies to develop and test new ideas with greater agility and reduced risk, while the startups benefit gain scalability (Steiber & Alange, 2019).

Startups are extremely innovative companies with a strong technological base, which allows the development of new business models, based on new business ecosystems (Steiber & Alange, 2020). In addition, the World Economic Forum (2022) evaluates startups as crucial institutions for responsible growth, especially in times of economic fragility.

Therefore, this article aims to identify the motivation that industry 4.0 awakens in companies already consolidated, for the establishment of startup-industry collaboration, as well as the challenges of this partnership, through a systematic literature review, carried out through the PRISMA Method, which had the qualitative analysis of a portfolio of 20 articles using the MAXQDA software.

Theoretical Background

The Challenge of Industry 4.0 for Large Companies

Disruptive technologies, which define industry 4.0, are challenging in their implementation even for already consolidated industries. Tilson, Lyytinen e Sorensen (2010) characterize the process where digital technologies are used in order to shape industrial processes and infrastructures as sociotechnical digitization processes. That is, digitization for the technological innovations of industry 4.0 involves not only machines, but also the entire structure and human capital of a company. The changing capabilities that disruptive technologies bring there manufacturing provide an intelligent verticalization of the production system based on communication and the speed of response of information technologies, generating a horizontal integration of production networks causing a new global network that provides a greater value aggregation for the production chain being, this value, directly related to the exponential implementation of these technologies (Deloitte, 2015).

The adoption of emerging technologies from industry 4.0, currently, is increasingly being demanded if the company wants to remain competitive and with strong market positioning. Bongo et al. (2020) suggest that some factors are critical to the success of this adoption, and that they involve both the qualification of a workforce and an infrastructure receptive to new technologies, as well as financial support and high level of process management.

In addition, there is a lack of field studies that confirm the most effective ways to introduce the concepts and technologies of industry 4.0 into the production lines of large and also small companies. Tortorella, Narayanamurthy e Thurer (2021) explain that not only is there a limitation in studies aimed at the application of industry 4.0, most of which are conceptual studies, but that this is partly due to the low level of technological readiness of many companies.

Startup-Industry Relationship

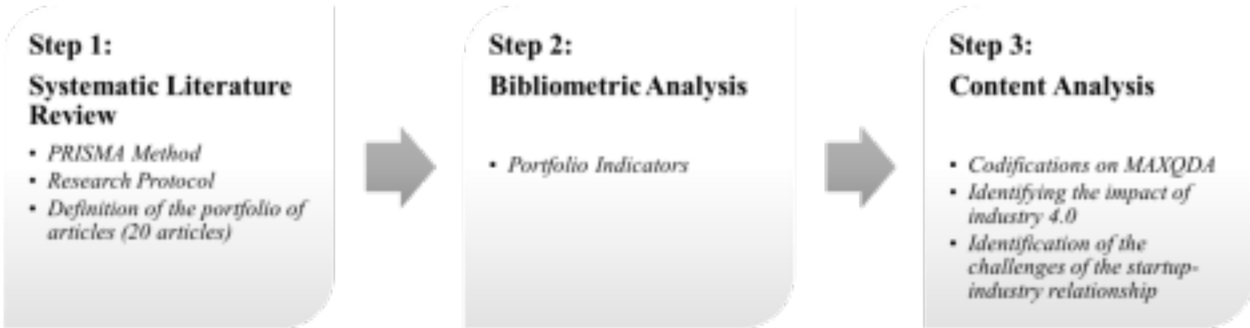
The intercollaboration between startups and large industries emerges as a way to protect both institutions from their own weaknesses. Developing this type of partnership brings benefits for both large companies and startups. The World Economic Forum (2018) demonstrates that the benefits for startups are mainly the greatest security in establishing themselves in the market and having a predictable revenue from an already consolidated company, ensuring sustainable growth, as for the large company the benefits are from an expansion of revenue, or market, derived from the results of collaborative innovation, ensuring a strategic position compared to competitors. Moreover, in a two-way way, institutions are able to increase the value generation they offer in their products, which becomes very important in the implementation of industry 4.0, since, as Schwab (2016) points out, industry 4.0 needs not only the application of technologies that permeate it, but even more, the creation of value through the use of them.

Interactions, therefore, can take place in ways that involve, or not, equity value and that have a direction of exchange of knowledge from inside to the outside, as well as from the outside to the inside of the walls of large companies (STEIBER e ALANGE, 2019). Forms of knowledge flow and equity options are crucial to determining the level of proximity and exchange of information between the companies involved.

Methodological Procedures

To achieve the research objectives, three main steps were followed, and step 1 was composed of the Systematic Literature Review, step 2 bibliometric analysis as characterization of the portfolio and step 3, and content analysis was performed through the maxqda qualitative data analysis software. Figure 1 below illustrates in detail the steps performed.

Figure 1 - Stages of construction of the study



Source: Authors (2022)

Systematic Literature Review

For the construction of the theoretical foundation of the research, the methodology of Systematic Literature Review (RSL) was chosen, which, according to TRANFIELD, DENYER e SMART (2003) consists of a scientific process that allows replicability and ensures the organization and mapping of the information researched.

Regarding the search protocols, indicated in Table 1, three axes were constructed with the objective of returning studies that included not only the themes of innovation and digitization of industry 4.0 in large companies or startups, in isolation, but rather the partnership relationships between large companies and startups for the development of innovations. Thus, axes 1 and 2 established a return of studies limited to the themes of industry 4.0 in large factories (axis 1) and in startups (axis 2). For the union of these two actors, large companies and startups, there was the need to create axis 3, which is the forms of partnership between startups and industries with the objective of generating technological innovations.

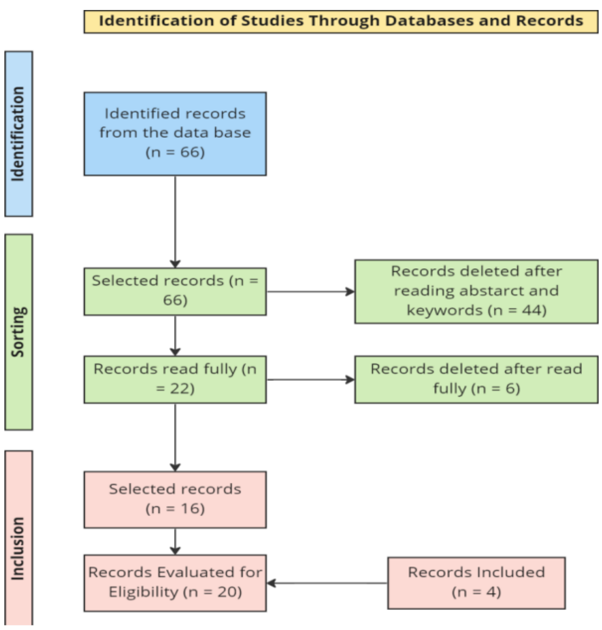
Table 1 - Search Protocol

Search Axes			
Axis 1 - Industry 4.0 *("industry 4.0" OR "industrie 4.0" OR "Fourth Industrial Revolution" OR "4th Industrial Revolution" OR "Digital Transformation" OR "Smart Industry" OR "Smart Manufacturing" OR "Smart Factory")* **Axis 2 - Startup** *("Startup" OR "Start-up")* **Axis 3 - Startup-Industry Partnerships** *("Open Innovation" Or "Collaboration" OR "Partnership" OR "Corporate" OR"Compan*" OR "Accelerat*" OR "Co-creation" OR "Cooperat*" OR "Organization")*			
Database	**Language**	**Search Terms**	**Period**
Scopus	English	Title, Summary and Keywords	No Filters

Source: Authors (2022)

After the search steps, the filtering procedures were performed based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method. PRISMA simplifies the replication and updating of systematic review studies, being a method of high reliability (PAGE et al., 2021). Figure 2 below shows the flowchart of the methodology where it is possible to observe the 3 macrosteps that constitute it, namely: "Identification", "Screening" and "Inclusion".

Figure 2 - PRISMA flowchart



Source: Authors (2022)

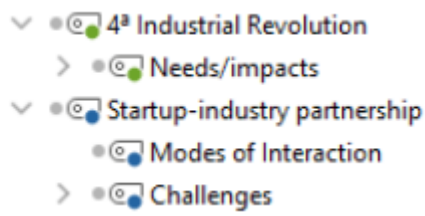
In the "Identification" step the search takes place in the selected database, and this step is the result of a return of 66 articles. In sequence, these 66 articles went to the "Screening" stage, where each article was evaluated qualitatively by reading their respective titles and abstracts, considering the proximity of their themes to the axes researched. In this stage, a total of 44 articles were excluded, six articles for not being related to industry 4.0, three for not relating to startups, two because they did not contemplate collaboration between large companies and startups, and thirty-two because they are not related to any of the thematic axes. After that, the full reading of the 22 selected articles was carried out, from which 6 articles were excluded. Once the filters were carried out, the selected articles (n = 16) moved on to the last phase, called "Inclusion", in which the articles already existing in the preliminary portfolio were kept, but plus 4 articles from sources external to the database used. With this, when finishing the filters and insertions of the PRISMA method, the final portfolio of 20 articles was obtained.

Bibliometric Analysis and Content Analysis

To obtain quantitative information about the studied portfolio, bibliometric analysis techniques were applied, which, according to Macias-Chapula (1998), is a form of analysis that uses mathematical patterns and models that allow extracting quantitative information from published studies. For the present study, the analyzed information was taken from the Scopus database itself and allowed a temporal analysis of the publications, illustrated through a bar graph; in-depth analysis of the main authors who are part of the portfolio of articles as well as the keywords most used by them, being represented by a table; and an analysis of the main countries that conduct research on the startup-industry partnership.

For content or qualitative analysis, full readings of the 20 articles that comprised the portfolio were performed, using the MAXQDA data analysis and exploration tool. Content analysis allows for identifying and constructing theories about the textual content of analyzed studies, with the objective of integrating, conceptualizing, and establishing relationships between the research data collected (BRINGER, JOHNSTON e BRACKENRIDGE 2004). For this, an axis of interest was constructed, which guided the search for information in the analyzed articles, aiming to obtain the information necessary to meet the objectives of (i) identification of motivation, which industry 4.0 awakens in companies already consolidated, the establishment of startup-industry collaboration and (ii) challenges of this partnership by the vision of large companies. Figure 2 shows the performance of these axes of interest.

Figure 2 - Axis of interest MAXQDA



Source: Authors (2022)

The axis of interest "4th Industrial Revolution" was responsible for identifying the impacts and needs that industry 4.0 exerts on large companies and that motivate them to seek external partnership with startups. The axis of interest formed by "Startup-Industry Relationship" served to understand, previously, the forms of interaction that make up the startup-industry relationship and, from this, understand its challenges of collaboration from the perspective of industries.

Results and discussion

Bibliometric Analysis

Observing the portfolio through its distribution over time it is possible to notice the presence of a growing trend about the subject researched. Of the 20 articles that made up the portfolio, approximately 35% of the publications are concentrated in 2021, and show greater interest in the academy in studying the impacts of the startup-industry relationship.

Another data that allows high relevance analyses is referring to the overview of the articles that comprised the research portfolio. Table 2 below presents the most cited articles, as well as their year of publication and affiliated Journal.

Table 2 - Characterization of the Most Cited Articles

Article	Number of citations	Year	Journal	CiteScore
Digital transformation challenges: strategies emerging from a multi-stakeholder approach	45	2020	TQM Journal	4.9
Startups and the innovation ecosystem in Industry 4.0	34	2019	Technology Analysis and Strategic Management	5.1
Corporate accelerators: fostering innovation while bringing together startups and large firms	31	2017	Journal of Business Strategy	1.9
External corporate venturing modes as new way to develop dynamic capabilities	24	2020	Technovation	10.1

Source: Authors (2022)

By observing the data present in the Scopus platform, it was possible to observe a predominance of Journals with thematic areas focused on business, management, and accounting, with the exception of the Journal "Technovation", which has a greater focus on engineering area. This is also repeated in relation to the complete portfolio, which is composed in 41.7% of "Business, Management and Accounting", 14.6% by "Social Sciences" and 12.5% by "Engineering". Another interesting fact is referring to researchers of Brazilian nationality, who presented a significant representativeness rate (15.4%) and which shows that interest in technological innovations driven by the startup-industry relationship has been gaining relevance also in developing countries. Among the most found keywords were also "Startups" (20%), "Innovation" (13.3%), "Industry 4.0" (11.7%) and "Digital Transformation" (10%).

Decision Factors for the Startup-industry Partnership

With the results obtained from the coding of the article portfolio, it was possible to observe how industry 4.0 impacts large companies and the way corporations respond to the changes that innovation and digitization require of organizations. But to generate these impacts, industry 4.0 generates needs within the industry to remain competitive. These needs can be divided into two groups: (i) Innovation as an Organizational Strategy and (ii) Digital Transformation. Table 3 below represents how these needs generate the impacts that become decisive in external collaboration with startups.

Table 3 - Needs of startup-industry collaboration

Need	Impact	Authors
Innovation as an Organizational Strategy	Fast Learning	Annika Steiber (2020); Steiber et al (2021); Silvello et al (2019); Bzhalava et al (2021); Molloy e Ronnie (2021); Amann et al (2021)
	Open innovation	Galena Pisoni (2021); Silvello et al (2019); Bzhalava et al (2021); Rocha et al (2019); Ferrás Hernández et al (2019)
	Risk aversion	Molloy e Ronnie (2021)
Digital Transformation	Internal Digitalization	Brunetti et al (2020); Rocha et al (2019); Ferrás-Hernández et al (2019)
	Human Capital	Molloy and Ronnie (2021); Rocha et al (2019); Ferrás-Hernandez et al (2019)

Source: Authors (2022)

It was possible to analyze that the need for innovation triggers three factors that impact the company, being (i) Rapid Learning, (ii) Open Innovation, (iii) Risk Repulsion. Rapid learning concerns the nature of innovation projects. Silvello, Alves e Alcarde (2019) point out that the success of innovating a company depends on a culture that gives learning opportunities, since failures in innovation projects are common, and that well-passed feedbacks and actions performed in an agile way can be capitalized on successful projects. The development of a culture of continuous learning requires management open to change and concerned with serving the interests of the organization, which goes beyond traditional management, (Molly & Ronnie, 2021).

Open innovation emerges as a response to the difficulties in breaking down internal barriers in the company. Today, companies that have strictly an internal focus, may lose R&D opportunities due to the distribution of innovative knowledge that we have throughout the market, and actions that increase inter-organizational ties, and developing ideas jointly, are critical to the development of organizations (Rocha, Mamédio & Quandt 2019). Molly e Ronnie (2021) highlight the importance, not only of isolated partnerships, but an ecosystem that ensures the exchange of information between different actors. The impacts of open innovation can be felt in better recognition of external factors that impact the business, as well as production trends and consumption habits, as well as in the more technical areas ensuring improved knowledge of productive capacities and optimization techniques (Silvello, Alves & Alcarde 2020).

In turn, despite the two impacts mentioned in a positive way, the repulsion to risk comes as a response that often blocks innovative actions in companies. This way of avoiding risks can manifest itself in ways that generate (i) structural inertia, which would be protectionism of outdated mechanisms on the part of the company's own bureaucracy, (ii) cultural inertia, where there is a difficulty on the part of employees in adopting new practices or technologies (Molly & Ronnie, 2021).

For the digitization needs, it was possible to identify two factors that impact the company, called (i) Structuring of internal digitization and (ii) human capital. By seeking greater digitization within the sectors of an organization, companies are subject to processes that involve factors that go beyond the walls of the institution. Brunetti et al., (2020) say that it is important that companies face digital changes with systematic approaches and that often have a notion of multidimensional development, of a regional character – as technological poles – favor the development of internal digitization. Because of this, it is possible to observe the complexity of the impacts of scanning. Triggering much beyond focused technological disruptions, through the increase of technologies identified by Sebastian et al. (2017), called SMACIT (Social, Mobile, Analytics, Cloud and Internet of Things), digitization processes may incur structural, cultural and market challenges (BRUNETTI et al., 2020). Therefore, the impacts of increasing industry 4.0 technologies depend on well-managed investments in infrastructure, corporate leadership and fostering digital culture in organizations, as well as a good relationship with stakeholders and external partners (ROCHA et al., 2019).

As a result, the impact on the human capital of organizations, has repercussions on the insecurity that technologies, in chief of disruptive technologies, bring to employees. According to Molly e Ronnie (2021), jobs whose workforce are not at high manufacturing rate levels or high use of technical skills – being mid-level skills – are the most affected by labor replacement. A solution for this is described by Rocha et al. (2019), where the training of employees by the company, in order to train them for a better adaptation to disruptive technologies, has been highlighted by managers. But a scenario is certain, with the increase in robotization and the accelerated change of traditional jobs, corporations have an important role in changes that can define the survival of the capitalist system itself (FERRÁS-HERNÁNDEZ et al., 2018).

Regarding the impacts caused by innovation as an organizational strategy, it was possible to observe two positive phenomena, being the change from a thought of repulsion to risk to a thought of rapid learning and that from space to errors in means to innovative R&D processes. Another positive phenomenon would be open innovation, later also described in partnerships with startups. Open innovation breaks down traditional barriers between learning sharing between institutions and can ensure greater assertiveness to the market position and quality of industry products. Nevertheless, a phenomenon was negative when exploring such impacts, and this is due to the repulsion to risk, which may be present both in low-level employees and in the highest boards. However, this is a challenge that tends to be dealt with from the top down, i.e. through good management practices and that inhibit acts of internal protectionism.

When it comes to digital transformation, the phenomena are found to stand out in two large groups. The first would be the structuring of internal digitization, which consists of management actions that foster the digital culture within the company. In addition, this phenomenon can be impacted by external factors as well, and therefore it is valid a global view of the company in the face of actions that promote digitization. The second major impact would be referent, which feels insecure by the automation and robotization of functions. This is often one of the major challenges that bar a culture in favor of increasing new technologies and are strictly linked to how industry managers deal with the dynamics of replacing or cutting functions resulting from digitization.

Challenges of Partnership Between Startups and Large Companies

The Startup-industry partnership has been an important tool for companies to succeed in their innovation projects and digitalization of internal sectors. Startups being institutions that have an extremely agile culture and processes, and product development focused on the customer, deliver results from a partnership that can generate improvements from customer satisfaction of a large company to greater employee engagement (Deloitte, 2020). But still, due to the high degree of complexity in exchanging knowledge between such different institutions, the startup-industry relationship also brings its challenges to industries. Through the analysis carried out in the present study, it was possible to list the main challenges encountered today in the literature on the subject. For the challenges that still need to be overcome, 4 topics (i) Organizational Culture, (ii) Evaluation Metrics, (iii)Limitations by external factors and (iv) Limitations by time horizon were listed.

Table 4 - Challenges of the Startup-industry relationship from the perspective of large industry

Challenges	Causes	Authors
Organizational Culture	Employees resistant to knowledge exchange; Culture resistant to change	Annika Steiber (2020) e Amann et al (2021)
Assessment Metrics	Little engagement between companies; Inefficient indicators; Lack of alignment of expectations between large companies and startup	Annika Steiber (2020); Steiber et al (2021) e Amann et al (2021)
External limitations	Limitation of development by geographic factors; Limitation of development by local economic factors; Technological maturity of competitors	Annika Steiber e Sverker Alange (2019); Annika Steiber (2020); e Amann et al (2021)
Time limitations	Internal objectives with divergent time horizons between the companies involved	Rocha et al (2019) e Annika Steiber (2020)

Source: Authors (2022)

In the context of organizational culture, we have in the mentality of employees of large institutions the revulsion for actions involving the exchange of knowledge or processes between an institution that comes totally from outside the domains of the company. This challenge can trigger actions that, according to Steiber (2020), can be called "Not Sold Here", where there are barriers linked to the norms, values and principles of the company, and "Not Invented Here", which would be caused by psychological patterns or restriction of information that lead to contradictory actions. However, for this class of challenges, the importance of the absorption capacity of senior management or board of large companies in facing the problems of resistance to change is emphasized (Amann, Granström, Frishammar & Elfsberg 2022).

With regard to the challenges of evaluation metrics, these unfold in the joint effort to take actions that generate the engagement of both industry and startup. The efforts made by the company in co-heart projects directly affect the business opportunities resulting from the project (STRIBER et al., 2021). The lack of such efforts, for example, is reflected in the lack of strong indicators that ensure the monitoring and achievement of the objectives of the participating parties. What determines the success of a co-creation action between startups and companies is precisely how aligned are the two institutions about the project to be performed.

The limitations due to external factors are the most uncertain when controlled, precisely because they involve factors to which the company may not have control or cannot exert influence. External factors may present difficulties regarding competitive pressure, sector dynamics or local technological development (STRIBER et al., 2021). In addition, there is also the difficulty of monitoring the development and launch of technologies that enter the market, which can generate restrictions of understanding between startups, with disruptive proposals, and companies (AMANN et al., 2022).

Finally, the presence of difficulty involving the time horizon between the two types of organizations can influence not only the result, but also the quality of information exchange and relationship during the co-creation process. A large organization, because it has a focus on long-term development, often 2 to 8 years, is not affect by assuming innovation proposals that result in a long-term relationship with the startup, however, the need for a short time horizon for most startups can become a conflicting characteristic among the objectives of the institutions (ROCHA et al., 2019; STEIBER., 2020).

In the context of the challenges encountered in the relationship between startups and industries to assist in the development of technological innovations, the first two major challenges, as well as the limitation by time horizon, are strictly related to the way the company treats innovation and co-creation projects with startups. Having structure and personnel prepared to deal with the exchange of external knowledge, is extremely important for the success of the relationship of open innovation with startups. Another factor to be considered would be the limitations due to external factors, but it is something that goes beyond the possibilities of action of the company, leaving it strategies to contain damages.

Conclusions

Technological advances arising from technologies with disruptive potential belonging to industry 4.0 are being increasingly disseminated and penetrating in various industrial segments. But an increase in the correct way, which guarantees a high technological potential to companies, is not so simple when developed by large corporations. With this, external aid, through the steps of open innovation, shows great potential by uniting startups and industries for the development and growth of technological innovations. The present study sought, through a portfolio composed of 20 articles to identify the motivation that industry 4.0 awakens in companies already consolidated, the establishment of startup-industry collaboration, as well as the challenges of this partnership.

With this, it can be concluded that, through the identification of the needs of innovation and digitization, and how these impact specific sectors of large companies, the objective of understanding the motivations that lead a large industry to carry out a project partnership and exchange of knowledge with highly technological startups was fulfilled. It was also possible to understand, through the mapping of the main causes, how the challenges of partnerships between startups and industries take place. Thus, it is expected that this study will provide companies with the knowledge of how industry 4.0 impacts their methods of exchanging knowledge with external institutions of high technological level, which are represented by startups, and assist in the construction of decision-making about facing challenges that this form of partnership can offer to the institutions involved. For the academic sectors, it is expected to provide a contribution to the theme that still lacks studies, due to its extreme contemporaneity and various ramifications, and that, with this, it awakens, mainly, the need for future case studies to put to test the hypotheses exposed here.

It is noteworthy that the study focused on startup-industry relations is still in the initial phase by the academy, and that there is possibly a lack of information that strengthens the results found here, which are limited to the portfolio studied. Therefore, the authors emphasize the importance of new studies, whether exploratory or case studies, on the impacts of the startup-industry relationship as a response to the innovation needs of digitization in companies.

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INCLUSIVE AND FRUGAL INNOVATION I

May 1st: 10h30 am – 12h30 pm

Chair

Osman Ahmed (Pacific Northwest National Laboratory, United States)

Papers

Gender diversity in innovation environments of large companies

Vitoria da Silva, Wagner Lopes da Silva, Fernanda Reichert

Agent-based modeling: Methodology for understanding the complexity of inclusive innovation systems

Maria Luisa Villalba, Eliana Maria Villa, Walter Lugo Ruiz

Evaluating frugal innovation opportunities for the South African timber construction industry

Tsireledzo Maliege, Schalk Grobbelaar

Frugal geeks: Startups founder's knowledge and frugal innovation contributions to performance

Rosana Vaz Barbosa Dangui, Andre Moraes Santos

Gender diversity in innovation environments of large companies
Abstract ID#211

Vitoria da Silva (Federal Institute Sul-Rio-Grandense); Wagner Lopes da Silva, Fernanda Reichert (Federal University of Rio Grande do Sul)

Purpose

This article seeks to contribute to the existing discussion on gender diversity, especially applied in innovation environments, because although studies have shown that environments with greater gender balance are more prone to innovation (Ostergaard et al., 2011), women continue to face strong barriers that cause considerable damage to their career progress. Barriers range from blocking women's access to better positions and better-paying jobs due to implicit gender bias, which is an unconscious belief that women are less capable than their male peers (Moss-Racusin et al., 2012; Carli et al., 2016); to structural barriers, for example, investors tend to invest resources in male-led businesses (Ranga & Etzkowitz, 2010).

Given this context, the question is: How is the gender diversity agenda perceived in large innovation companies? Thus, this study's main objective: to describe how the gender diversity agenda is perceived within large innovation companies, with the following steps: a) to identify the strategies developed by large innovative companies to promote gender diversity; b) to understand the motivations that led to the proposition of these strategies; and c) to capture managers' views on the effectiveness of these strategies.

Literature Review

Ostergaard et al. (2011) point out that companies whose gender composition is more balanced are 68% more likely to innovate than companies dominated by one gender. Díaz-Garcia et al. (2013) add that companies with greater gender diversity in the R&D area have greater chances of radical innovation and, for Xie et al. (2020, p.11), "gender diversity in R&D teams increases the efficiency of innovation throughout the process, promoting high-quality innovations due to the various perspectives and experiences that women add".

Still, the data show underrepresentation of women in various segments of innovation, such as R&D, patents, leadership of technology companies. Furthermore, Frietsch et al. (2009) demonstrate that the higher the academic level, degree or position, the smaller the share of women, characterizing a phenomenon called leaky pipeline.

In this sense, Sifontes & Morales (2020) suggest that there are losses due to the inefficient use of female talent in innovation environments. For Ranga & Etzkowitz (2010) organizations have made efforts to recruit women. However, these actions, unaccompanied by strategies for retention and promotion, generate a false expectation that the "system" alone would try to balance women and men in organizations.

Methodological Procedures

A qualitative and exploratory approach was used. For data collection, managers linked to innovation of large Brazilian companies were interviewed, selected based on revenue, market coverage and national relevance, because according to Morris (2018), investments in R&D are correlated with the size of companies, with those of large companies more capable of generating innovation.

Thus, we selected three companies with the following characteristics: (A) company in the communication sector, focused on the regional market, with sales of more than R$ 1 billion and 3000 employees; (B) multinational company in the consulting sector, operating in the international market, revenue of US$ 41.3 billion and approximately 250,000 employees; (C) multinational technology company, with operations in the international market, revenue exceeding R$ 1 billion and 3000 employees.

All interviews were transcribed, so we could carry out a content analysis, highlighting the following themes: actions, motivation for diversity and predominance in the profession.

Findings

The main strategies pointed out by the companies are: creation of affinity groups that offer reception and sharing of resources that help the collective success of women; mentoring programs for them and training for all employees aimed at raising awareness of diversity; and dedication of a professional focused on working on this topic in the company.

The motivations are based on social pressure, driven by public opinion that is increasingly attentive to these issues, as well as to better align product and service innovations to the consumer public, as it is diverse, and feels that it should be represented in products or services generated by companies, as well as having their needs recognized and considered in the creation and development process.

Representatives understand the importance of gender in senior management, but confirm that their boards are made up mostly, if not exclusively, of men. Which could represent the phenomenon of the leaky pipeline, where the female presence drops as it approaches the senior management. In addition, the professions related to information technology are also heavily occupied by men, which the interviewees justify by the historical predominance of the male gender in the profession. However, it only reinforces the need for organizational change and commitment in this regard.

Implications

The social appeal of the diversity agenda has made companies give relevance to diversity in a broad sense, above all, to try to better connect the innovation process with the needs of the consumer public.

Despite this, the presence of women in innovation teams, as well as in company boards, is still timid. This denotes the need for organizational commitment to bring about structural changes that ensure not only the entry of women, but also their permanence and success. As suggestions for future studies, the expansion of interviews and an analysis of the effect that affirmative actions exert on gender equity are pointed out.

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Agent-based modeling: Methodology for understanding the complexity of inclusive innovation systems

Abstract ID#221 | Full Paper ID#429

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Abstract: Social inclusion has begun to be considered in the dynamics of innovation systems thanks to innovation' potential to solve problems related to poverty and inequality. Inthis sense, it is important to analyze Inclusive Innovation Systems (IIS) as an emerging phenomenon that could contribute to sustainability processes in their three dimensions (environmental, social, and economic) to improve human well-being. This paper argues for theuse of Computational Modeling and Simulation (CMS) to study inclusive innovation systems,specifically through Agent-Based Modeling (ABM), as a powerful tool for analyzing the complexity of these systems, whose characteristics differ significantly from Conventional Innovation Systems (CIS) given the increase in the number and types of agents, their new relationships, and the uncertainty.

Keywords: Inclusive Innovation Systems (IIS); Agent-based Modeling (ABM); Computational Modeling and Simulation (CMS), Complexity.

Introduction

From the Schumpeterian perspective, innovation has been understood as the driving force behind economic development of the capitalist world (Schumpeter, 1934). The basis of this focuses on the capitalist system being the result of technological change and entrepreneurial activity (Schumpeter, 1942). This paradigm has become the foundation for the proposals by Freeman (1982, 198) and Lundvall (1985) on Innovation Systems (IS), which are recognized as responsible for technological change (Hekkert et al., 2007). As a consequence, there are over 30 years of solid theoretical construction on IS supported by Shumpeterian principles (Piano, 2022) that contribute to the understanding of their complexity, which still increase, undeniably. Based on the above, it stands out that a relevant characteristic of these innovation systems is that they have prioritized economic growth (Lundvall, 2022); we call this type of systems Conventional Innovation Systems (CIS).

However, due the existence of structural problems, such as income inequality, concentration of wealth, poverty and social exclusion (Sutz, 2010) - global challenges - (see Sustainable Development Goals (United Nations Sustainable Development, 2022)) new paradigms have emerged on how an IS might work, considering a transition of the systems towards sustainability is required (Lundvall, 2022). In this line, the Global South view has focused on the issue of social exclusion and its relationship with IS, due to one of the main problems of the Global South corresponds to the inequality of large groups of the population who are excluded from the benefits of the innovation and development processes (Arocena & Sutz, 2012; Couto & Cassiolato, 2013; Dutrénit & Sutz, 2014), therefore the IS of developing countries to operate in different contexts than those of developed countries (Lundvall et al., 2009), that is, contexts with a high level of complexity determined by specific needs, less formalized institutional frameworks and different key agents (Altenburg & Lundvall, 2009). This inclusion can occur from IS, which has led to the introduction of the concept of Inclusive Innovation Systems (IIS), kind of innovation system that emphasizes the importance and challenges to achieve the inclusion of marginalized populations (Alzugaray et al., 2012; Arocena, 2018, 2019; Couto & Cassiolato, 2013). These systems focus on the interaction of actors who generate, diffusion and use knowledge and technologies to solve problems of excluded communities (Arocena et al., 2018), where those who are in said condition of exclusion are no longer seen as patients of the process and are seen as active agents of the system (Alzugaray et al., 2012).

However, there are multiple questions about the functioning of IIS, mainly because the theoretical supports on the relationship between inclusivity, innovation and development are still incipient; the literature in this regard is under construction and has focused on gathering empirical evidence (Van Der Merwe & Grobbelaar, 2016), literature reviews, and position papers or conceptualizations (Heeks et al., 2013). In addition, it is necessary to consider that the complexity of this kind of system is major that conventional system due to IIS have new variables, new relationships, new purposes, new rules (Villalba et al., 2019) that lead to new system configurations (Cirillo et al., 2019); consequently the actual literature and methodologies do not facilitate the exploration of possible evolutions of the systems (Arocena & Sutz, 2021). Hence, given the complexity and the presence of heterogeneous actors in the system, it is not easy to understand its dynamics (Gilbert et al., 2001).

The characterization of IS as complex adaptive systems (CAS) distinguished by their complexity (many variables), uncertainty (variables affected by various phenomena) and dynamism (vary rapidly over time) is reported in the literature (Chen et al., 2011; Gilbert et al., 2005); Additionally, a CAS has as its fundamental characteristic learning and adaptation over time (Cooke, 2013; Gilbert et al., 2005; J H Holland, 1992; Iñigo & Albareda, 2016). Due to the above, Computational Modeling and Simulation (CMS), is considered an innovative and suitable tool for the study of IS as CAS (Cooke, 2013; J H Holland, 1992; Iñigo & Albareda, 2016; Katz, 2016; Roshany, 2018; Ruiz et al., 2016). This is how, through the Computational Modeling and Simulation (CMS), studies can be carried out according to the complexity of this type of system, since it is possible to generate rules, patterns, behaviors, links, and actors for the understanding of the phenomenon that would be almost impossible to carry out in a study. of real systems (Cadavid, 2015; Quintero, 2016; Ruiz, 2016).

Given this, CMS offer benefits, especially ABM, which exceed the limits of other methodologies to study phenomena from a systemic perspective. Thus, this work argues for the use of CMS, to study the complexity of IIS, particularly, ABM.

Theoretical Background

IS have been widely studied in the field of knowledge of both the phenomenon of innovation and public policy frameworks for science, technology and innovation and its importance lies fundamentally in the revitalization of the processes that will result in innovation for organizational, regional, national and global competitiveness (Couto & Cassiolato, 2013; Chris Freeman, 2002; Godin, 2009; Hekkert et al., 2007, 2020; Quintero-Campos, 2010; Ruiz et al., 2016). As the concept evolved and was used to carry out studies of innovation processes not only at the national (National Innovation System, SIN) but regional (Regional Innovation System, SRI) and sectoral (sectoral innovation system, SSI)), the systemic perspective begins to be used to improve the understanding of the IS, around the adaptability, learning, uncertainty and flexibility of systems, from the general theory of systems, which postulated that their properties are interdependent by both must be studied jointly (agents, interactions) in order to understand the system (Bertalanffy, 1976; Castillo, 2004; Suárez, 2018; Weckowicz, 2000).

Additionally, in the evolution of the study of the SI, the theory of complexity is included, which allows the study of non-linear emergent phenomena (without a clear correspondence between cause and effect), this non-linearity can result in large effects, or effects on third parties; and it is due to this characteristic that the emergent phenomena in these systems are not explained only from the agents but also from the interactions between them (Cedillo, 2003). With the theoretical basement provided, it is then understood that an IS has characteristics and processes that are not easily understood due to their complexity and the diversity of agents involved in them. So, they can be understood as complex adaptable systems (CAS) since in addition to the fact that their agents interact with each other, they have the ability to learn (accumulating experience) and adapt (to changing conditions over time) (Holland, 1992; Ruiz et al., 2016).

In other hand, according to Sen (2000) social exclusion is understood like the disadvantages that certain groups of people experience given their no participation in certain social relationships and opportunities that others enjoy. In the context of IS, exclusion is related to knowledge in such a way that the prevailing innovation policies do not consider populations in exclusion conditions and, in other cases, further reinforce these conditions (Arocena & Sutz, 2021). For example, the development of innovations can generate exclusion for reasons such as high cost, possibility of access, design, development process and inputs. Thus, inclusive innovation refers to new goods and services created for, by and with those who have been excluded from the mainstream of development (Foster & Heeks, 2013). It is accessible and affordable innovation, which provides solutions to reduce social, economic, political and cognitive gaps, includes the excluded, promotes human well-being and environmental sustainability (Fressoli et al., 2014). To promote this, IS play a fundamental role, since they participate in the generation of these dynamics (Arocena et al., 2018).

Therefore, IIS is a system whose agents produce and use knowledge and tecnhologies towards social inclusion (Arocena & Sutz, 2021) that is, the importance of the generation, diffusion and use of knowledge is planned, under the premise of 'knowledge for inclusive development' (Conceiçao et al., 2001). Along the same lines are authors such as Sutz, Arocena, Dutrénit, among others, who identify the role of IS (mainly national systems) for inclusive development (Dutrénit & Sutz, 2013). According to Villalba et al. (2019) an IIS has the following characteristics:

- Heterogeneous agents (excluded and not excluded):
    - Explorer of knowledge, e.g., Higher Education Institutions
    - Exploiter of knowledge, e.g., firms
    - Intermediaries of knowledge, e.g. a NGO
    - Excluded, who may have several roles in the system;
- The relationships among agent need to include excluded agents;
- Every agent has different and complementary capabilities to contribute toinnovate.

As mentioned above, in the same way that an innovation system is considered a CAS, an IIS meets the characteristics that will allow it to be analyzed under the systemic, complex and adaptive approach of a CAS (Holland, 1992) :

- An IIS has multiple agents;
- Agents have different capabilities and attributes;
- The agents can have interrelationships between them and the environment in which they are immersed;
- Relationships can generate changes in the capabilities and attributes of agents;
- These changes allow agents to learn and adapt;
- This learning and adaptation allows the agents to survive in the system;
- Through survival, agents present emergent properties (new capabilities and attributes);
- Agents behave under the principle of bounded rationality (that is, they have incomplete information, cognitive limitation of the individual mind and time restriction to make decisions (Gonzalez, 2003).

These characteristics show that IIS may be analyzed as a CAS characterized by its complexity (existence of many variables), uncertainty (variables affected by various phenomena) and their dynamism (they vary rapidly over time); Additionally, a CAS has learning and adaptation over time as a fundamental characteristic (Holland, 2004). Therefore, an appropriate methodological tool to carry out analysis of this type of system is CMS, since it allows addressing the systemic, complex and dynamic characteristics of this type of processes and systems (Gilbert et al., 2005).

Methodological Procedures

The methodology used to propose CMS as a strategy for the analysis of IIS is supported by the development of a Literature Review focused on methodological contributions and limitations of some studies to address the complexity of the IIS and creation of proposal about how drawing an IIS as a CAS that may study by Agent-based Modelling.

Stage 1. Identification of methodological limitations: In this stage, we used two procedures: 1) finding out works focused on inclusive innovation. The search equation proposed by Villa et al., (2017) is used: TITLE (inclusive W/2 innovation) OR KEY (inclusive W/2 innovation) OR ABS (inclusive W/2 innovation); 2) finding out works focused on CIS or inclusive innovation that using ABM. In total, seven (7) works were analyzed.

Stage 2. Propose an IIS as complex adaptive systems and argue Agent-Based Modeling as an appropriate technique to analyze the phenomenon: Based on the results of the limitations and advantages of the work carried out on inclusive innovation and the CIS, the four properties and the three mechanisms of a CAS are proposed following Holland's proposal.

Results and discussion

Methodological limitations to study the complexity of the IIS

The study of IS has an important trajectory since Freeman (1987) proposal. The contributions of the literature allow the identification of approaches to the understanding of the dynamics and emergence of these systems (Ruiz et al., 2016), finding different elements that must be considered, such as the actors, the processes, the interactions and the results of IS.

Thus, Van Der Merwe and Grobbelaar (2016) ensure that IS are an appropriate analysis framework for the study of innovation as an inclusion factor, but they require adaptations that consider the new characteristics, without the literature yet providing a complete analytical framework. Some approaches are detailed in Table 1, which indicates the contributions and limitations of the proposals, where the one that is closest to the study of the complexity of IIS corresponds to the proposal by Gras (2012).

The proposals focused on the study of IIS offer important elements on the structure that IS have or would have, as well as the elements that compose them. However, they are limited to conceptual proposals, or static analyzes that do not allow studying the emergence of systems. The Gras (2012) proposal, unlike the other proposals, is based on a systemic perspective, which is why it offers important inputs that can serve as a basis for studying the emergence of IIS; A limitation or aspect susceptible to improvement is the linking of the Bottom-Up approach, since the approach addressed to the problem is limited to the Top-Down approach.

The foregoing implies resorting to the advances on the study of IS, not necessarily inclusive, but that can contribute to the understanding of the emergence of an inclusive system. This type of work is one that proposes models of interaction between heterogeneous agents and can serve as the basis for building a model that includes agents that have been excluded from IS, to find new structures, patterns, and properties that account for of the emergence of IIS, considering the following elements already identified and reflected on numeral 4.2.

- New and complex actors in the system (and their respective decision rules)
- Bottom-Up Approach
- Existence of learning processes and generation of trust
- Existence of conditions and hierarchies that are formed in the environment
- Existence of decision rules for the actors to be part of the IIS

Table 1 Contributions and limitations to study the inclusive innovation.

Authors	Proposal	Contributions	Limitations
van der Hilst (2012)	Functional-structural analytical approach. The following are identified: Actors, Functions, interactions, infrastructure, and institutions	Allows the functional characterization of system actors	Punctual analysis Static analysis
Van Der Merwe y Grobbelaar (2016)	Functional-structural analytical approach. It is based on Van Der Hilst proposal and add evaluation criteria	Proposes an approach to the description and conceptualization of an IIS.	Punctual analysis Static analysis
Gras (2012)	Systemic approach of innovation; importance of the role of research and scientific and technological knowledge for development	Allows the analysis of projects with a focus on public universities, from a systemic and dynamic perspective	Based on the development of specific projects Top-Down approach
Sampedro and Díaz (2016)	Systemic approach to innovation	It highlights the presence of the learning process associated with the construction of social capital and the participation of diverse actors.	The proposal does not have an empirical validation

In this order of ideas, the approach to the emergence of IIS requires a systemic vision and tools that make it possible to cover their complexity, with computational simulation works offering findings that have allowed us to broaden our understanding. of this type of phenomenon, due to the correspondence between the methodology and the characteristics of complex systems (Jianhua et al., 2008). Thus, the literature offers models that seek to study the interaction between heterogeneous agents that can be a starting point for the study of IIS complexity. Table 2 shows four previous simulation models, with their respective potentialities and limitations for the analysis of IIS.

Table 2 Contributions and limitations to study the IIS complexity

Model	Authors	Later works	Approach	Potential for the analysis of IIS	Limitations for the analysis of IIS
SKIN (Simulating Knowledge Dynamics in Innovation Networks)	Gilbert et al. (2001)	(Gilbert et al., 2007) (Schroeder et al., 2016)	Competitive innovation / R&D projects	1. Agent heterogeneity 2. Agents have skills and capabilities 3. There is a learning process	1. Innovations are related to obtaining patents 2. Focused on R&D projects 3. Innovation model: technology push

Model	Authors	Later works	Approach	Potential for the analysis of IIS	Limitations for the analysis of IIS
Híper-cicles	Padgett (1997)	Padgett, Lee y Collier (2003); Padgett, McMahan y Zhong (2009), y Watts y Binder (2012)	Competitive innovation / productive chains	1. Agent heterogeneity 2. Agents have capabilities 3. There is a production and learning process 4. Agents interact with the environment 5. Type of learning: learning-by-doing	1. Innovations are related to a single type of product 2. Limitations of the relationships of the agents only to the closest ones and not according to the capabilities required to generate innovations
Innovation Systems	Ruiz et al (2016)	Ruiz, Quintero y Robledo, 2017)	Competitive innovation/ innovation systems	1. Heterogeneity of agents / intermediaries are included 2. Innovation model: technology push; market pull. 3. Agents have differentiable and variable capabilities 4. Agents have learning and unlearning processes 5. Transaction costs are considered 6. Model logic focused on taking advantage of innovation opportunities of any kind 7. Consider the comparison of the level of capabilities of the agents for the generation of links to take advantage of the innovation opportunity	1. Innovation opportunities are temporary 2. There are no waiting times for the generation of conditions for the type of inclusive innovation 3. The success of innovation is measured by the economic benefit
Inclusive innovations model	Gras (2012)		Inclusive innovation/ innovations oriented to social inclusion	1. Contemplates characteristics of inclusive innovation. 2. Pro-poor innovations approach 3. The model starts from the identification of social needs 3. Increased number of agents	1. The model is based on the development of specific inclusive innovation projects 2. Limited to product innovations in the health sector 3. The agents identified correspond to those related to the projects analyzed 4. Although the model is based on a social need, the flow of the process focuses on the executors of the projects, but not on the dynamics of the IS, which is why it places the projects as a specific condition that generally arise from the universities.

IIS as CAS and Agent-Based Modeling as an appropriate technique to analyze thephenomenon

An IIS, like a CIS, may be classified as a CAS, which can be supported by collecting the characteristics of IIS available in the literature and contrasting them with what has been established by Castañeda, (2009) on CAS.

It begins with the characteristic of the multiplicity of agents, which, in an IIS, increases in relation to CIS (see characteristics 4 and 5 of Table 3). These agents have differentiable capabilities and attributes that establish bidirectional relationships between them and with the environment (see characteristics from 6 to 8 of Table 3). These relationships lead to changes in the capabilities and attributes of the actors, generating learning processes that allow them to adapt and survive in the system (see characteristic 5 of Table 3). That is, from these systems it is possible to obtain emergent properties (see characteristic 3 of Table 3) that lead them to evolve.

Based on the above, IIS comply with the four properties of CAS (aggregation, nonlinearity, flows, and diversity) and the three mechanisms (labeling, structure, and theoretical block) proposed by Holland (2004):

- **Aggregation property** seeks to simplify complex systems in such a way that agent aggregates made up of individual agents can be created. These aggregates produce emergent behaviors from the interactions of individual agents. For IIS there is a series of heterogeneous agents (explorers, exploiters, and intermediaries, excluded and not excluded) that when interacting will give rise to inclusive innovations and with it, routines and patterns that represent aggregation.

Table 3 Elements of IIS complexity

Nu.	Element/ characteristic	Description
1	Nature of innovation	Innovations that are generated in IIS can be of any of the types proposed in the Oslo Manual, with the following characteristics: 1) Focus on incremental innovation, 2) Focus on diffusion processes, 3) Innovation oriented to local needs, 4) innovation driven by demand, and 5) mainly non-technical innovation (Foster & Heeks, 2013).
2	Stages/requirements	Heeks et al. (2013) propose conditions that are required in the different stages of the innovation process (Intention, use of products, development and creation of products and processes, structure, and impact).
3	*Top-Down* versus *Bottom-Up*	In the generation of innovations with a social approach, the presence of Bottom-Up entrepreneurial behavior predominates, assigning importance to spontaneous upward experiences that are possibly more enriching than a Top-Down plan (Bianchi et al., 2015).
4	Multiplicity of actors	An IIS emerges as long as there is interaction between various actors in the system (Alzugaray et al., 2013), considering important actors such as the excluded population, intermediaries and universities, among others (Sampedro & Díaz, 2016).
5	The excluded as agents	The beneficiaries of inclusive innovations (excluded) are significantly different from the other agents in the system, mainly because they may be non-traditional innovators and, for the most part, they are informal (Foster & Heeks, 2013) and can play a doublerole: as producers or as beneficiaries of innovations (Chataway et al., 2017). They also have learning processes (Foster & Heeks, 2013; Sampedro & Díaz, 2016), and they must generate alliances and trust to guarantee the success of the innovations (Zhang & Wu, 2016). Villalba et al (2019) expand the understanding about the role of excluded agent in an IIS.
6	Institutionalist and the environment	Rui (2013), based on Williamson (2000), identifies four levels at which the analysis of inclusive innovation activities can be carried out, allowing them to be classify in four levels of hierarchies (Firmly rooted, Institutional environment, Governance and Resource and employment allocation). Regarding the environment in which the innovations take place, Bianchi et al. (2015), indicate that inclusive innovations are generated and disseminated in conditions of scarcity and prototypes are framed in the context of a single implementation.
7	Transaction costs	Transaction costs are due to market failures. Inclusive innovations are not exempt from these effects. Among the factors with the greatest impact are: 1) High Intellectual Property costs when innovations are not competitive, 2) consumers may be too poor to access some innovations, 3) presence of significant sunk costs, among others (Rui, 2013).
8	Networks	An IIS can originate from networking, whether these networks are made up of members of the same community, who develop their own innovations - grassroots innovation - (Smith et al., 2014) by businessmen who are part of the base (Zhang & Wu, 2016) or by networks that involve the integration of various actors until participation in IS is achieved (Iosif & Tăchiciu, 2016).

- **Non-linearity property** means that you cannot "obtain a value for the whole by adding the values of its parts" (Holland, 2004, p. 31)) is fulfilled in IIS, because it is not possible assign a reaction rate for the aggregate according to the contributions of each of its agents; therefore, it is not possible to predict the effect of external actions on the system, for example, the public policies of Science, Technology and Innovation.

- **Flows property** in IIS is possible due to the need to generate interaction between agents (conventional and excluded). These relationships are given by connectors and exchange of resources (Holland, 2004). The main resources in IIS are scientific knowledge and traditional knowledge.

- **Diversity property** is given by the heterogeneity of the agents, their contributions to the different elements of the system's function and the capacities they have; For IIS, a broader typology of agents is identified than the typology of CIS.

- **First and second mechanism, the tagging and internal models**: Each agent of the system must be able to be recognized and act according to their capabilities, therefore, each one is created a vector of capabilities that represent the levels of the capabilities it possesses (innovation capabilities and capabilities for inclusion) to contribute with the system function, which are represented by a place in a vector (see Equation 1). Due this vector, the Diversity property may be showed for each agent. Table 4 drawing some examples of agents in an IIS.

$$V_{IC}= [CI_1\ CI_3\ \ldots.\ CI_i] + V_{CI}= [IC_1\ IC_3\ \ldots.\ IC_i] \qquad [1]$$

Where:
CI = capabilities for inclusion
IC = innovation capabilities
I = position in the vector
V_{IC} = capabilities for inclusion vector
V_{IC} = innovation capabilities

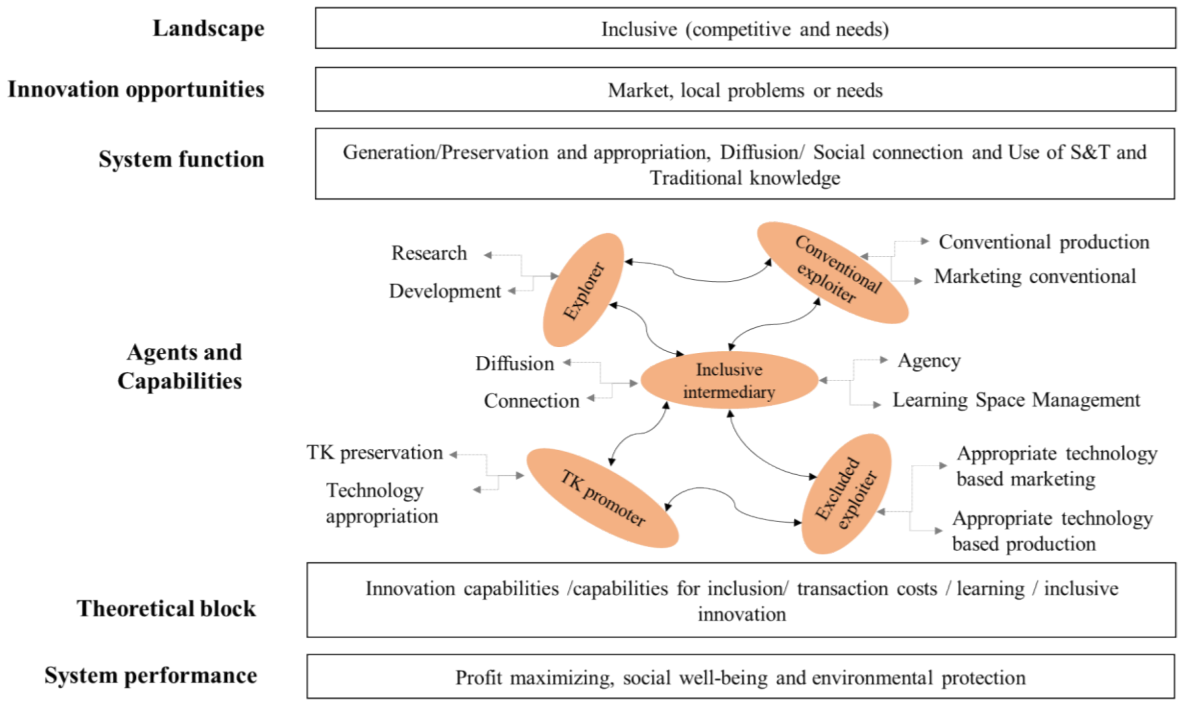
Table 4. Agent's tagging

Agent	Tagging
TK promoter	
Explorer	
Excluded exploiter	
Conventional exploiter	

- **Third mechanism, building blocks** correspond to the theoretical bases of the model. For IIS, the theoretical supports have been identified in last item, they are:
    - Innovation capabilities
    - Capabilities for inclusion
    - Transaction costs
    - Learning processes
    - Inclusive innovation
    - CIS bases

Based on the limitations and contributions of the literature on IIS and its understanding as a CAS, it is concluded that the study of its complexity requires methodologies that allow having different ranges of abstraction, greater detail and defining different categories (Borshchev & Filippov, 2004) and 2) it offers valuable information on the dynamics of systems with heterogeneous actors (Rahmandad & Sterman, 2008) as allowed by Agent-Based Modeling. The general impact of IIS study as a CAS is represented with the system performance. This can be measured through the definition of variables such as the number of excluded from the system, thanks to the fact that the methodology allows representing different types of agents (such as those listed in Table 4); In the same way, the ABM allows showing the exploitation of innovation opportunities, which is one of the variables that represents how much local problems or needs of excluded populations are solved. Thus, we represent IIS as CAS through Figure 1.

Figure 1 IIS as CAS



Conclusions

IIS have been studied through qualitative approaches, especially through case analysis and comparative studies, therefore it is interesting to approach this study with an innovative tool designed for the analysis of complex phenomena. Due to the above, CMS is considered an innovative and adequate tool for the study of IS as CAS. This is how, through the MSC, especially Agent-Based Modeling (ABM), studies can be carried out according to the complexity of this type of system since it is possible to generate rules, patterns, behaviors, links, and actors for the understanding of the phenomenon that would be almost impossible to do in a real systems study.

The value of this research lies in evidencing how ABM constitutes the starting point for the generation of a novel study framework for the topic of IIS, by focusing on the complex dynamics of the phenomenon and framing it within an innovation system. This is how inclusive development should be one of concerns for some theoretical currents about innovation systems. In this sense, innovation systems should promote a structural change that allows the excluded to stop having a passive role in the innovation process and be seen as agents, that is, with a higher level of participation and not just as the beneficiaries of the results; from this new perspective, the need for its study from a systemic approach arises. However, the processes by which the systems are formed are not easy to understand, mainly due to the complexity of the dynamic processes and the heterogeneous actors involved. It is proposed as an alternative for the analysis of the complexity of the phenomenon. Understanding a IIS as a CAS, it will possible to apply ABM to study with a higher degree of abstraction of those dynamics and patterns that are not evident with qualitative methodologies or with another type of non- systemic approach.

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Evaluating frugal innovation opportunities for the South African timber construction industry

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Abstract: Frugal innovation has been defined as a cost-effective concept where the smart use of resources satisfies area-focused challenges. Frugal innovation has proven to deliver savings in cost and resources, open new markets, and increase profits in different industries. This literature review set out to investigate frugal innovation opportunities within different industries and determine which approaches would benefit the South African timber construction industry and what frugal innovation enablers would be needed for adoption to be possible. This review considered literature reviews and case studies within different industries to determine what frugal innovation approaches are in current use and what benefits are experienced from them. The results show that frugal innovation has become a buzzword in many industries, and great benefits can be realized when properly implemented. Four approaches were determined to potentially benefit the SA timber industry: frugal innovation-inspired business models, design reuse, artificial intelligence (AI), and implementation of technology-based services. The approaches are based on efficiently and cost-effectively addressing local market needs. The results also show enablers such as support from management, local businesses collaboration, and attention to local market needs are needed to foster frugal innovation in the industry.

Keywords: Frugal innovation, timber, industries, timber construction, AI, enablers

Introduction

Industries have been forced to look seriously at the efficiency and effectiveness of innovation due to globalization and industrialization (Ebolor et al., 2022). In addition, disruptions such as political instability, pandemics, and natural disasters have increased the need for goods and services with fewer resources. As a result, industries have begun using frugal innovation to respond to these disruptions (Ebolor et al., 2022). Frugal innovation (FI) is based on the concept of smart use of resources to fulfil area-specific market challenges (Kaziolas et al., 2017). This literature review evaluates frugal innovation opportunities identified in different industries, contextualizes them in the South African timber construction industry and evaluates what cultures (enablers) would need to exist within the industry for adoption to be possible.

The review aimed to answer the following questions:

- Which frugal innovation approaches could benefit the South African timber construction industry?
- What enablers would need to exist or be introduced into the industry to promote the adoption of frugal innovations?

Theoretical Background

The construction industry is a significant generator of waste and other anthropogenic emissions. A move towards cleaner construction methods and technologies is needed to minimize the waste of resources and pollutants like greenhouse gases (Ebolor et al., 2022). Timber structures can be used as a sustainable solution for building houses and commercial buildings (Kaziolas et al., 2017). Timber has been a reliable building material for centuries. This was due to timber being easily sourced, shaped, lightweight, and having other competitive mechanical properties (Smith & Snow, 2008). Timber is also a renewable material and plays an important environmental role by capturing carbon (Cuadrado et al., 2015). A comparison between timber-hybrid buildings and pure strengthened concrete buildings showed that timberhybrid build to have obvious environmental advantages. The study showed that timber-hybrid produced only half of the greenhouse gas emissions and had half of the non-renewable energy usage compared to the pure concrete strengthened buildings (Leyder et al., 2021). South Africa has shown a great propensity to capitalize on the beneficial properties of timber as the first African country to develop and implement a green building rating tool. As a result, it boasts an increasing number of building projects rated green (Crafford et al., 2017). Over 70% of the country's sawn timber is utilized in buildings, primarily roof structures. Other uses of timber include flooring and door frames (Crafford et al., 2017).

Despite timber's beneficial properties, the timber industry has seen a widespread aversion within urban areas to utilize wood due to challenges like perceived fire performance and supply chain issues (Smith & Snow, 2008). However, in the past two decades, the use of timber in the building industry has steadily increased, specifically in multi-story construction (Svatošražnjevi & Orozco, 2022). This turnaround in the timber industry growth can be attributed to innovation enabled by the collaboration of the supply chain and other stakeholders within the timber industry (Gosselin et al., 2018). Furthermore, maintaining the efficiency and sustainability of the industry can be done via frugal innovation-inspired business models and adapting to the local market requirements (Mourtzis et al., 2016).

Frugal innovation can be defined in various ways, and the definition tends to overlap with numerous other similar concepts (Hossain, 2021). In general, frugal innovation entails the creation of faster, better, and cheaper solutions that use minimum resources (Prabhu, 2017). For many generations, people from the developing countries of Asia and Africa have been left to live outside the formal economy and deal with unmet basic needs such as food, healthcare, and energy (Prabhu, 2017). Frugal innovation was developed as a local market-based solution to the sidelined populations in developing countries (Prabhu, 2017). Although frugal innovations were developed in and for local resource-constrained markets, concerns for the environment and the decline in income and sustainability have thrust frugal innovation in developed markets as well (Hossain et al., 2016; Prabhu, 2017). Frugal innovation tends to place weight on sustainability compared to mainstream innovations; some examples of frugal innovation include medical devices, cars and healthcare services (Hossain, 2018). Four frugal innovation diffusion patterns are recognized: local diffusion, proximity diffusion, distance diffusion, and reverse diffusion (Hossain et al., 2016). Frugal innovation can enable industries to find new innovation opportunities and to impact and change old mindsets for product development for new market sections (Hyvärinen et al., 2016).

Methodological Procedures

The review methodology taken was that of a systematic literature review. The two main databases that were used in this research were SCOPUS and Web of Science. The search included Journal articles and other academic papers. The search was limited to literature published within the past 25 years, and preference was given to the latest publications. The search included various industries where frugal innovation was utilized in different countries. Any literature not in English or where full texts were unavailable was excluded.

Initially, a limited search was done on SCOPUS and Web of Science to determine keywords, abbreviations, and synonyms in the titles and abstracts relevant to the research. The main keywords used for this review were Timber industry, Frugal innovation, Timber, Industries, and Technology. Articles found in the search and from the reference list were checked against the objectives of the research, and if found compatible, they were obtained for further examination. Secondly, an extensive literature search was done using the determined keywords, abbreviations, and synonyms. References found in the articles of the second step were also explored

	Inclusion	Exclusion
Date of publication	Publications 25 years and less	Publications older than 25
Language of publication	English	Other languages
Graphical location	Global	
Type of publication	Journal articles, conference papers and books	Letters or editorials
Availability	Full text only	Only the abstract or title was available

Table 1: Inclusion and exclusion criteria

A total of 920 papers were included in the dataset from SCOPUS and Web of Science and vetted for relevance. Duplicates were removed from the dataset, and the remaining papers were screened based on the inclusion and exclusion criteria illustrated in Table 1. After applying the inclusion and exclusion criteria, the remaining articles were evaluated based on their relevance to frugal innovation in industries and the timber construction industry. A total of 30 articles remained after screening and were used for this literature review. Figure 1 illustrates the screening process.

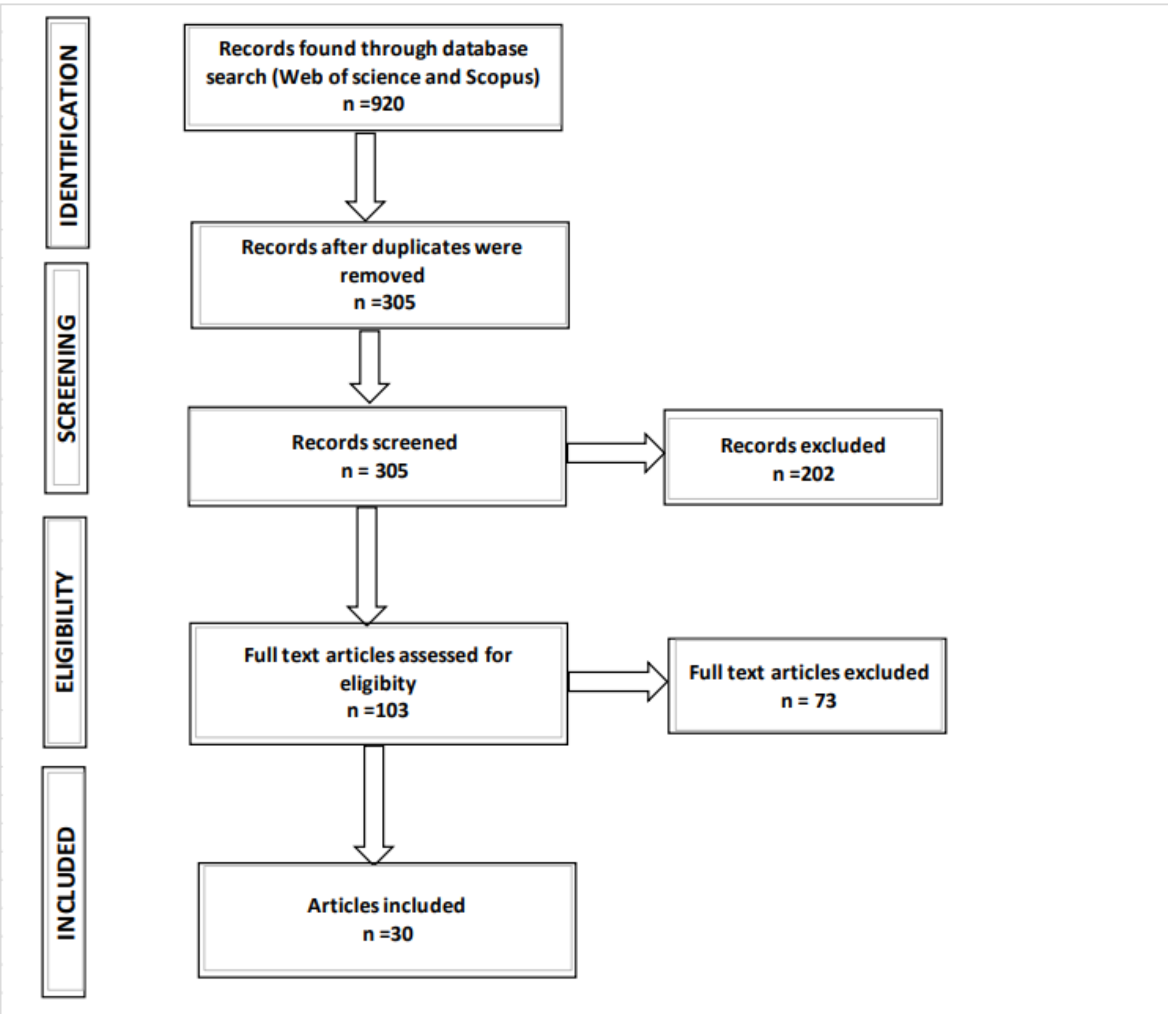

Figure 1: Inclusion and exclusion diagram

Results

Data analysis

Using the concept matrix, literature related to frugal innovation in different industries and timber construction was grouped and analyzed. Figure 2 illustrates an upward trend in publications related to frugal innovation in various industries. Furthermore, an increase from 2010 to 2022 can be seen in publications linking frugal innovation to various industries.

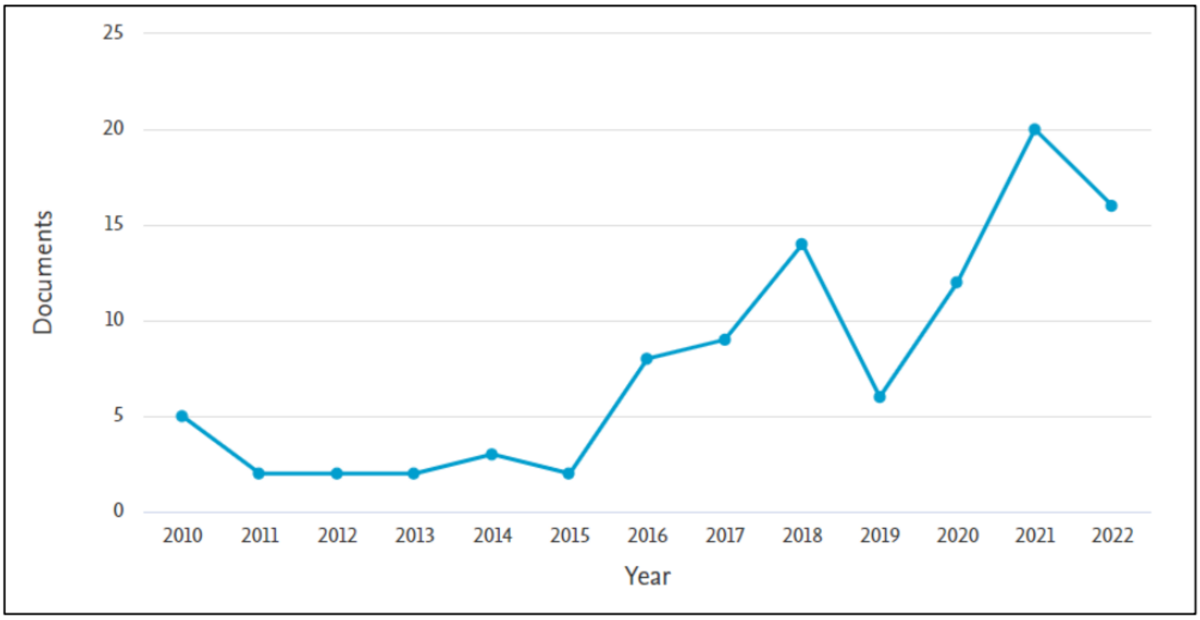

Figure 2: Documents by year

A breakdown of subject areas showed the subject areas considered in this review. The top three subject areas were business management, engineering and other. This aligns with the claim that incorporating frugal innovation in business models (Mourtzis et al., 2016) is one approach that can be used to introduce an industry to frugal innovation.

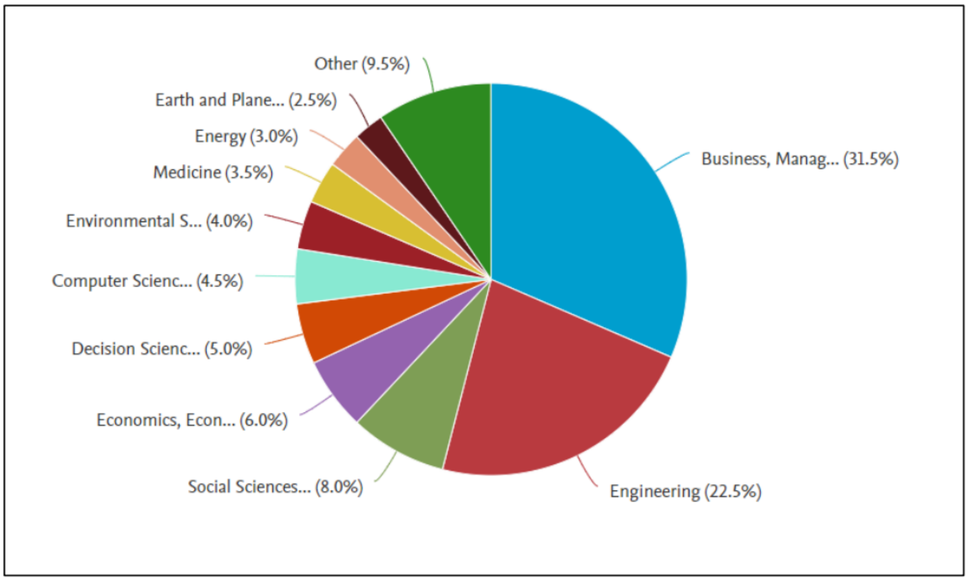

Figure 3: Documents by subject area

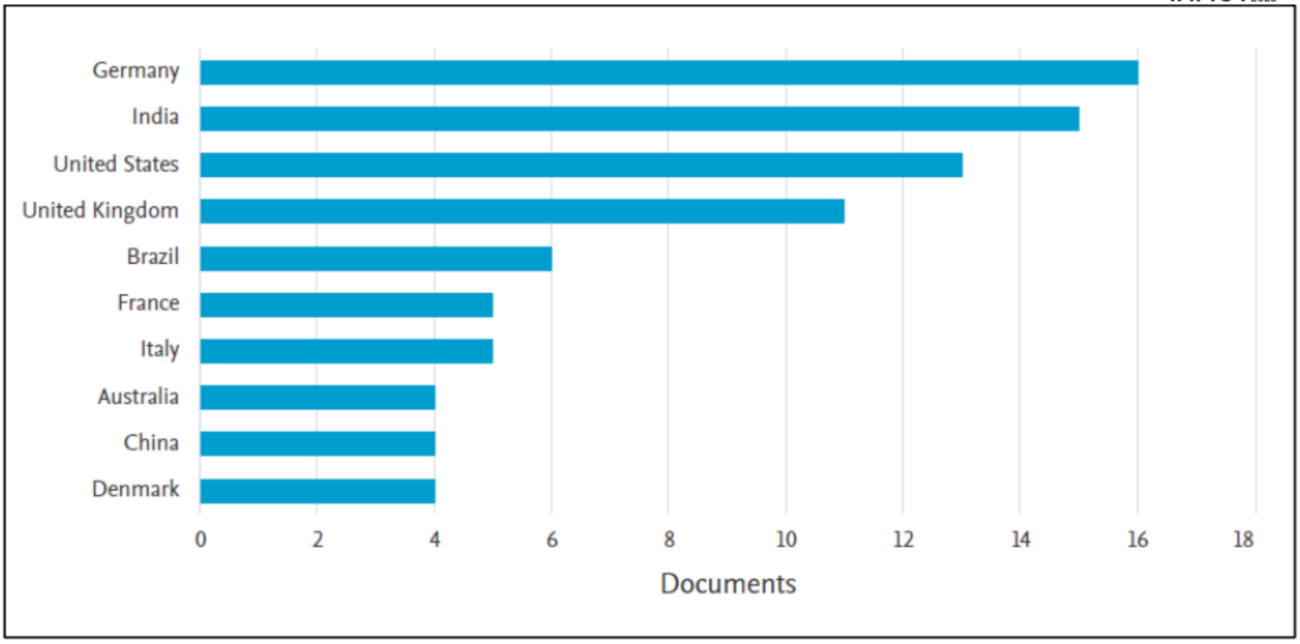

Figure 4: Documents by country of origin

The dominant country with the most publications relating to frugal innovation in industries is Germany, a developed country, followed closely by India, a developing country often considered the face of frugal innovation (Agnihotri, 2015). This shows that the frugal innovation concept can succeed in developing and developed countries (Winkler et al., 2020).

Which frugal innovation approaches would best benefit the South African timber market

Frugal innovation approaches from other industries include frugal innovation-inspired business models that focus on adapting to the local market needs and providing high-value and costeffective products (Mourtzis et al., 2016). Business models for frugal innovation result in firms creating value and capturing mechanisms to reach and retain new customers in remote rural areas (Winterhalter et al., 2017). These remote areas have unprecedented value proportions (Winterhalter et al., 2017). Research conducted by Winterhalter in the device and laboratory equipment industry empirically demonstrates the value proposition of frugal business models. Figure 5 below visualizes the value proposition for the med-tech sector towards their customers.

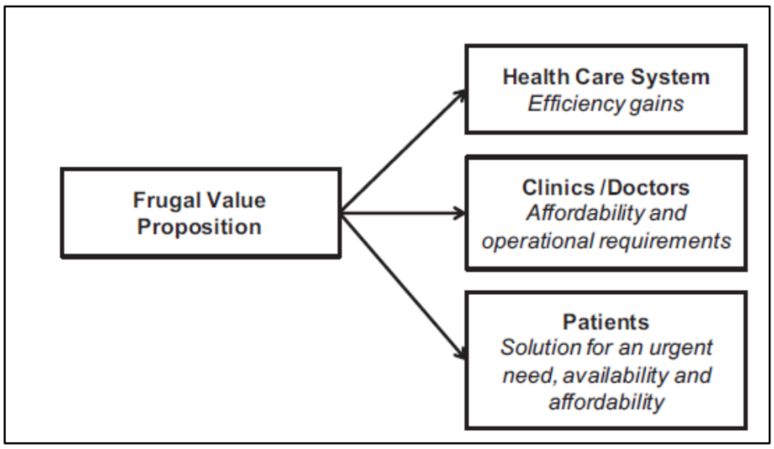

Figure 5: The value proposition of frugal business models in the med-tech sector (Winterhalter et al., 2017)

Using frugal innovation-inspired business models showed an increase in efficiency as more efficient distribution of scarce resources was noted. Another value proposition was the ability to offer customers/patients low-cost, easy-handling, durable products (Winterhalter et al., 2017). Similarly, complexity and global competition in manufacturing environments require changing business models (Mourtzis et al., 2016). As a result, manufacturing and distributing products created by local suppliers are more favourable for consumers (Mourtzis et al., 2016).

Design reuse was also identified as an approach that could be introduced in the South African timber construction market. Systematic design reuse is defined as making designs reusable and storing these reusable elements till they are needed (Pakkanen et al., 2016). The benefits of design reuse include cost savings in labour and resources (resource constraints) and reduced effort and risk (Pakkanen et al., 2016).

With Industry 4.0 being identified as a major contributor to the era of digitalization, its implication for sustainable development has received significant attention (Khan et al., 2021). Industries have been forced to consider the impact of innovations, and many have started integrating innovative thinking within their companies. Combining artificial intelligence (AI) with sustainable, frugal innovation has shown beneficial advantages, although studies are limited (Govindan, 2022). According to Govindan, the most influential success factors for integrating AI with sustainable, frugal innovation are understanding the concept of AI and the level of AI investment (Govindan, 2022). Although frugal innovation is commonly thought of as thrifty and economical in AI, it is also regarded as functional, robust, user-friendly, growing, affordable and local (Govindan, 2022). Figure 6 is an example of AI meeting sustainable, frugal innovation in the concept of APAT (APKI Padayee Apka Time). This proposed AI-based software scheme could replace the conventional dual-teacher system. The proposed scheme can assist dropped-out students and the elderly with customized learning experiences while utilizing local facilitators (Mani, 2022).

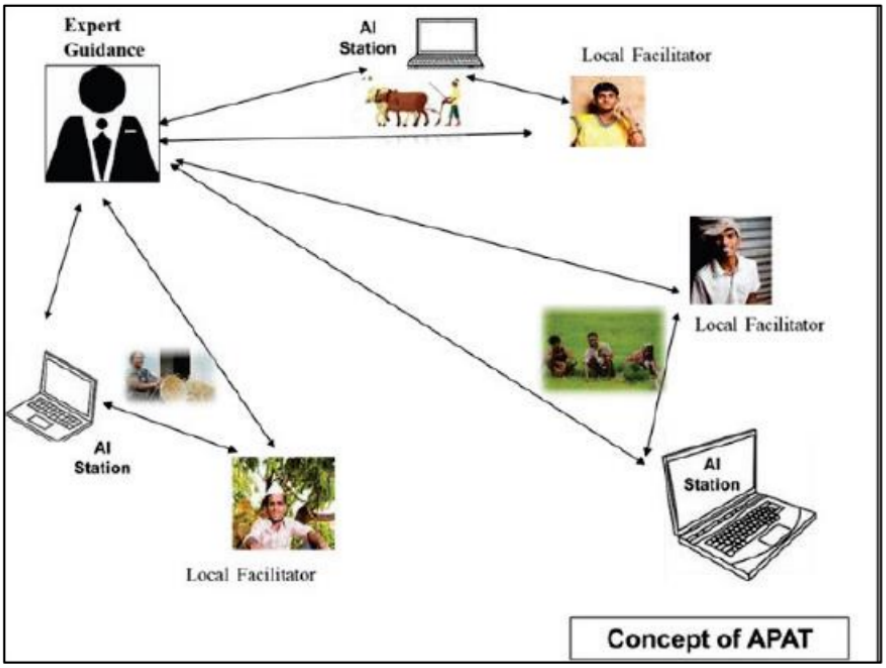

Figure 6: AI-based dual teacher system adapted for Indian rural conditions (Mani, 2022)

The last approach investigated was technology-based product services to efficiently and cost-effectively address the local market's needs. For example, a relatively new trend in manufacturing companies is to apply product service systems (PSS) as a strategic way to differentiate themselves from competitors and offer integrated bundled products and services (Colledani et al., 2016). Figure 7 below shows a model of PSS. An example of a product service system is the Apple iPhone, where the phone is sold; however, subscriptions, features and software are services that come with the phone.

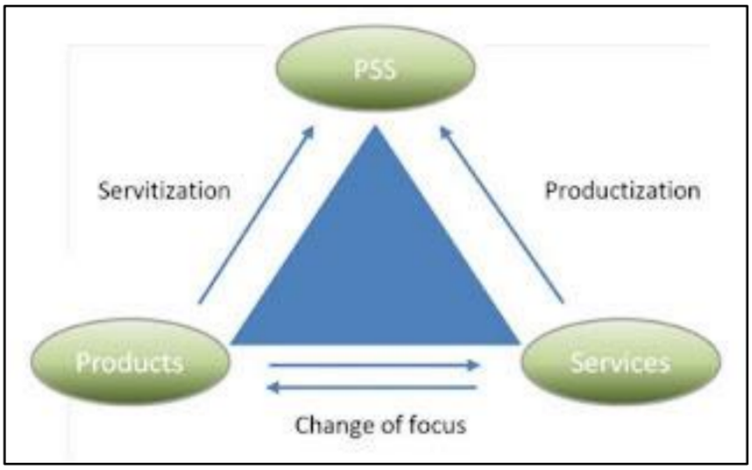

Figure 7: Product service systems (Colledani et al., 2016)

Frugal innovation has been introduced within the product-service systems to target resource constraints, region dependent customer needs (Colledani et al., 2016). Incorporating area-specific needs can increase the customer base exponentially for an organization. ProRegio is a customer-driven design of product services based on the region's requirements. Figure 8 below shows examples of product services ProRegio offers for different industries (Colledani et al., 2016).

ID	Industrial sector	ProRegio partner	Product-service proposed
1	Aeronautics	Airbus	1. Just-In-Time-Specification/Customization
			2. Visibility of Production Status
			3. Virtual Customer Inspection
2	Domestic appliances	Arcelik	1. Frugal product design/re-design for region dependent markets
3	Machinery industry	Comau	1. Production system design/re-design with virtual tools
			2. Digital Production System Visualization
		Gizelis Robotics	3. Remote maintenance and diagnosis service

Figure 8: ProRegio product service-industry and proposed product service(Colledani et al., 2016)

Frugal innovation enablers necessary for the adoption of frugal innovation

Frugal innovation needs to be fostered within industries, and enablers and critical success factors have been investigated and developed (Niroumand et al., 2021). The main identified enablers and CSFs of frugal innovation were:

- Management support – Management plays a substantial role in scoping and exploiting opportunities and decisions that affect innovation within the firm.
- Human capital – Humans are considered the most critical assets of a business. When the whole workforce participates in the innovation process, the benefit to the firm is great.

- Efficient R&D – Local R&D centres close to the customer and local research will result in better innovations directly related to the relevant market.
- Frugal culture – Understanding the local and resourceful cultures gives different perspectives that can be beneficial.
- Localization – Pay attention to the local capabilities, resources, and proficiencies.

AI has also been identified as a real, meaningful enabler of frugal innovation; however, the sustainability factor of AI is still being investigated (Walshe et al., 2021).

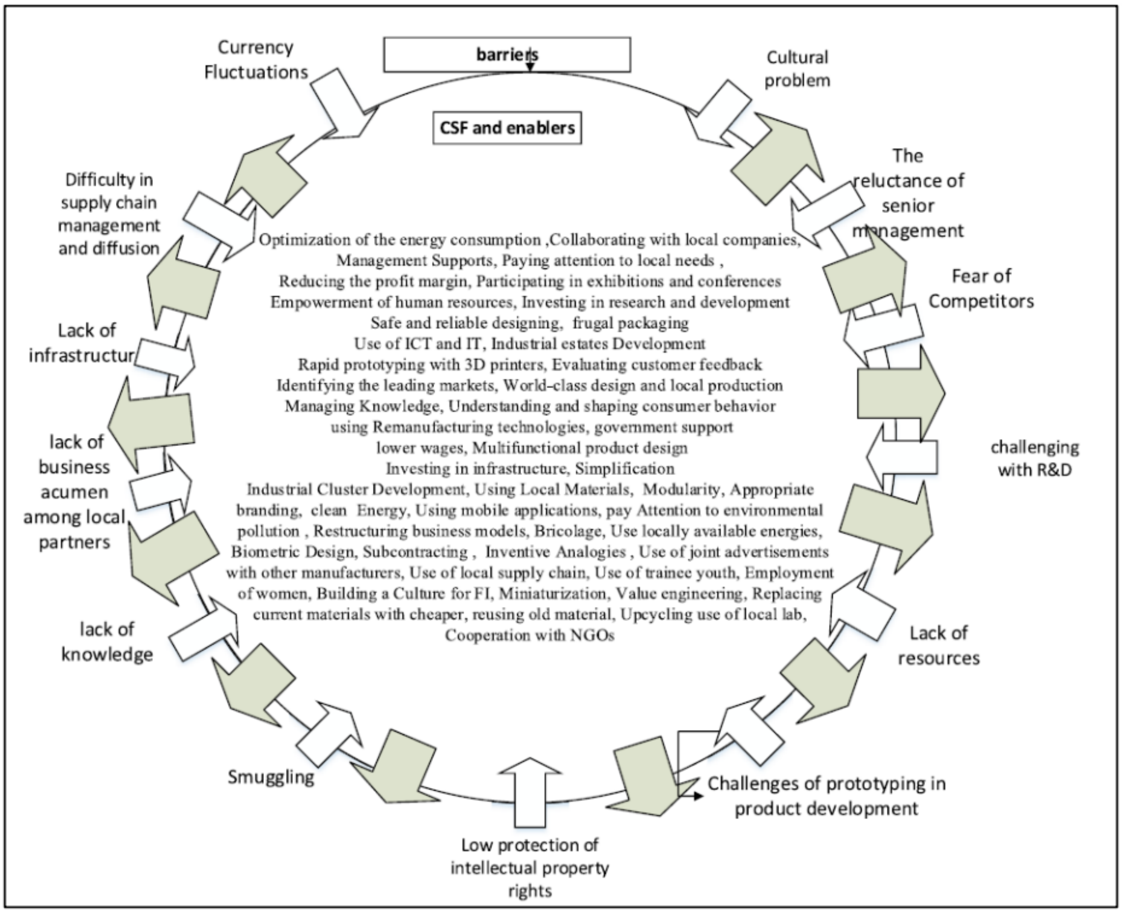

Figure 9: Suggested model for barriers, critical success factors (CSF) and enablers of frugal innovation (Niroumand et al., 2021)

Discussion

Analysis of frugal innovation approaches that can be adopted into the South African timber construction industry yielded multiple results. The literature showed that technology is one of the best ways to implement frugal innovation in firms (Park et al., 2022). Frugal innovation in technology has been linked to appropriate technology, which is essentially defined as a technology with a human face, technology for social justice and environmental sustainability (Bishop, 2021). Appropriate technology principles are widely important. For example, appropriately balanced approaches are needed in the AI space to ensure it is used to help solve sustainability challenges without unknowingly affecting other aspects of life (Walshe et al., 2021). For example, AI could automatically develop new structural designs based on local conditions and requirements in the timber industry. This could possibly save time, human effort, and costs. AI could also potentially be used to develop optimal material combinations for engineered wood products using local wood resources.

Using frugal-inspired business models may result in tangible benefits, like in the Heilongjiang province timber enterprise case. By using an innovation-inspired business model, they were able to integrate technological resources, effectively reduce transactional costs, and increase the efficiency of the enterprise (Geng et al., 2008). These gains are similar to the value proposition presented by Winterhalter in the med-tech sector. Furthermore, the development of local solutions for local problems has been found to be a critical enabler for frugal innovation. Thus, establishing local wood resources, manufacturing, engineering, research, and development will be vital to promote frugal timber innovations. In addition, design reuse has also been shown to promote frugal innovation. Developing modular timber building designs that could be reused is an example of how this tactic could be used.

The development of integrated PSS can potentially increase the value added by innovations and their adoption. Smartphones come to mind as a popular example of this application. Timber manufacturers could use this tactic to integrate services into their offerings. For example, they could develop online self-use design applications, provide design services, or automated product configuration systems that enable users to build their solutions and subsequently automatically generate a bill of materials and costs.

The diffusion of frugal innovation is not the same as conventional innovations; it flows from local low-income markets to high-income markets in terms of consumers and regions (Hossain, 2020). Complexity within the diffusion processes of new products and services has emerged due to consumers being exposed to various influences such as word of mouth, social signals and network externalities (Peres et al., 2010). This shows the need for strong enablers and critical success factors to adopt frugal innovations into different industries. Having managerial support within the industry and adequately understanding the culture and market of the local community are some of the significant enablers of FI. Lack of understanding of the culture and lack of local market can become barriers to the successful adoption of FI, as well as a lack of infrastructure and business acumen, as shown in Figure 9 (Niroumand et al., 2021). In producing products and services with frugality, the design process should cater to resource constraints, local needs, cost and sustainability. This product development process will lead to cost, resources and materials savings and improves the local situation (Brem et al., 2020).

Conclusions

This review evaluated frugal innovation approaches from both developing and developed countries. A systematic methodology was used to evaluate approaches to and enablers of frugal innovation. The objective was to consider how these strategies could be used in further research to promote the use of timber in developing countries like South Africa. By adopting frugal innovation approaches, like innovation-inspired business models, design reuse, PSS, or AI, the South African timber industry stands to gain in profit, consumers, and R&D.

The frugal innovation enablers discussed in the review show that an important factor in frugal innovation is immersion in the area of need, the challenges, capabilities, resources, and the cultures of the local area. In doing so, better value can be gained in frugal innovation endeavours. Another major enabler is management support, which sets the tone for the innovation appetite within the firm. Maintaining sustainability and responsible, frugal innovation should be at the forefront of approaches the industry decides to take on, ensuring growth not just for the company but for the communities and/or societies the industry is based in.

This review only considered published papers on the topic of frugal innovation. Research publications focusing on frugal innovation are limited, specifically in the timber industry. For this reason, findings from other industries were considered to provide potential routes for the timber industry. It is recommended that further research is performed to evaluate specifically the potential of applying frugal innovation in the timber industry. Case studies and surveys could improve contextual relevance and generalization of findings. Further research into the timber construction industry in South Africa is recommended, as current studies are limited and do not capture the current happenings within the industry. For frugal innovation approaches to be adopted, it will also be critical to illustrate how they could lead to success.

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Frugal geeks: startups founder´s knowledge and frugal innovation contributions to performance

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Abstract: Startups have a relevant social role in generating solutions and jobs, but need strategies to deal with a restricted environment, which they are usually in. It is common for startups to fail due to a lack of resources, especially in emerging economies. In this sense, entrepreneurial bricolage (EB) and frugal innovation (FI) can contribute to improving startup performance and success odds. Moreover, founders' knowledge can be a valorous resource to startups FI. Because they are small companies with a small number of employees, several studies point out that the performance of startups may be related to the founders' knowledge. In this way, recent literature claims to study startups that need to innovate using scarce and limited resources. This study aims to evaluate the relationship between the knowledge resource of the founders and the performance of technology-based startups mediated by FI and EB, and, to do so, a multiple case study was conducted with Brazilian startups. It was found that the previous founder's ICT knowledge use has influenced product development strategy through FI and bricolage resulting in different performances.

Keywords: bricolage, founder; frugal innovation, KBV, startup, performance

Introduction

Startups have a high mortality rate and fail prematurely, especially in an emerging market like Brazil (Nogueira & Oliveira, 2015). The lack of resources is one of the main barriers faced by startups. They are often without human, technological, managerial, and financial resources capable of leveraging their development. The environment of restrictions, added to the market's competitiveness, makes survival an almost insurmountable challenge. Indeed, in emerging economies, where there is greater resource scarcity, the failure rate is very high, thus few businesses reach maturity and sustainable growth.

In emerging markets and constrained environments, FI can be critical for startup performance and success. Entrepreneurs who have technical skills or worked as technicians in various roles are prominent frugal innovators (Hossain et al., 2022). Startups that operate in a Digital Transformation environment, need to innovate frugally(Yousaf et al., 2021). But human resources with technological skills are an additional challenge for technological-based startups, especially in Brazil, where only 3% of professionals have advanced knowledge of Information and Communication Technology (ICT) and more than 60% have no knowledge (ITU, 2020)

The founders' technological-based knowledge combined with EB methods can be a way for startups to deal with the lack of resources EB can be defined as making combinations of available resources applied to new problems and opportunities (Baker & Nelson, 2005). As demonstrated by Shen (2018), EB mediates the relationship between knowledge constraints and innovation. This finding also suggests that EB is a mechanism through which companies with knowledge restrictions achieve their innovation goals.

Based on the arguments so far exposed, it is possible to assume that startup founders with ICT skills and knowledge are valuable resources to promote innovations more quickly and at a lower cost. These are aligned with the principles of FI and thus generate a competitive advantage for the startup so that it has adequate performance.

Although research has demonstrated that organizations use FI as a possible response to resource constraints, there is still little discussion about how this process can occur in intensive technology contexts. As an emergent theme, with exploratory theoretical advances, the literature needs more studies that describe the mechanisms by the companies can use ICT to innovate frugally (Khanal et al., 2021; Tan et al., 2016). In this context, EB has been pointed out as an important link that can be of great theoretical and practical interest for the field of technology-based startups, as well as for organizations, in resource-constraint environments (Yu & Wang, 2021).

Regarding recent studies discussing managerial founders' experience, this paper aims to explore the relationship between founders' ICT knowledge and FI in startups resulting in performance, in the presence of EB. We want to investigate how the founder's knowledge and ICT are related to FI in the product/service development strategy.

This research contributes to the theory by relating the concepts of FI and bricolage with KBV, highlighting human resources as valuable and related to the founders' knowledge. From a managerial perspective, this study brings information to founders and investors about how much the composition of the founders´ team especially in technology companies, can boost the performance and consequently the startup success in restriction-based environments.

Theoretical Background

Founders' Knowledge and KBV

To maintain competitive advantage, companies in emerging economies, which are challenged by restricted resources and flexible improvisations, and take a low-cost approach, seek new innovative paradigms such as FI. Resource-restricted organizations have focused on optimizing their internal and external knowledge to develop their learning capabilities in a frugal environment to continuously provide a value-added service to their clients and improve the financial wealth of their shareholders (Yousaf et al., 2021).

Knowledge is considered a fundamental resource, and its use leads to a competitive advantage. In the firm's knowledge-based view of the firm (KBV), knowledge is seen as a resident within the individual, and the organization's main role is the application of knowledge and not the creation of knowledge (Cooper et al., 2023; Nonaka, 1994). So, all human productivity is dependent on knowledge, and machines are simply personifications of knowledge (Grant, 1996).

According to KBV, the firm's primary role is to incorporate specialized knowledge residing in individuals in goods and services (Grant, 1996) (Kogut, 2000). The emphasis on the role of the individual as the main actor in the creation of knowledge and as the main repository of knowledge, according to Grant (1996), is essential to unveil organizational knowledge and clarify the role of organizations in the creation and application of knowledge. Consequently, KBV also conceptualizes the company as a generator and incubator of knowledge as human capital (Chowdhury et al., 2022 Cooper et al. 2023).).

Human capital can be defined as the set of literacy, formal education, and previous experiences. It should also be noted that prior technological knowledge is particularly valuable for expanding the set of knowledge to identify a greater variety of opportunities (Marvel et al., 2020). Recent literature points out that knowledge, as well as knowledge management, can impact FI (Dost et al., 2019). Kun (2022), in a study applied to small and medium-sized enterprises in China, confirmed the hypothesis that the acquisition, dissemination, and application of knowledge have a significant impact on FI. Finally, KBV has also been used to reveal how frugal innovators use their resources and capabilities in restrictive environments when developing their innovations, how they deal with resource constraints, and the role of the environment in FI outcomes (Dabić et al., 2022).

Founders´ knowledge of a technology startup is a resource that, when converted into currency, can be called intellectual capital, and is necessary for generating innovations that impact its performance (Sveiby, 2001).

Frugal Innovation and Entrepreneurial Bricolage

FI has been defined in several ways, characterized mainly by the scarcity of resources, cost reduction, and acceptable quality. In this way, the definition of FI comprises a solution of scarce resources (i.e. product, service, process, or business model) that is designed and implemented despite financial, technological, material, or other resource constraints, for which the result is significantly cheaper than competitive offerings (if available) and is good enough to meet the basic needs of customers who would otherwise remain unmet (Hossain, 2016, 2022). To define FI, Weyrauch & Herstatt (2016) used three main criteria: substantial cost reduction, focus on core features, and optimized performance level. FI should not be confused with the cheapest product; instead, they need to display accessibility, quality, ease of use, and sustainability.

The bricolage term is used to define the creative and innovative way to use the resources available to create something, regardless of the original purpose of the resources, and thus allow the generation of FIs. Lévi-Strauss's bricolage concept, first formulated in La Pensée Sauvage (The Wild Mind) in 1962, was originally presented as an analogy of how mythical thinking works, selecting fragments or leftovers from previous cultural formations and reusing them in new combinations.

In entrepreneurship, bricolage is the act of improvising by applying combinations of the resources that are at hand for new problems and opportunities. (Fisher, 2012). The characteristics of bricolage, according to Ted Baker; Reed and. Nelson, (2005), and Fisher (2012) can be defined: (a) improvising with what is available and (b) creating something from nothing through improvisation, combining resources in new purposes and using available resources.

The operationalization of doing more with less for more people, the definition of FI, is especially challenging due to the scarcity of resources. This is the main reason why FI was born as an alternative to BoP (Base of the Pyramid), as proposed by Prahalad, (Prahalad et al., 2012). Thus, bricolage is a common practice existing in the theory of FI, cited in many studies, such as: (Bhatti & Ventresca, 2013; Pisoni et al., 2018; Rosca et al., 2017; Winterhalter et al., 2017). Winterhalter et al. (2017) even position bricolage as a key to the assembly of business models of frugal entrepreneurs.

FI and EB are strongly related. EB offers the ability to adapt available resources, while FI aims to provide simple, affordable, and value-added services to BOP consumers. (Iqbal et al., 2021). Thus, FI can be seen as a result of bricolage strategies (Gurca & Ravishankar, 2016).

Frugal innovation is an important part of business performance, as it helps entrepreneurs reduce their resource needs and gain first-mover advantages (Zahra, 2021). Cost and affordable value innovation can be understood as frugal innovation perspectives, so cost innovation contributes to the performance of emerging market firms by achieving low costs through tailoring functionalities and features while affordable value innovation contributes to the performance by emphasizing new functionalities and features with lower cost (Cai et al., 2019). Additionally, bricolage capability helps emerging markets firms address scarcities of key technological resources (Cai et al., 2019). Thus frugal innovation is inherently related to economic performance, as it helps organizations achieve their targets, relative performance, and implementation of business strategies (Iqbal et al., 2021).

Startup Performance

The result of a startup can be measured in several ways. The literature points to studies dealing with performance measures (Rompho, 2018), survival (Soto-Simeone et al., 2020), and success

(Santisteban & Mauricio, 2017) of startups or new ventures. A possible approach to the evaluation of startup performance can be made through the founders´ perception of competitors. This alternative is useful in situations where the comparison of objective indicators is not possible. This is the case of the study conducted by Wiklund & Shepherd (2003) that includes financial and non-financial measures and was later adopted in a quantitative study (Wiklund & Shepherd, 2011).

Conceptual Framework

Based on the theories discussed, the conceptual framework was proposed:

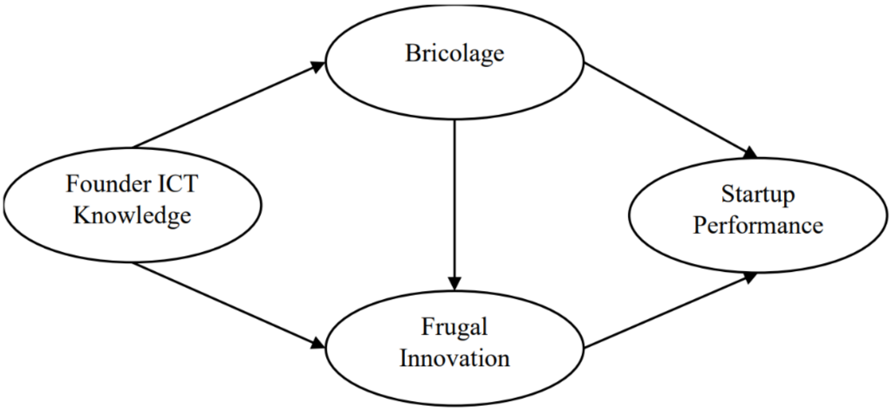

Image 1 – Conceptual Framework
Source: Authors

Summarizing the theoretical discussion that supported the proposed exploratory model, we derive three propositions:

Proposition 1: The founder's knowledge of ICTs should provide a better ability for the company to innovate with few resources (frugal innovation)

Proposition 2: The founder's knowledge of ICTs should serve to expand his repertoire of possibilities on bricolage with these resources to innovate frugally.

Proposition 3: Increased bricolage capacity should allow for a greater ability to innovate frugally. Bricolage Frugal Innovation Startup Performance Founder ICT Knowledge

Proposition 4: Associated with the founder's knowledge and his ability of bricolage, frugal innovation should provide better performance to the startup.

Methodological Procedures

The multiple case study was adopted for better variance along relevant dimensions (Seawnght & Gerring, 2008). The initial categories, derived from the literature review, can be seen in Table 1.

Table 1 Summary of Categories

Construct	Categories	Subcategories	References
Knowledge Prior technological knowledge is particularly valuable for expanding the pool of knowledge to identify a wider variety of opportunities(Marvel et al., 2020)	Education	Graduation and Pot Graduation	Marvel et al., (2016).
	Experience	ICT Work experience	
Bricolage Making combinations of available resources applied to new problems and opportunities (Baker & Nelson, 2005)	improvise with what is available	Reuse	Ted Baker; Reed e. Nelson, (2005) e Fisher (2012)
	create something from nothing through improvisation, combining features in new purposes and using available resources.	improvise	
Frugal Innovation Products, services, technologies and business models that are financially accessible, ecologically responsible and continue to provide technological excellence. (Herstatt & Tiwari, 2020)	Cost Reduction	good and cheap products/services	Tiwari & Herstatt (2012) Weyrauch & Herstatt, (2017)
		Resource optimization in the operational process	
	Focus on main functionalities	Central functionality	Weyrauch & Herstatt, (2017)
		Ease of use	
		Durability	
	Sustainable Co-creation	Social	Herstatt & Tiwari (2020)
		Environmental	
		Local Partnership	
Startup Performance Results from business activity related to inbound resources and outbound results. Wiklund e Shepherd (2011)	Relative Performance	Sales increasing	Wiklund e Shepherd (2003) Wiklund & Shepherd, (2011)
		Customer Satisfaction	
		Product/ Service Quality	
		Product / Service Innovation	
		Process Innovation	

Source: Auhtors

In this research, we focus on FI processes involving the use of ICTs, both because of innovation and as essential support for their development. The cases were selected to obtain contrast with the founder's knowledge and way of using IT resources to innovate and generate solutions for their business, considering the same stage of development and resource restrictions, as Table illustrates.

Table 2 - Cases´ details

Case	Segment	Business Model	Founders	Starts on	Responsible for ICT	Founders ICT Skills and Knowledge	Respondent (code, role)
Case 1	Agrotech	B2B	1) Electrical Engineer 2) Telecommunication Engineer	2013	Founder / Internal	High	F1 - Founder (male) CEP & CEO
Case 2	Healthtech	B2B2C	1) Production engineer 2) Electrical engineer 3) Electrical engineer and master's in system engineering	2020	Founder/ Internal	High	F2 - Founder & CEO
Case 3	Civil Engineering Startup	B2B2C	1) Architect 2) Architect	2017	Partner / External	Low	F3 - Founder & CEO
Case 4	Traveltech	B2C2C	1) Production Engineer and PhD in Production Engineering 2) Advertising and 3) Administration	2020	Missing	Very Low	F4- Founder & CEO

Source: Authors

As recommended by Yin (2016), we used sources triangulation. The interview data was collected through semi-structured, in-depth interviews with founders (and co-founders) in the four participating companies. Secondary data was collected on the institutional websites of startups, customer relationship sites, startup registration sites, and news about startups published on news sites on the Internet.

To achieve the the research findings validity, we used the structuring of the content analysis suggested by Bardin (2011). Atlas.ti tool was used to support the processes of registration, coding, and analysis. The analytical strategy of adequacy to the standard was used (Denzin & Lincoln, 2017; Yin, 2015)

Results

Case 1: Aggrotech

The startup Case 1 was founded in 2013 and develops counting systems using computer vision, mainly focused on Agrobusiness, running a B2B model. The solution is easy to install and does not require complicated cabling, panels, and other facilities, enabling customers to easily use products. The startup has 2 (two) founders, an electronic engineer, and a telecommunications engineer, both with more than 15 years of previous experience in technology, including software development using ARM architecture as part of mobile design teams. As noted, the previous knowledge was important for the strategy development of the startup's innovations: adapting mobile phones as a hardware platform to the computer vision system.

About bricolage, it was observed that this was one of the main characteristics to develop the startup´s technology. The use of ARM architecture, as the "base for hardware" allowed the startup to find a frugal solution to a market problem. There were many solutions available, but all were costly. According to F1 (Case 1 founder), "*this feature, reduced the chipset cost too much and it was thinking* *about it that we returned so our product to accommodate in this hardware. Using more powerful machines would be easy using existing market solutions. So, our differential ended up being to do this on top of the ARM architecture that today our differential and we ended up taking the one step forward aiming at the low cost without a doubt*."

Bricolage allowed innovation at low costs. The production of exclusive hardware was would be very expensive. The solution was the ARM platform that is embedded in regular mobile phones. The mobile phones were disassembly or modified to compose the final product. The previous founders´ experience was critical to realizing this adaption. Also using bricolage, the company had flexibility to meet customized demands or create products, based on the recombination of what already exists. From prospects ‘requests to adapt the existing solution, that is, to find a viable solution to meet new challenges from existing resources, the startup has developed 2 (two) new products. As stated by F1, "*reused the technology making small adjustments to serve completely different markets*".

Regarding FI, through frugality, the company achieved substantial cost reduction, allowing it to reach unexplored niches and smaller client companies, neglected by the most expensive solutions in the market. F1 said that is the focus of the startup's product and service development strategy to produce good and inexpensive solutions even so the startup could have a healthy cash flow. And about cost reduction in the operational process, “*all our projects left the drawing board already with this mindset*”. Additionally, F1 considers in operational process, they needed to keep costs low to maintain profit margins and pay for the investments made with the project. They also needed hire employee for sales functions previously performed by him.

FI was also evidenced by F1 as doing the basics to generate the value that the client seeks and then thinking about features that generate secondary values "*Basic first, then the features that add value*". Regarding ease of use, F1 says that they highlight the deployment, both the time and the absence of the need for a technician for installation and, regarding the software ergonomiy, from the client’s understanding, who is from Agribusiness, designed "a solution more simply and practically possible, with few screens and interactions".

The startup also cares about the electronic waste generated by its hardware adaptation process and so it sought local partners for the proper destination of this material that demonstrate FI´s sustainable co-creation characteristics.

The startup perceives its performance as much better than its competitors in sales growth, product quality, customer satisfaction, and innovation in products and processes. The product and service development strategy characterized by bricolage and FI enabled its performance. The startup is going to the international market with 2 (two) multinationals as customers that leveraged their international sales and are expanding to China market. In addition, the founder believes that so far, they are ahead of competitors in innovation, precisely by the adoption of the solution type they chose from hardware and software, but the internationalization of sales fear that this distance from competitors will decrease if they do not invest in innovation properly.

Case 2: Healthtech

The startup Case 2 is a Healthtech founded in 2020 to assist its customers in detecting health problems before they are worsened. Their solution combines a cloud platform and uses wearables to collect users´ data and generates risk alerts for healthcare professionals. The startup is running in a B2B model. The startup has 3 (three) founders, a production engineer, an electrical engineer and, an electrical engineer with a master’s in system engineering, all of them pursuing more than 15 years of experience in technology before the startup’s creation.

Despite having a high ICT knowledge, the startup uses intensive outsourcing to develop their solutions, based on the principle of “buy not builds”. The ICT knowledge was applied to the project and governance of innovation. According to the case 2 founder (F2), the startup does not use bricolage to find internal solutions. He believes that the startup ended up spending more external resources than it should and so it should have used more insource rather than outsourced resources. Meanwhile, using outsourcing, in this case, was necessary, since the innovation uses a set of complementary assets of knowledge, sourced from multiple partners.

Despite the low evidence of bricolage practice, the F2 stated "*we should do more of this -in the development of products and services, to find viable solutions to new challenges using our existing resources -, because in fact whenever something new appears, a new situation we tend to seek new resources to try to solve this,*". It was possible to evidence that in the use of all existing resources that seem useful to respond to a new problem or opportunity, the startup uses human resources for analysis and learning of new requirements and market regulations.

About frugality, the startup has characteristics of substantial cost reduction, focus on the main functionalities, and sustainable co-creation in the product and service development strategy. The F2 said that the startup always seeks to formulate a product that is cheap and affordable. They seek to have "*a very efficient operational process with very optimized costs,*" he said. The previous founders’ ICT knowledge and experience help to support decisions and strategic planning to manage organizational and human resources and achieve operational efficiency. This evidence points to the characteristic of FI substantial cost reduction.

F2 believes the startup focuses on core functionality. In addition, he considers that the product/service ease of use is an "Achille´s heel" of technologies´ adoption such as the startup "*because it may seem intuitive and useful but if it is not simply the customer will not use*". And, related to the product/service durability, considering that the hardware will certainly be obsolete quickly, the startup seeks to transfer durability to the service.

In co-creating sustainably, startup contributes in the environmental sense by adding greater efficiency in the use of its health data, reducing displacement and execution of repetitive examinations. Additionally, as the hardware is delivered in a statement, environmental sustainability in the operational process is done through responsible disposal.

The performance of Case 2, in the F2 view, is the same as its competitors except for the product quality because he understands that the startup´ssolution has a scientific base that gives it a superior result. With customer satisfaction, the startup has already received feedback from its customers highlighting its maturity solutions. The highlight of innovation in this case is related to the ability to reduce the process and operational costs by making them increasingly efficient.

Case 3: Contrutech

The third case is a construtech that wants to democratize decoration. The startup was founded by two architects with no experience in information technology in 2017. The construtech uses technology to optimize decoration projects reducing the time and costs of the project to final customers. Four years after the foundation, an ICT services supplier joined the founders taking a CTO role.

Despite not having a founder with knowledge in ICT since the beginning, the startup differentiation relies on the way it uses technology to meet the decoration needs of its customers at a low cost. The startup was able to generate solutions from the previously existing founders’ knowledge and bricolage of existing technological resources. The founder of case 3 (F3) states that they used existing resources, basic computer software, and a questionnaire tool to deliver solutions. Using its database, they were able to create projects with statistics and create projects in an automated way using the existing knowledge resources of other projects. According to F3, the idea has always been to make the best decoration project for the lowest price and thus serve the largest number of people with this solution of extreme quality. In this way, to reduce costs significantly in the operational process, the startup adopts the technology to optimize more and more the project production and reduce the execution time. "*So today our idea is to increase the number of projects without having to increase the team,*" she says.

F3 perceives the startup's performance relative to competitors as much better except for the increase in sales that considers similar and states that its marketing would need to be more efficient than competitors. It considers product quality much better, delivering far ahead of its competitors which is reflected in customer satisfaction where it performs much better than competitors measured through NPS (Net Promoter Score). Regarding product innovation, she said, innovation is in "technology concerning competitors is so shot something that we have they don't". innovation in processes is considered much better than competitors because its business model was based on technology and only because they understood was a startup that was working with innovation, which was doing something disruptive and not only locally could get reach the national market.

Case 4: Traveltech

Traveltech was founded in 2020 by an advertiser, an administrator, and a Production Engineering Ph.D. The solution aims to connect adventure experiences providers to final customers, in a B2B2C model.

The startup Case 4 value proposition is based on internet and mobile solutions, like a procurement platform. But Case 4 has founders with no knowledge or experience in ICT and thus chose to outsource the development solution activities. The process was considered traumatic by F4 because they could not obtain timely results or acceptable services that comply with the contractual conditions and runs costly. The outsourcing strategy hurt its performance.

The startup presents difficulties to find solutions using existing resources, both to solve problems and to take on new challenges. Sometimes, the startup has only a bricolage feature, using the founders´ knowledge in obtaining external financial resources combined with the result they already have. When dealing with new problems, the startup does not act assuming that it will find a solution, considering that sometimes pity a little to be able to find solutions when it comes to taking on new challenges. For the case 4 founder (F4), the startup has difficulty combining its existing resources to take on a wide variety of new challenges, and credit so the opposite happens in the startup.

The startup case 4 solution presents little application of frugality in the product and service development strategy. For cost reduction, the startup sought suppliers who were in the region’s vicinity and that were within the budget that the startup had mainly compared to other budgets that were from more developed regions or with a larger portfolio. However, according to the founder, due to the large number of technical problems number arising from the outsourcing strategy adopted by the lack of founders´ ICT knowledge, the resource optimization issue in the operational process has just been deprioritized. According to F4, the startup in the B2B2C model ends up having as a fundamental need the partnership with local service providers.

For the F4, the startup's performance is like its competitors in terms of sales and product quality, but still cannot evaluate customer satisfaction and regarding innovation is considered better. The technological difficulties faced by the lack of ICT knowledge in the startup also happen in the startup’s competitors. Despite of this, the F4 considers that innovation is precisely in bringing technology applied to the adventure tourism sector, in its performance is like competitors. Covid-19 pandemic has hurt the tourism industry. However, the case 4 startup was not affected by the pandemic as its solution was not functional to be widely used at that time.

Discussion

The four cases selected shown interaction between ICT knowledge, FI, EB, and startup performance. Product development strategies were guided by the previous founder´s ICT knowledge, as can be seen, summarized in Table 3. In Case 1, the founder's knowledge allowed for accelerating the processes of the minimal viable product (MVP), prototyping, and pivoting. The ease of orchestrating existing troubleshooting resources has been facilitated by ICT knowledge. This helped to recognize opportunities and new uses for the technologies available and accessible to startups, considering the resource restriction environment. It was found high EB and high FI resulted in high performance perceived. Although the founder does not act directly in development in Case 2, his expertise is essential for more efficient choices and correct answers. In this case, EB was not strongly evidenced as an action element but still have high FI, ensuing medium performance as result. Startup Case 3 growth suffered due to difficulties and a lack of ICT skills in the early stages. But the embedding of a partner with high knowledge accelerated the processes and boosted performance, presenting high EB and high FI in subsequent years. The lack of EB and ICT knowledge at startup case 4 results in technological development barriers. Difficulties in specifying and negotiating with outsourced developers impacts the capability to innovate resulting in low EB and low FI startups and consequently medium performance.

For Case 1(Agritech) and Case 4 (Traveltech), the relevance of ICT knowledge was presented in opposite ways. While the Case 1 founder presents ICT knowledge as an antecedent to FI and key for competitive advantage, the Case 4 founder points out that the absence of a CTO has made the outsourcing process of application development exhausting and inefficient for the startup. The gap in ICT knowledge between founders and third part and startup performance impact can be explained by agency theory as information asymmetry(Eisenhardt, 1989) and results in additional transaction costs (Coase, 1937) for the startups. It seems that startup strategy uses ICT knowledge as a differential for startups 1 and 3 that provide better results and also were antecedent for EB and FI for them. On the other hand, the outsourcing strategy used by startups 2 and 4 made it difficult to make EB and frugality in the innovation strategy in product development.

Table 3 – Summary of case studies´ outcome

	Case 1 Agritech	**Case 2 Healthtech**	**Case 3 Construtech**	**Case 4 Traveltech**
Founders ICT Knowledge	present	present	Present/ Partner	Missing
Bricolage behavior	High	Low	High	Low
Frugal Innovation – Cost Reduction	High	High	High	Low
Frugal Innovation – Focus	High	High	High	Low
Frugal Innovation – Sustainability	High	High	High	Low
Performance	Above average	Average	Above average	Average

Source: Authors

The founder’s ICTs knowledge provides a better ability for the company to innovate with few resources (FI), supporting our first proposition. All cases analyzed demonstrate evidence of the direct or indirect contribution of previous knowledge on the capacity to innovate with limited resources in a scarcity environment.

The founder's ICTs knowledge also helps the exploration of new possibilities and resources to innovate frugally, supporting our second proposition. All startups relied on ICT resources for their innovations. The capacity to identify more appropriate resources or combine new ones contributes to startups achieving FIs, keeping the costs low with high value.

The entrepreneur’s bricolage behavior allows for a greater ability to innovate frugally, supporting our third proposition. The capacity to explore existing resources, by the creative and innovative way to use the resources available to create something, contributed to boosting the FIs of startups.

Finally, the combination of the founder's knowledge and his ability of bricolage, FI, proves to contribute to the startup’s performance, supporting our fourth proposition. ICT knowledge was important to bricolage and explore the possibilities of use and combination of existing resources to innovate frugally.

Although the method does not allow generalizations, this study of contrasting cases, even they are limited, allowed the deepening of the relations between the founders´ ICT knowledge, bricolage, frugal innovation and the performance in the context of technology startups in Brazil. As frugal innovation is a recent concept, research in other countries, emerging or not, as well as quantitative studies, can be done to broaden understanding. In addition other studies should explore further ICT and FI relationship, considering that is an intrinsic characteristic in this type of technology that enables scalability, mass customization and agile launches.

Conclusions

This study focuses on ICT knowledge as relevant to firm performance as an antecedent to FI and EB. Based on its empirical results, this study contributes to three areas: theoretical, practical, and social. Accordingly, it contributes to the theory by relating the concepts of FI with KBV, through human resources as valuable and related to the founders´ knowledge. As a practical contribution, this study brings information to founders and investors about how much the composition of the founders´ team especially in technology companies, can boost the performance and consequently the startup success in restriction-based environments. Therefore, it is expected that startups´ success will contribute to society by generating jobs and wealth in their surroundings. It was observed that only existing startups and extinct startups observation would bring more insights into the impact of founders´ knowledge on startup performance and survival.

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SPECIAL TOPICS ON MOT I

May 1st: 3h10 pm – 5h pm

Chair

Carlai Netto (Federal University of Rio Grande do Sul, Brazil)

Papers

Seeing convergence in electric vehicle technology through patents
Madhur Srivastava, Karuna Jain

A framework for introducing precision agriculture technologies in Egypt
Mahmoud Abdelsalam Abdelnabby, Tarek Khalil

The role of emerging technologies in reshaping the future of business and public services toward resilience and sustainability
Mohamed Azzam, Tarek Khalil

Leveraging technology in protecting traditional knowledge: The case of India and Kenya
Shubham Anand, Karuna Jain

Seeing convergence in electric vehicle technology through patents

Abstract ID#139 | Full paper ID#379

Madhur Srivastava, Karuna Jain (Indian Institute of Technology)

Abstract: The changing technology and policy landscape has propelled the nascent Electric Vehicle (EV) markets. Among the three EV categories, the Battery Electric Vehicle (BEV) accounts for the largest share of all new EVs sold. We present a system engineering approach at the sub-system level to depict the technologies that converge to develop a BEV using patent analysis. To address the question of which all technologies flow into making a BEV, we use the technology convergence approach, using the International Patent Classification (IPC) codes. We identify and find the most significant technologies in a BEV using the IPC networks. Analyzing the networks obtained at different IPC levels, we find insights that multiple technologies have converged in a BEV, from electrical engineering to thermal management of electrical machines. The paper adds an evidence-based approach to the body of knowledge to identify a BEV's built-in technologies.
Keywords: Management of Technology, Technology Convergence, Patent Analysis, Battery Electric Vehicle

Introduction

In the new millennia, one impending crisis for the human race is global warming, and the global emission footprint of the automobile sector is estimated to be approximately 15%. Though evidence of battery-operated electric vehicles (BEVs) has been found since the 19th century, the changing technology and policy landscape has propelled the nascent Electric Vehicle (EV) markets. Global electric car registration increased by 41% in 2020, and the driving factors for this observed growth are changing customer sentiments, improved technology, policy, regulations in the market, and government incentives. Among the three EV categories, it has been predicted that BEVs will account for 81% of all new EVs sold (Hamilton et al., 2020). Inherent advantages of a BEV, like no pollution, independence from fuel, the potential to integrate renewable energy for power generation, easy maintainability, low infrared signature, and silent operation, also make it suitable for rugged terrains and military applications. Both developing and developed nations have advanced steps towards developing and deploying EVs as substitutes for conventional internal combustion engine-based automobiles. Though scholars have attempted to analyze EV technology development, most studies have discussed the subtechnologies and general developmental trends (Baumann et al., 2021; Golembiewski et al., 2015; Ma et al., 2022; Sanguesa et al., 2021). A comprehensive technology-level analysis depicting its rippling effect on technology management is not found. This motivates the authors to explore technology development using reliable, authentic, and statute-based patent metrics with the following research question:

RQ 1: Which all technologies converge to develop a BEV?

We present a system engineering approach based on patent analysis depicting the technologies that converge to develop a BEV (Nguyen & Moehrle, 2022). Patent analysis can be employed to identify technology convergence, and both IPC (structured) and semantic analysis of descriptive patent data (Abbas et al., 2014) can be used for the purpose, however for large data sets, using IPC codes provides reasonably good results (Preschitschek et al., 2013). Hence, we anticipate technology convergence using the IPC codes to address the question of which all technologies flow into making a BEV. Using the different levels of IPC networks (Luan et al., 2022), we identify and find the most significant technologies in a BEV.

From many network analysis tools available, Gephi (version 0.9.7), an open-source network visualization software, was employed for this purpose. Its features to analyze large datasets and the availability of various additional plugins and analysis algorithms facilitated its use. The paper adds an evidence-based approach to the body of knowledge to identify a BEV's built-in technologies. We found a high degree of vertical technology convergence from automobile, chemical, thermal, and electronic engineering disciplines into a BEV.

Theoretical Background

Systems Engineering of a BEV

The BEV system, which has a high energy density battery as the sole source of propulsive power, comprises a battery, battery management system, charging port & charger, DC/DC converter, speed controllers, drive system, and over-the-basic vehicle body and electronic features. The BEV derives propulsive power from the energy stored in the battery, obtained after charging it from an external supply line using the charging infrastructure and charging system. This propulsive power is supplied to motors, which are the prime-mover in the vehicle. The subsystem-level disintegration of a BEV and the interaction among these design features are depicted in Figure 1.

Technology Convergence

Convergence is "*the blurring of boundaries between at least two hitherto disjoint areas of science, technology, markets or industries. Through this convergence, a new segment is being created in a new spot as a merger of the old segments*" (Curran & Leker, 2011). Swift technological development has resulted in the blurring and redefinition of boundaries between industries.

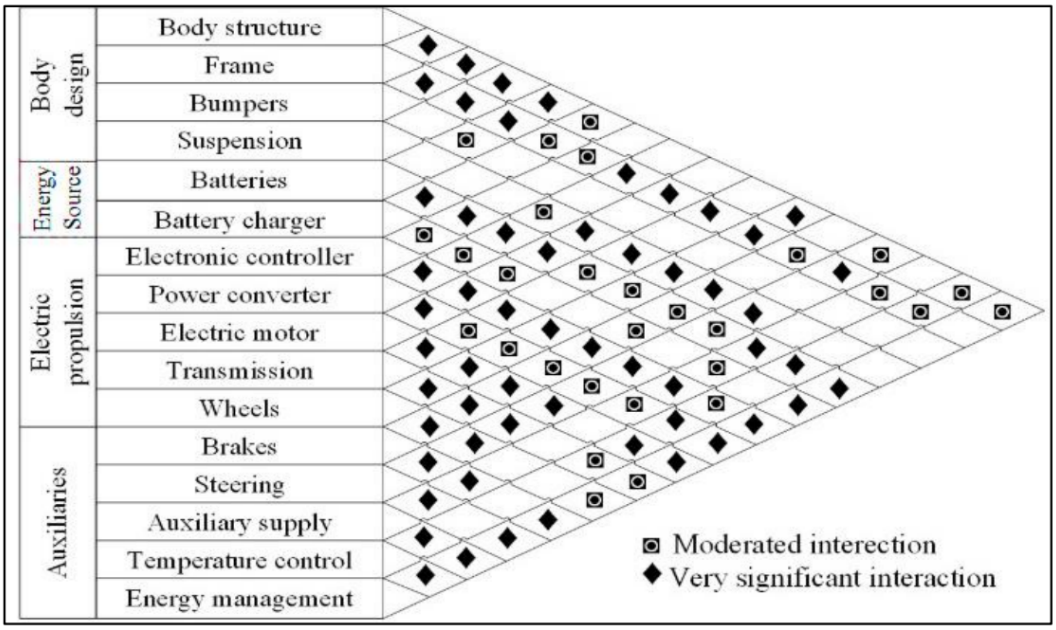

Figure 1 Sub-system Disintegration of a BEV
Source: (Chan, 2007; Un-Noor et al., 2017)

Technology Convergence refers to the intersection of two or more disjoint areas of technology, leading to the development of new products from cross-fertilization (Curran & Leker, 2011). Technology convergence can occur in horizontal and vertical directions (Nguyen & Moehrle, 2022), with vertical focusing on hierarchical system architecture and horizontal on elements at each level.

Patent Analysis

The development of global online databases containing patent information facilitated obtaining and analyzing patent data that can produce credible and reliable information, which has importance, both in technical and managerial aspects. Tseng et al. (2007) explained a seven-step patent analysis procedure, encompassing task identification (agenda and scope of analysis are decided here), searching (retrieval of patent documents), segmentation (data cleansing and normalizing), abstracting (analysis of data retrieved from patents), clustering (grouping based on specific features), visualization and interpretation (deriving results from the visual maps). Since patent data is globally acceptable and reliable, it can be readily employed for studying technological knowledge flow and convergence study.

Network Analysis

Deriving from the graph theory literature, we briefly reiterate some metrics we employ for our analysis. The level of network analysis is broadly classified into the entire network and ego network analysis (Ahuja et al., 2012). Ego networks have a focal node (ego) and other nodes (alters) connected to the ego node. Ego networks are instrumental when the analysis has an identified principal agent of focus. Depth in an ego network refers to the degree of direct connections. One depth represents ego-alter direct connection. Two depth implies ego-alterand alter's-alter relationship and so on.

Centrality measures identify the power of influence of a node in a network. Though various centrality measures are reported in the literature, we would employ betweenness centrality for our analysis. Betweenness Centrality (BC) is an indicator employed to identify the critical technological fields that bridge technological convergence (Luan et al., 2022). BC measures the number of shortest paths that crosses a node, i.e., how many times one particular node is encountered while traversing between two nodes. It depicts the power of one specific node to moderate the flow of information in a network (Brandes, 2001). These bridging nodes integrate, drive and aid in developing emerging areas.

Methodological Procedures

Due to the potential of technology convergence to drive market and industrial convergence, it is paramount to assess technology convergence based on reliable data input (Yun & Geum, 2019). Song et al. (2017) introduced a methodology using IPC to study the directional flux of technology. It is based on the fact that the presence of more than one IPC class in a patent document indicates that several technologies have converged into the embodiment depicted in the individual patent. The key technologies can be identified by employing the BC indicator in the corresponding convergence networks (Luan et al., 2022). We retrieved patents from the global WIPO database using the open-source Patentscope service. Data were extracted by searching the string "battery electric vehicle" in any descriptive field of individual patents (Borgstedt et al., 2017). Since most jurisdictions have a patent life of twenty years, we have restricted our data points to the period ranging from 01 Jan 2000 to 31 July 2022 over the date of publication field. The data was obtained for all the jurisdictions listed with WIPO and all PCT applications. Raw data was obtained for 7216 data points, which, after cleaning and removing duplication and issues with incomplete data, resulted in 6449 data points, finally used for analysis. We developed an ego network for the main IPC class representing a BEV. This would depict the flow of IPC into a particular ego IPC, which indicates the flow of technology (knowledge, in essence) to the development of BEVs.

An important consideration when working with graph and network visualizations is the selection of a visualization algorithm. An appropriate algorithm enables restructuring the network to visualize it in a way in which the required parts of the graph are enhanced, and other features are distinguishable from each other with improved resolution (Cherven, 2015).

The Fruchterman Reingold layout algorithm belongs to the class of force-directed algorithms. In this algorithm, the nodes are assumed to be entities made of steel, and the edges are believed to be springs (Cherven, 2015). The attractive force between the nodes mimics the spring force, whereas the repulsive force between the nodes is analogous to the electrical force. This algorithm aims to minimize the overall energy of the whole system and develop an optimized network layout that satisfies this objective (Khokhar, 2015). We chose the Fruchterman Reingold layout algorithm for our analysis due to its inherent capability to handle large datasets. The input parameters with the definition for the algorithm are listed in Table 1.

Table 1 Fruchterman Reingold Layout Algorithm Input Values

Parameters	Definition	Value Used in Analysis
Area	The area over which the final graph will be laid out	250000
Gravity	The attractive force on all nodes that attracts them toward the center of the graph	10
Speed	The speed of convergence of the algorithm	1

Results

The use of electric power for vehicles has led to the emergence of the term "electric-mobility," which has led to the reconstruction of the entire value chain associated with mechanics to "mech-chem--tronics" (mechanical, chemical, and electronics). This section assesses the descriptive results obtained from the dataset and the network analysis results to understand technology convergence.

Descriptive Analysis

For our dataset of 6449 patents collected, as represented in Figure 2, we observe that until 2010, the trajectory of patent publication numbers was steady; however, from the decade starting 2010, the number of patents published (hence technologies protected for BEVs) has increased exponentially. Since organizations patent to earn monopolistic rents, the increasing trend is representative of market intelligence of an uptick in demand for BEVs. The International Energy Agency (Global EV Outlook, 2022) report supports the fact that during this period sharp rise in user acceptance and diffusion of EV technology transpired. Figure 3 depicts the geographic distribution of the patents in our dataset. Most patents are registered with USPTO, followed by PCT, EPO, and China. Since these nations have proven technological prowess in the field of EVs, this result meets the expected common belief. However, China's presence in the top list indicated the growing stature of Chinese researchers in developing EV technologies.

Figure 2 Publication Trend of BEV Associated Patents

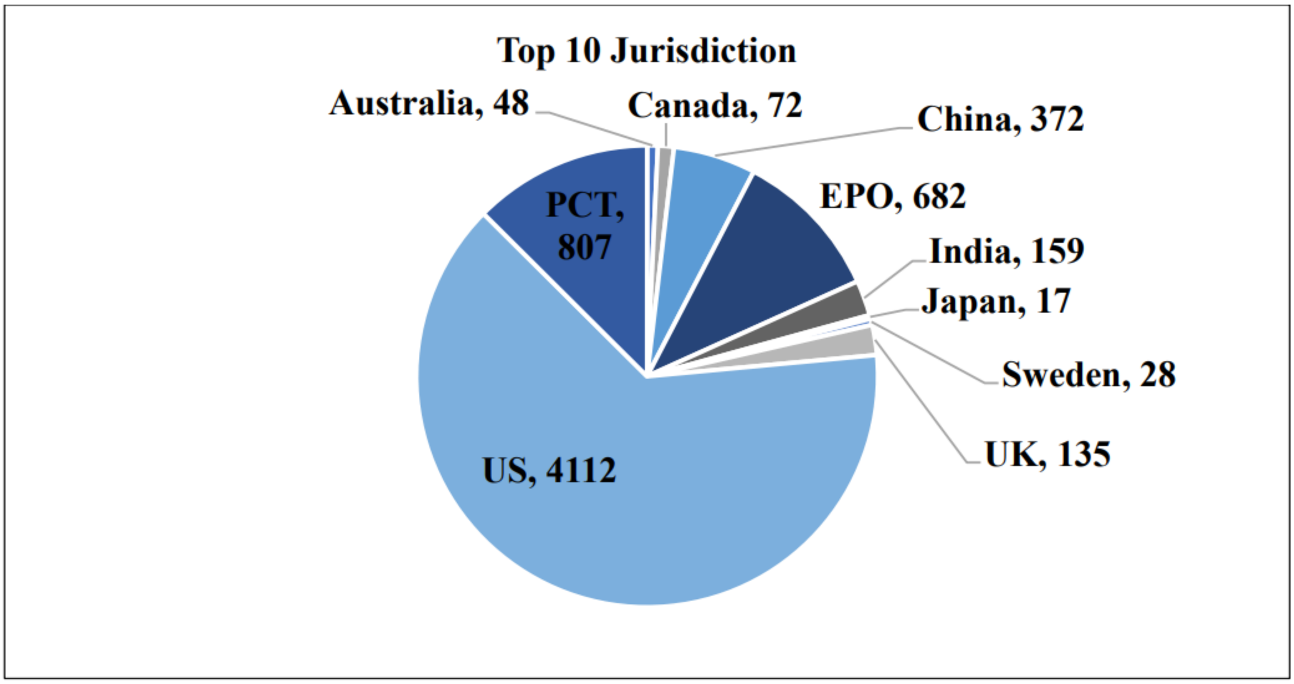

Figure 3 Geographical Distribution of Patents in Dataset

Mapping

Network construction is a type of mapping activity. Mapping describes developing a spatial representation of linkages or relationships amongst distinct units (technology in our case). Deriving from the network theory, our representation node represents individual IPC, with the node's size proportional to frequency. The data imported in Gephi presented 265 unique nodes connected by 2004 edges.

Full Network

The nodes are portioned by the colors governed by the value of BC, whereas the node's size is a linear function of the frequency of occurrence of the node as a data point. The degree of edge weight represents the intensity of the connection. BC depicts the power of one specific node to moderate the network. We calculated its value for all IPC; however, only those with a BC value of more than 500 are enlisted in Table 2, considering resolution requirements due to the spectrum of values ranging from 0 (min) to 7288 (max).

Table 2 Network Properties

Sr.	IPC	Frequency	Betweenness Centrality (BC)
1	B60L	4494	7288
2	H01M	4034	7158
3	B60K	1176	4769
4	B60R	413	1797
5	B60W	1272	1691
6	H02J	1529	1684
7	B60H	258	1531
8	G06F	291	948
9	H02K	273	773
10	B62D	316	574
11	G01R	491	538
12	H01G	182	517

Propulsion (B60L) and energy conversion (H01M), mounting devices (B60K and B60R), vehicle control (B60W), along with circuitry (H02J), electrical data processing (G06F), and electrical machines (H02K) are the technologies with high BC and therefore qualify to be recognized as the core technologies in a BEV. Figure 4 represents the complete network obtained using the Fruchterman Reingold layout algorithm.

The thickness of the links represents the linkage strength between the nodes, which reveals that B60L (propulsion) has a strong correlation with H01M (process/ means for direct conversion of chemical into electrical energy), H02M (AC-DC and DC-DC converters), H02J (circuit arrangements for supplying or distributing electric power), G01R (measurement of electrical variables). This forms the cluster associated with regulating a BEV's electric power storage and control. A strong connection is also observed between H02J (circuit arrangements for supplying or distributing electric power), H01M (process/means for direct conversion of chemical into electrical energy), H01F (magnetic material, transformers, and inductors), H01R (electric conductors, coupling devices, and current collectors). This is representative of technologies associated with the flow of electric power and the construction of other equipment like motors and inductors. Both these clusters, combined and their strong linkages, form the backbone of the propulsion system of a BEV.

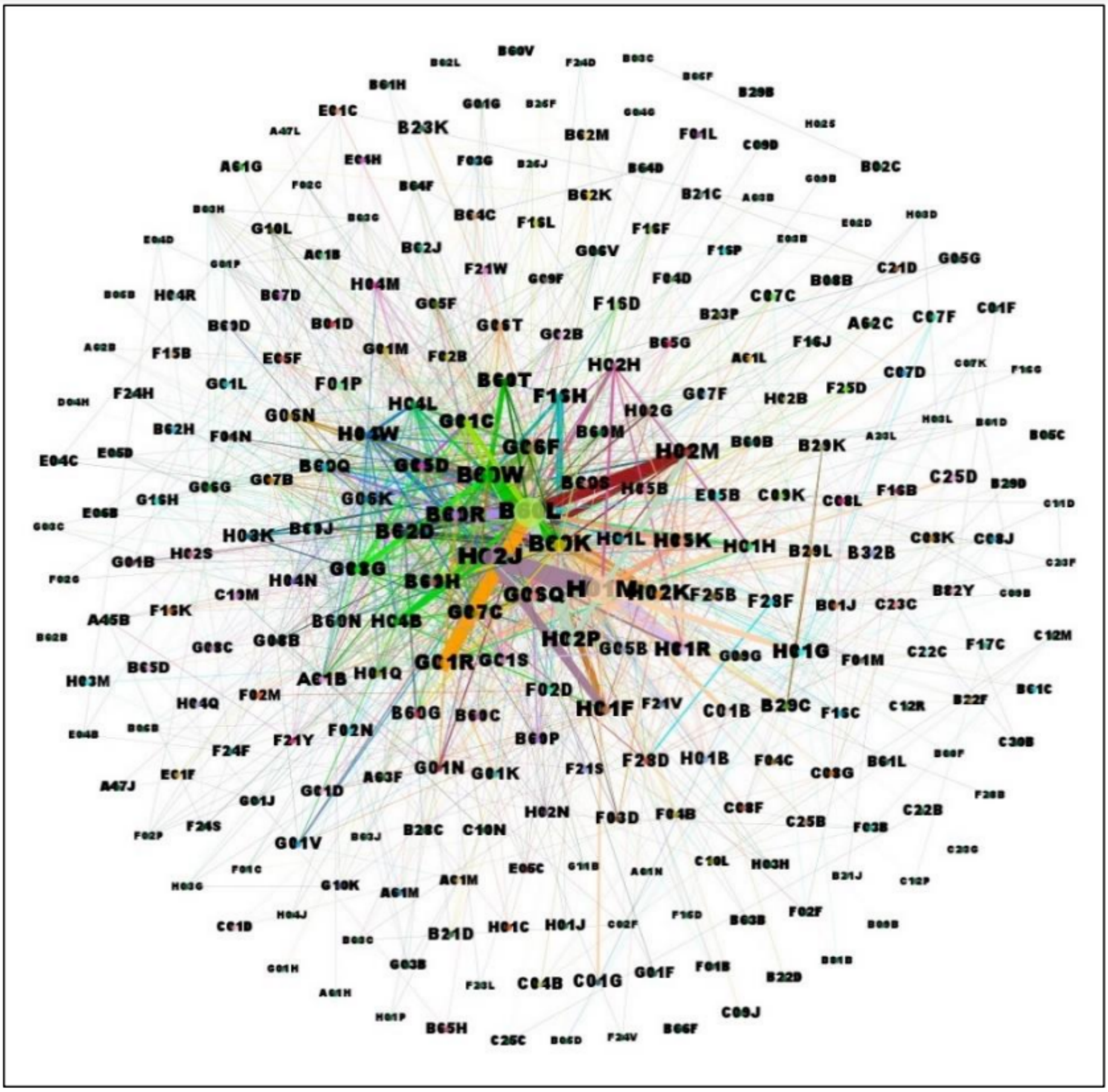

Figure 4 Full IPC Network

Connections are also observed between B60H (vehicle environment management), B60R (vehicle over-body construction), B62D (trailers), G08G (traffic management system), B60W (conjoint control), G01C (navigational instruments), and G06F (electrical data processing). This cluster focuses on auxiliary units required for a BEV's safe and effective operation, with an essential contribution in for mechanism supplying traction power to the vehicle's wheels and navigation for semi-autonomous operation. Unlike conventional IC engine-based vehicles, with clutch, brake, and accelerators as the control units, a BEV has only power and brake units for controlling the vehicle on the road. The dense connection between H02P (control of electric motors), B60L (propulsion of electrically-propelled vehicles), and H02M (AC-DC and DC-DC converters) represents the critical technological cluster aimed at controlling the speed of the electric motor, which is the prime mover in the BEV. This cluster focuses on the control aspect of BEV

Ego-Network Topology (B60L Level)

We developed ego networks with one and two depths for the IPC with the highest BC (B60L). The nodes with higher BC direct the technological convergence process. Considering all 265 nodes and 2004 edges as input for ego-network topology, we obtain the output networks with the following parameters listed in Table 3.

Table 3 Ego Network Properties

Ego Network Level / Graph Properties	One Depth	Two Depth
Nodes	163 (61.51%)	256 (96.6 %)
Edges	1622 (80.94%)	2003 (99.95 %)

In the one-depth ego network, we obtain a graph with only 61.51% of nodes from the complete network, as shown in Figure 5. This represents that only 61% of technologies fed directly into a BEV at the system level. Strong connections between B60W (conjoint control of the vehicle), B60T (vehicle braking), H01F (magnetic and electrical machines), H01M (batteries), H02M (convertors), H02J (circuits), H04W (wireless communication networks), G01R (measurement of electrical and magnetic variables), G07C (registry devices), moderated by the central presence of B60L represents the technologies getting converged at the sub-system level in a BEV. Each IPC enlisted in Table 2 is in a one-depth ego network and connected to several nodes. Figure 6 depicts the network connections of the one IPCs (H01M) in the one-depth ego network of B60L. The dense connections represent that multiple technologies have converged and fused into the technologies represented by IPCs. Direct connections are observed for H01M with B60K, B60R, B60W, B62D (mounting of propulsion systems, vehicle fitting, and conjoint control of the vehicle and trailers), C23C (coating of metallic material), F03D, F16H, F28F (motors, gearing, heat exchangers), G06F, G01R, G05B (electric digital data process, measurements, digital control), H02M, H01L, H04B, H01R, H05K, H01F, H02J, H02K, H01G, H02P (semiconductor devices, magnetic material, capacitors, electrical connections, converters, power distribution, electric motor control, and electrical transmission).

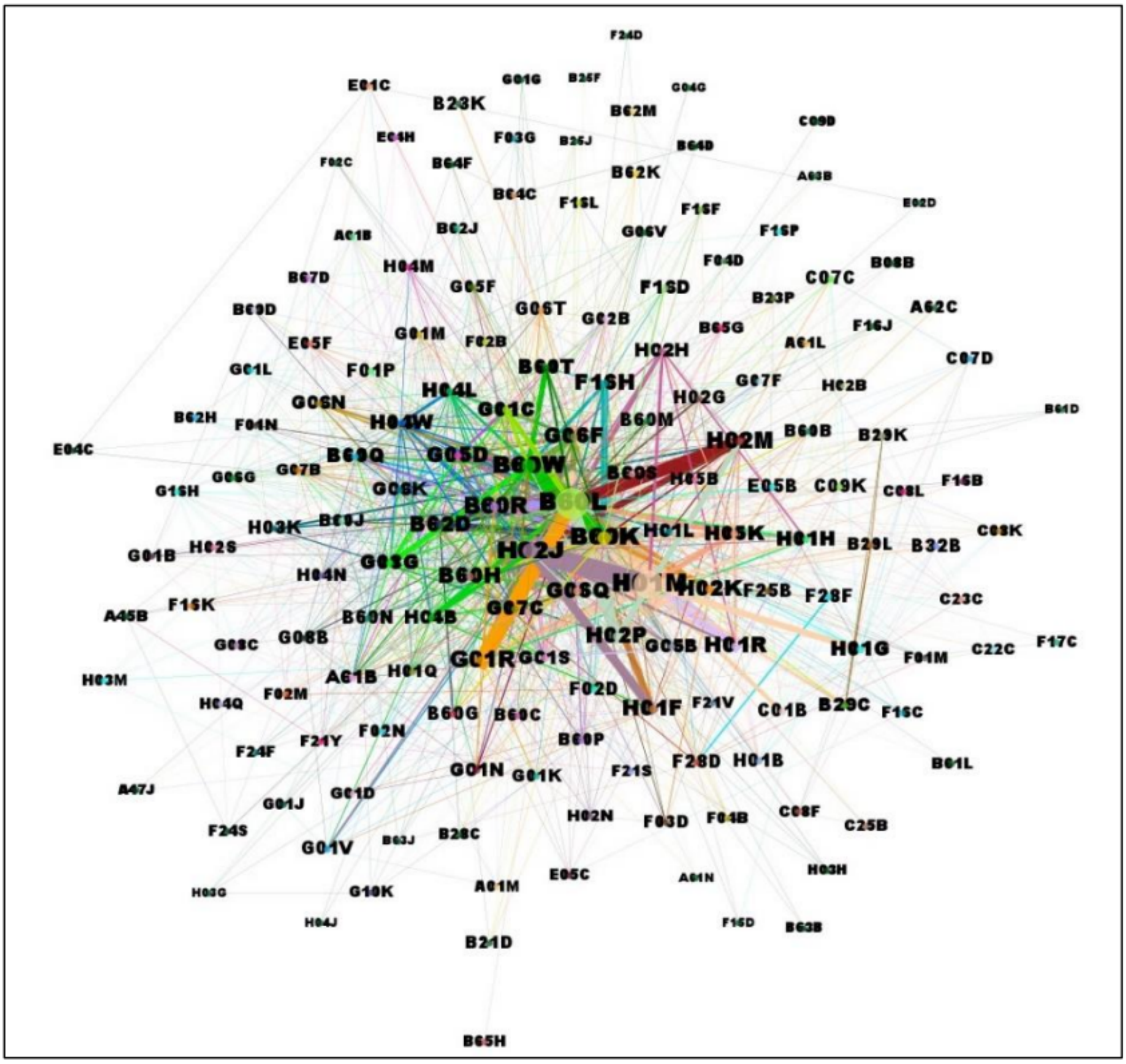

Figure 5 One Depth Ego Network

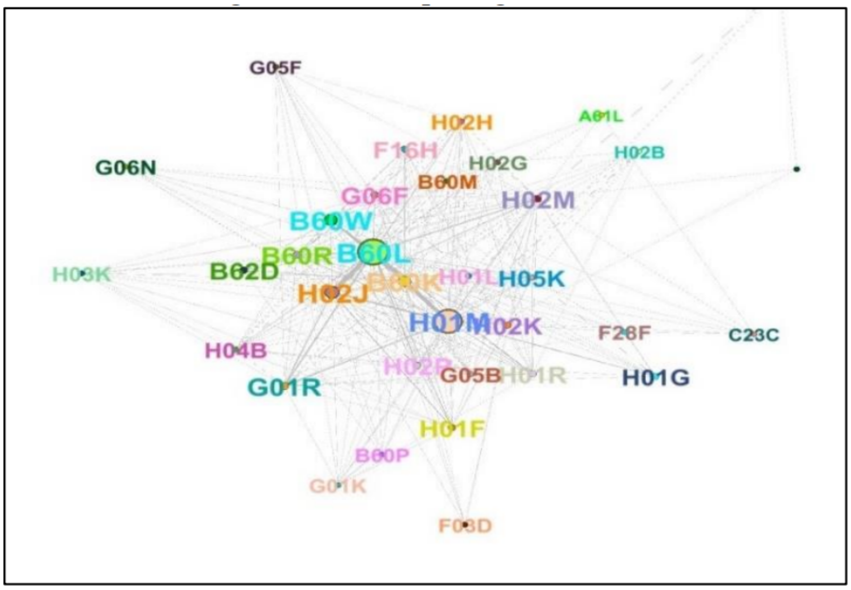

Figure 6 Network Connections of H01M (Batteries) in one depth Ego Network

This cluster forms the sub-system for mounting batteries, the transmission of electric power and control using semiconductor devices, and thermal management of batteries. They represent the heart of a BEV, i.e., battery power supply to the wheel axis. With a similar approach, other sub-systems can be studied for the convergence of technologies.

From the one-depth analysis network, we establish the vertical technology convergence (Nguyen & Moehrle, 2022) in a BEV at the sub-system level. A dense convergence is observed between automotive, chemical and electrical engineering-based technologies. The presence of only 61% of nodes indicates that convergence is higher at the sub-sub-system level hierarchy than at the sub-system level hierarchy, which we studied in a two-depth ego network analysis. From Table 3 and Figure 7, we establish the presence of 96.6 % nodes and 99.95 % edges represented in a two-depth ego network.

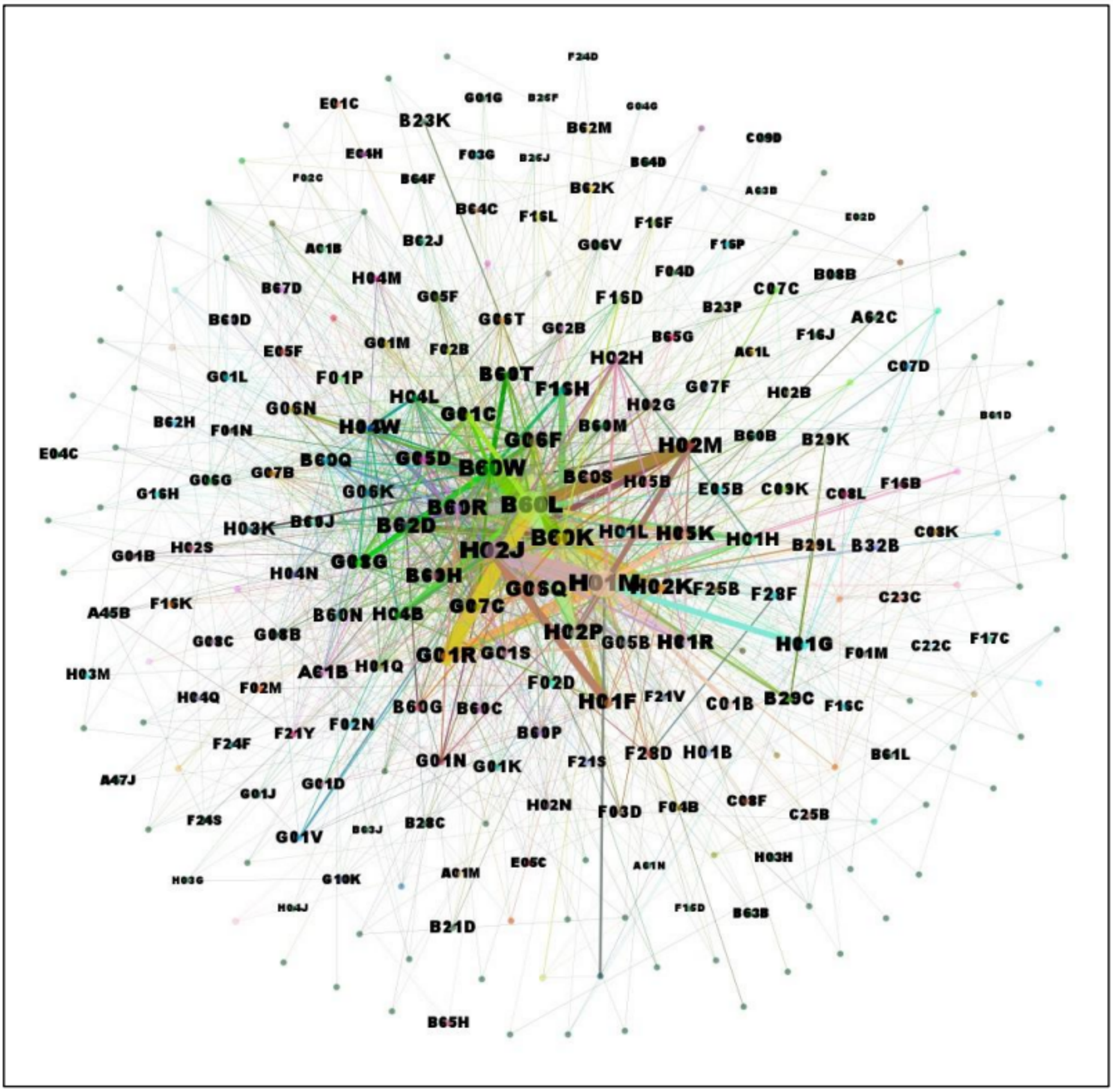

Figure 7 Two-Depth Ego Network

From observation of Figure 5 and Figure 7, we appreciate that though the network remains similar in the center, prominent nodes have been observed at the peripheral boundaries in the northwest, southeast, and eastern regions in Figure 7. Ninety-three new entries are observed in the two-depth network, and the ones with BC of more than 50 are represented in Table 4. Considering the lower value of BC in newly featured IPCs in the two-depth network, we considered 50 as the cut-off value for BC.

Table 4 New IPCs in Two-Depth Ego-Network with BC more than 50

S. No.	IPC	Frequency	Betweenness Centrality (BC)
1	B01D	11	306.29
2	B01J	17	160.53
3	C10L	3	56.11

For instance, Node B01D finds its direct connection with H01M from the one-depth network, along with B62D, B60H, B60K (shaping or joining of plastics, arrangements of heating, cooling, ventilating, arrangement or mounting of propulsion units), G06F (electrical data processing), and F24F, F25B (air conditioning, and refrigeration). Node B01J in the two-depth network also connects with H01M from the one-depth network, along with B23P, B62D, B60H, B60K, B29C (metal-working, shaping or joining of plastics, arrangements of heating, cooling, ventilating, arrangement or mounting of propulsion units, motor vehicles), C01B, C23C, C08K (non-metallic materials, coating of materials, use of inorganic or non-macromolecular organic substances as compounding ingredients), F01P, F25B (cooling of machines, refrigeration), G06F, G01N (electrical data processing, material characterization), and H05B (electric hearing and light source). Most of these IPCs are related to auxiliary subsystems delineated in Figure 1. We observe from Table 4 that though around a hundred IPCs have been introduced in the two-depth network, the BC value for newly inducted IPCs is comparatively low; their presence marks that certain technologies have converged at the sub-subsystem level. We find most technologies representing associated technologies with battery construction, separation, storage, and catalysis. The remaining nine IPCs (265-256) do not contribute to the ego network of B60L at any depth and can be considered a part of any other sub-system.

Discussion

BEVs account for the largest share of all new EVs sold. We presented a system engineering approach to depict the technologies that converge using patent analysis. Using BC as the indicator to identify the critical technological fields that drive convergence, we established that energy conversion, mounting devices, vehicle control, circuitry, electrical data processing, and electrical machines are the core technologies in a BEV. In the one-depth ego network, 61.51% of nodes from the complete network provided for vehicle braking, magnetic and electrical machines, wireless communication networks, measurement of electrical and magnetic variables, and registry devices represent the technologies that converge at the sub-system level in a BEV. High vertical technology convergence (Nguyen & Moehrle, 2022) between automotive, chemical, and electrical engineering-based technologies is observed in BEVs. The presence of 96.6 % nodes and 99.95 % edges represented in a two-depth ego network indicates that most technologies converge at the sub-subsystem level. However, B60L does not connect with a few technologies (represented by 9 IPCs) at any depth of the ego network.

For IPCs with a BC value of more than 50 (enlisted in Appendix 'A'), we find sixty-four (64) technology subclasses in performing operation and transportation (16), chemistry and metallurgy (7), mechanical engineering, lighting, heating (12), physics (12), electricity (16) sections of IPC codes excluding our focal IPC: 'B60L'. Figure 8 depicts the significant technologies converging in a BEV, classified as per the IPC classes.

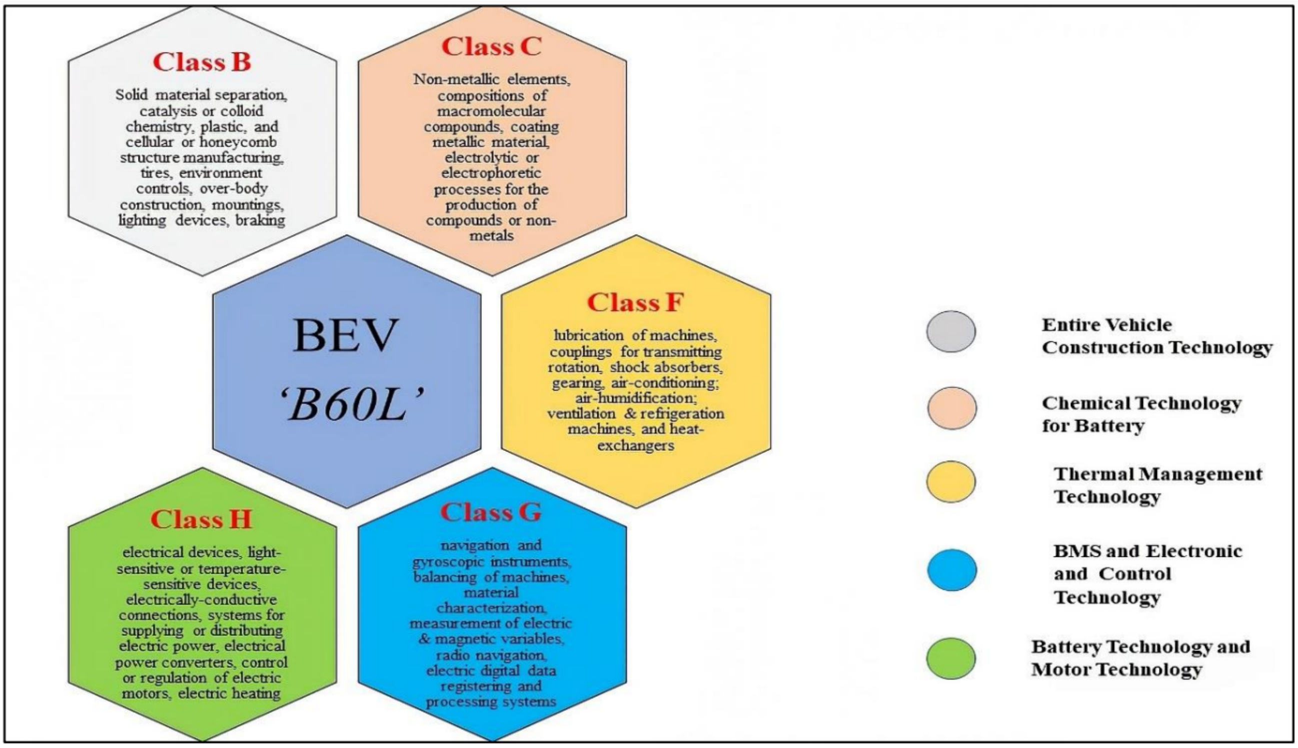

Figure 8 Major Technologies Converging in a BEV

From the IPC description, we find that solid material separation mechanisms, chemical or physical processes, e.g., catalysis or colloid chemistry; plastic and cellular or honeycomb structure manufacturing, tires, environment controls, over body construction, mountings, lighting devices, braking are amongst the technologies converging into a BEV from class B of IPC. Converging class C technologies focus on non-metallic elements, compositions of macromolecular compounds coating metallic material, and electrolytic or electrophoretic processes for the production of compounds or non-metals from the chemical engineering domain. The contribution to convergence from the mechanical engineering domain represented by class F covers lubrication of machines, couplings for transmitting rotation, shock-absorbers, gearing, air-conditioning; air-humidification; ventilation and refrigeration machines, and heat-exchangers, principally focusing on energy transfer, environment and thermal management of the entire BEV system. Class G representing patents in physics discipline were found to converge surveying, navigation, and gyroscopic instruments; balancing of machines, material characterization, measurement of electric and magnetic variables, radio navigation, electric digital data registering, and processing systems into a BEV. The distinctive feature of a BEV, electric propulsion; has a major representation of class H based electrical energy technologies focusing on cables; conductors; insulators; selection of materials for their conductive, insulating, or dielectric properties magnets, inductances, transformers; selection of materials for their magnetic properties, capacitors, rectifiers, detectors, switching devices, light-sensitive or temperature-sensitive devices, electrically-conductive connections, systems for supplying or distributing electric power, electrical power converters, control or regulation of electric motors, electric heating and printed circuits.

Conclusions

In this article, we developed a technology convergence network to identify critical technologies in a BEV. The results of this research have several implications, particularly for emerging technology management. The outcome of this work will lead to the identification of EV (BEV in particular) technologies, which can be further developed to assess the trends of technologies and associated gaps and provide prescriptive guidelines for subsequent technology selection, acquisition, and exploitation decisions. By examining the IPCs-based visualizations, we inform S&T management for strategy formulation. For example, measurement techniques and electronic devices appear underrepresented in BEV patenting, and the training to develop focused knowledge warrants consideration. This work can also benefit decision-makers at various levels of organizations. For example, the results of measurement and visualization at the IPC section level, being comparatively macro level, could aid top-level organizations and policymakers of nations to focus on S&T policy. The paper added to the body of knowledge an evidence-based approach to identifying the built-in technologies to produce a BEV. Further work under development aims to create a framework to select collaborative partners based on the technology gap from the global technology development network

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Appendix 'A'
IPCs with Betweenness Centrality (BC) value of more than 50

Section	IPC	Representative Technology
Performing Operation and Transportation (17)	B01D	Separation mechanisms
	B01J	Chemical or physical processes, e.g., catalysis or colloid chemistry; their relevant apparatus
	B29C	Shaping or joining of plastics; shaping of material in a plastic state
	B32B	Layered products, i.e., products built-up of strata of flat or non-flat, e.g., cellular or honeycomb
	B60C	Vehicle tires
	B60H	Arrangements of heating, cooling, ventilating or other air-treating devices specially adapted for passenger or goods spaces of vehicles
	B60J	Windows, windscreens, non-fixed roofs, doors, or similar devices for vehicles; removable external protective coverings specially adapted for vehicles
	B60K	Arrangement or mounting of propulsion units/transmissions in vehicles
	B60L	Propulsion of electrically-propelled vehicles
	B60N	Seats
	B60Q	Arrangement of signalling or lighting devices
	B60R	Vehicle fittings or vehicle parts
	B60S	Servicing, cleaning, repairing, supporting, lifting, or maneuvering vehicles
	B60T	Vehicle brake control systems or parts thereof; brake control systems or parts
	B60W	Conjoint control of vehicle sub-units of different types or different functions
	B62D	Trailers
	B62M	Rider propulsion of wheeled vehicles or sledges; powered propulsion of sledges or cycles
Chemistry and Metallurgy (7)	C01B	Non-metallic elements; compounds thereof
	C08K	General processes of compounding
	C08L	Compositions of macromolecular compounds
	C09K	Materials for applications
	C10L	Fuels
	C23C	Coating metallic material
	C25B	Electrolytic or electrophoretic processes for the production of compounds or non-metals

Mechanical Engineering, Lighting, Heating (12)	F01M	Lubricating of machines or engines in general
	F01P	Cooling of machines or engines in general
	F02B	Engine
	F02D	Control of Engine
	F02N	Starter of Engine
	F16D	Couplings for transmitting rotation
	F16F	Shock-absorbers
	F16H	Gearing
	F24F	Air-conditioning; air-humidification; ventilation
	F25B	Refrigeration machines, plants, or systems; combined heating and refrigeration systems; heat pump systems
	F28D	Heat-exchange apparatus,
	F28F	Details of heat-exchange or heat-transfer apparatus
Physics (12)	G01C	Measuring distances, levels or bearings; surveying; navigation; gyroscopic instruments
	G01M	Testing static or dynamic balance of machines or structures
	G01N	Investigating or analyzing materials by determining their chemical or physical properties
	G01R	measuring electric and magnetic variables
	G01S	Radio navigation
	G05B	Control or regulating systems in general;
	G05D	Systems for controlling or regulating non-electric variables
	G06F	Electric digital data processing
	G06K	Graphical data reading
	G06Q	Data processing systems
	G07C	Time or attendance registers
	G08G	Traffic control systems
Electricity (16)	H01B	Cables; conductors; insulators; selection of materials for their conductive, insulating, or dielectric properties
	H01F	Magnets, inductances; transformers; selection of materials for their magnetic properties
	H01G	Capacitors; capacitors, rectifiers, detectors, switching devices, light-sensitive or temperature-sensitive devices of the electrolytic type
	H01L	Semiconductor devices
	H01M	Batteries
	H01R	Electrically-conductive connections
	H02J	Circuit arrangements or systems for supplying or distributing electric power
	H02K	Dynamo-electric machines
	H02M	Apparatus for conversion between AC-AC, between AC-DC, or between DC-DC
	H02P	Control or regulation of electric motors
	H04B	Transmission
	H04L	Transmission of digital information
	H04N	Pictorial communication
	H04W	Wireless communication
	H05B	Electric heating
	H05K	Printed circuits

A framework for introducing precision agriculture technologies in Egypt

Abstract ID#197

Mahmoud Abdelsalam Abdelnabby, Tarek Hhalil (Nile University)

Precision Agriculture (PA) has been used in many countries along the past 30 years and serving the agricultural sectors. The use of PA solutions and applications intervened with many agricultural businesses and improved its operational management in addition to the support in decision making based on analytics and data management. Precision Agriculture provides accurate data representing the relationship between weather, soil, plants, and water which can be used in conduction of agricultural activities at farm level. Precision Agriculture depends on the use of several technologies such as image sensors, vision machines, drones, robots, machine learning, and artificial intelligence. The use of Precision Agriculture Technologies (PAT) depends on integration and complementarity between devices, sensors, and systems to ensure the proper implementation of activities. Therefore, the introduction of PA in Egypt must ensure that all the technological components are present at reasonable cost to be adopted by agribusiness and farmers.

There are many drivers to introduce the PAT in Egypt that include water scarcity issues, responding to environmental and climate change, increase production efficiency, support decision making and overcome the labour unavailability issues in the new reclaimed areas.

The agricultural ecosystem in Egypt enables the introduction of precision agriculture technologies as there are several universities and research centers focus on the use of PAT in agricultural but still this is conducted at research level and not reaching the proper diffusion of the technologies. There are many business development entities supporting startups in the PA field with technical support and access to market. In addition, there are international firms that are offering PA solutions in the market.

This paper is generated from research on the use and applicability of PA in the agricultural sector in Egypt that ended with a proposed framework for proper implementation and promotion of it. The conducted research depended on a survey, focus group discussions and an online questionnaire that reached 271 respondents from 19 Egyptian governorates. Statistical analysis has been used to test relations between variables and guided the development of a framework for appropriate introduction of PA in Egypt. The framework has been developed to enhance the role of an initiative leader or consortium to promote the introduction of PA through collaboration with other stakeholders in the agricultural sector. The proposed framework can be used by governmental, non-governmental entities as well as universities and private sector institutions. Furthermore, the proposed framework could be used at other countries similar to the Egyptian context or facing the same constrains.

Keywords: Precision Agriculture, Precision Agriculture Technologies, Image Sensors, Drones, Robots, Machine Learning, Artificial Intelligence, and Internet of Things.

The role of emerging technologies in reshaping the future of business and public services toward resilience and sustainability

Abstract ID#143 | Full Paper ID#422

Mohamed Azzam, Tarek Khalil (Nile University, EG)

Abstract: Since the outbreak of COVID-19 in March 2020, policymakers, business leaders, and even citizens realized that the heavy utilization of technology was the only path to deal with the consequences of this global health crisis on both economic and social levels. As well, the global health crisis and the war in Ukraine that started in late February 2022, proved that the desired socioeconomic resilience and sustainability would not be achieved unless we articulate and implement a holistic framework, in which emerging and disruptive technologies play a pivotal role in advancing businesses, public offerings, to match the sophisticated business and citizen demands and requirements. Therefore, the paper sheds light on the most recent emerging technologies, their role in reshaping the landscape of business and public offerings, and how such disruptive technologies would help achieve the ultimate goal of resilience and sustainability of countries and institutions.
Keywords: Innovation, MOT, Management of Technology, disruptive technologies, business future, sustainability, resilience

Introduction

Over the history of mankind, technology has always been the main driver of disruption. As technology progresses it opens new vistas for development for both public and private sectors. Each disruptive technology creates disruptive business models and changes the landscape of how we live and conduct business. Such disruptive technologies and their associated business models give policymakers and business leaders an opportunity to rediscover their businesses and increase their productivity and efficiency to provide better offerings for the different business and social sectors, and the community at large. However, it has always been a challenge to forecast how technology trends and their coupled business models will evolve and disrupt the status quo. Therefore, policymakers and business leaders should be prepared to monitor the advancement of emerging technologies and predict how such emerging technologies could affect their business practices now and in the future.

Therefore, the paper highlights the recent technology trends and the possible effect of such trends on business practices and public services. This is to form a guideline for public and business leaders to draw up a strategy for the future, a strategy that leads to economic and social development that is resilient and sustainable. Recent historical events, such as the outbreak of the COVID-19 pandemic in 2020, and the Ukrainian crisis in 2022, have shown the importance of building resilient, self-sufficient, and sustainable systems that can survive the shocks of global markets and supply chain interruption. Moreover, disturbances in supply chain operations and recent conflicts in open trade across borders to increase technological and competitive superiority reinforce the need of nations and institutions for resiliency (Mohamed Azzam and Tarek Khalil, 2022). Tracking and implementing emerging technologies in a timely manner is critical to overcoming these global shocks and guaranteeing survival and growth. Based on that, public and business leaders should know when to invest in these emerging technologies and when to implement them.

In the following section, we will draw attention to the major technological trends that might greatly impact socioeconomic development and create new business models in the near future.

The Major Technological Trends and the Expected Disruption

A recent report by McKinsey & Company (Michael Chui, Roger Roberts, and Lareina Ye, 2022), stated that there is an ambiguity concerning the emerging technological trends, however, it is noticeable that many industries would be transformed, in the near future, as a result of the spread of technology-enabled business, and technological innovation. Each emerging technology could influence more than one industry at the same time. Each industry could be associated with at least five technological trends. The amount of this influence would vary from one industry to another, as will be discussed later in this document. In the following sections, we will highlight the major technological trends and their impact on the main industries.

Applied Artificial Intelligence (AI)

Applied AI includes serval sub-technologies. Among these sub-technologies, there are machine learning (ML), computer vision, natural language processing (NLP), deep reinforcement learning, and knowledge graphs (Michael Chui, Roger Roberts, and Lareina Ye, 2022). This field has witnessed remarkable progression over the past decade in building intelligent machines capable of comprehending human intelligence and executing human assignments in a superior manner (Yue Wang and Sai Ho Chung, 2022). This technology is expected to have a major impact on most industries. These industries include aerospace and defense, agriculture, automotive, energy, healthcare, financial services, pharmaceuticals, logistics, media, telecommunications, and retail (Daniel Zhang et al., 2022). For the aerospace and defense industry, applied AI will enhance design techniques, by using visual simulation to test the performance of aircraft under various situations for increasing reliability and safety, as well as build novel models for mitigating security risks (Yue Wang and Sai Ho Chung, 2022). For Agriculture, applied AI will facilitate better optimization of different processes, including the ability to have precise forecasting for crop productivity. The development of unmanned tractor applications for increasing the agriculture sector productivity will be another significant application of applied AI. On the other hand, the automotive industry has started using robots on a large scale since the 1960s. The initial use of robotics in this industry was for spot welding and painting. The global automotive robotics market is expected to increase to $16 billion by 2026, out of $9 billion in 2020, at a Compound Annual Growth Rate (CAGR) of 10%, representing three times the CAGR of the automotive industry itself, during the same period. This is due to the rapid usage of robots in the production process of electric and hybrid cars; the rise of utilizing collaborative robots (cobots), which are used for handling an increasing range of tasks, including assembly, inspection, finishing, machine tending, and bin picking; and the proliferation of robotic 3-D printing technology used for producing parts on demand (Bogue, 2022). The applications of applied AI in the energy sector incorporate optimizing energy production, conducting preventive maintenance procedures for equipment, and analyzing consumption data. Also, the applications include applying computer vision to evaluate the size of reserves of the sites during the exploration of oil and gas and using ML to tailor drilling plans for geologically sophisticated areas. Applied AI applications in the healthcare and pharmaceutical sectors involve better diagnosis decision support and automated pathology discovery. The applications also include identifying molecules, creating chemical compound formulas, examining chemical combinations for optimized chemical development and production cycles, and discovering associations across various medical treatments and their combined results for finding novel medications. The financial sector will benefit from applied AI, as this technology will improve risk management in financial services, such as identifying credit card fraud to lessen cases of loss. For the retail sector, using ML to analyze the purchasing data and consumption patterns will assist the sector to increase sales by giving the buyers personalized and customized recommendations (Daniel Zhang et al., 2022) (Michael Chui, Roger Roberts, and Lareina Ye, 2022).

Next-Generation Communication Systems

The aim of having advanced communication systems is to enhance the geographic coverage of the communication networks and minimize the associated energy consumption and latency while leveraging the optimization of the spectrum and data utilization. This will assist individuals and industries to have high-quality access to networks and open the doors for innovative use models. The next-generation communication systems will consist of a combination of different technologies, such as fiber optics, which is considered the base for the most trustworthy high-speed low-latency wired networks; 5G and 6G mobile networks, which are the future of the mobile networks for providing high spectrum and bandwidth efficiency, and low latency; low-earth-orbit satellites, which help in offering better wide area coverage associated with considerably reduced latency compared to other satellite systems; the industrial Wi-Fi or Wi-Fi 6, which is of higher connectivity quality and security; and wireless low-power networks (LPWAN) for addressing the exponential growth of connected devices (Michael Chui, Roger Roberts, and Lareina Ye, 2022). The betterment of connectivity will be an enabler for other various technologies and applications to thrive. This includes the applications of Industrial IoT (IIoT) that will be dependent on advanced connectivity, such as 5/6G, LPWAN, and Wi-Fi 6. This will also be the case for other technologies, including mobile Augmented and Virtual Reality (AR/VR), mobile gaming, and cloud and edge computing. The rise of these technologies and applications will require low-latency high-throughput wireless networks to unlock their potential for different industrial sectors (Patricia Deflorin et al., 2021). On the other side the expected impact of advanced communication systems on the automotive sector incorporates the ability to have better preventive maintenance procedures, enhance navigation capabilities and decrease the possibility of collisions, and improve the vehicles' independence and shared-vehicle services while availing more personalized information in real-time to drivers and passengers (Elena Candelo et al., 2022). For the healthcare sector, the advanced low-latency communication networks coupled with the heavy utilization of connected sensors and devices will help the advancement and resilience of medical services by providing the possibility of real-time monitoring for patients at home, especially those suffering from chronic diseases (Maria Cristina Pietronudo et al., 2022). The benefits for the retail sector from using advanced communication systems can be summarized as the following: these systems will assist the retail industry to have better management of inventory, in addition to its supply chains, by tracking the raw materials and products flow and making data available to the different stakeholders within the supply chain, as well as utilizing AR technology for providing enhanced information for products to shoppers. Also, such technologies will help in the reduction of checkout activities. The adoption of advanced communication networks will be the foundation for eradicating the digital divide around the world. Having such high-speed low- latency networks will enhance the current user experience and open the doors for new use models that were unrealistic or unworkable in the past (Mohd Javaid et al., 2022).

Edge Computing

In the near future, computational nodes will be closer to the end-users for improving data latency and having better data autonomy. The computational nodes will include not only data centers, but also different nodes closer to the end-users that involve smartphones, gadgets and wearables, and cameras, or what is called (device edge). Also, these nodes include connected vehicles (remote edge); retail outlets, restaurants, and enterprise branches (branch edge); factories, airports, and hospitals (enterprise edge); and network access and aggregation points (network edge). This is to decentralize the computing process and run real-time computing at the point of presence (Michael Chui, Roger Roberts, and Lareina Ye, 2022). These emerging technologies will open new horizons for many applications, such as real-time fleet and traffic monitoring for better route optimization and efficient transportation systems. Also, this technology will form a platform for the improvement of autonomous driving technologies, as it will be able to process large data generated by autonomous vehicles' internal and external systems in real-time (Shengpei Zhou et al., 2021). This technology will also leverage healthcare services, including remote patient diagnostics and management, and tracking of active drugs. Moreover, it will enhance workforce safety on sites, by having real- time observation, and keeping the conditions of equipment monitored while optimizing their maintenance routines, for advancing efficiency (Sukumar Rajendran et al., 2022). Furthermore, edge computing will increase the development of local content exchange, proactive energy and asset management and maintenance within the facilities, pollution monitoring, customized content provision, passenger tracking and analytics within airports and train stations, and tailored personal promotions (Patricia Bazan and Elsa Estevez, 2022).

Quantum Technologies

Quantum technologies have been used in different applications for a long time, including laser applications and magnetic resonance imaging. However, quantum technologies are expected to be the base of radical disruption in three main sectors, which are computing, communications, and sensing, within a decade from today. Quantum computers will be capable of resolving computational challenges ahead of the capability of the current classical computers. This will help the industry to form sophisticated models for industrial chemicals and open the doors for a new wave of innovation for new materials. Modeling of quantum- mechanical structures such as molecules, chemical reactions, or electrons will establish novel use cases, including lead recognition in drug discovery, and simulation of proteins in pharmaceuticals and agriculture domains. As well, reducing computation times dramatically will establish new use models that will lead to portfolio optimization in almost all industries (Michael A. Piel, Karen K. Johnson, and Karen Putnam, 2019). Quantum communications will have a disruptive impact on cybersecurity. On a large scale, Chinese engineers and scientists employed quantum key distribution, which boosts the security of decryption keys by enabling verified randomness for creating shared keys. Moreover, Chinese technologists have progressed in quantum teleportation, which utilizes the properties of quantum entanglement to securely transmit data over a distance. As well, it is projected that the USA, EU, and China will use these technologies to construct a "quantum internet" of communications networks. Quantum sensing is expected to advance various applications, based on improved measurement accuracy. These applications include radar, navigation, microscopy, and magnetometers, as quantum sensing could deliver measurements of several physical quantities at a sensitivity that is better than traditional sensors. Therefore, such technology will develop the ability of submarines to avoid exposure and the capacity of surface vessels to maintain navigation in case of GPS disturbance (Oxford Analytica, 2022). Various industries will benefit from quantum technologies, such as the telecom industry, as it will be able to increase network security by using Quantum Key Distribution (QKD) technology and offer shared quantum-computing services. As well, the Oil and Gas industry will be capable of boosting the effectiveness of its exploration and extraction activities. The aerospace and defense industry will be utilizing quantum technologies to facilitate tamperproof communication practices and build augmented navigation systems. The pharmaceutical and chemical industry will be able to use quantum computing technologies to simulate molecules for developing new materials and discovering advanced drugs for treating different chronic diseases, including diseases, such as Alzheimer and Cancer (Michael Chui, Roger Roberts, and Lareina Ye, 2022) (McKinsey & Company, 2021).

Web3

Web3 represents the future of the internet. Web3 incorporates a set of platforms and applications that empower a decentralized internet; an internet with open standards and protocols for safeguarding digital ownership rights and offering end users better control of their data ownership and monetization while introducing new business models. This novel version of the internet will be dependent on blockchain technology. Blockchain technology is a decentralized and public database that permits data to be recorded on a network of computers securely, instead of centralized data centers (Alex Murray, Dennie Kim, and Jordan Combs, 2022). Also, Web3 will be based on using smart contracts which are software applications designed for building unchangeable code on a blockchain to be automatically implemented, when specific terms agreed upon between the signed parties are met. In addition to smart contracts, Web3 will use digital assets that are native digital intangible items, including cryptocurrencies and Non-Fungible Tokens (NFTs), which are exclusive digital identifiers that cannot be imitated, replaced, or divided. NFTs are recorded in a blockchain and employed to certify authenticity and ownership (Chohan, 2022). The development for Web3 is accelerated, as well as the investment. The number of active developers in the Web3 domain reached more than 35,000 developers in 2021, out of 5,000 back in 2016. Furthermore, the investment in this domain in 2021 was $30.4 billion, while this figure was less than $2 billion in 2017 (Michael Chui, Roger Roberts, and Lareina Ye, 2022). Now average individuals, even those who are not having coding skills, can build smart contracts using blockchain technology and protocols. Moreover, platforms such as DAOstack and Aragon are helping individuals to build blockchain applications. There are four main areas that will witness rapid development to form the backbone of Web3 that are cryptocurrencies, NFTs, Decentralized Autonomous Organizations (DAOs), and metaverses. Cryptocurrencies principally act as the native token of a blockchain protocol. Native tokens mainly differentiate Web3 protocols from the free protocols of Web 1.0 and Web 2.0. Fundamentally, any action that demands information creation on a blockchain consequently entails payment via its native token. This payment is mainly used to reimburse the individuals and organizations known as the "network validators". These network validators operate the physical hardware forming the decentralized network for a particular blockchain for executing the computational routines compulsory to add new blocks of data to this blockchain. In addition to native tokens, there is an important innovation that supports the emerging financial systems on blockchain, which is decentralized finance (DeFi). This innovation permits individuals and/or organizations to effortlessly generate their own currency on a blockchain protocol that can be exchanged between them. Therefore, Web3 will accommodate a variety of cryptocurrencies that can be exchanged within organizations and applications. This will be conducted by using decentralized exchanges (DEXs), such as Uniswap or Sushiswap; another remarkable application using blockchain protocols. DEXs allow users to exchange and liquidate native tokens and user-created (non-native) tokens, which makes DeFi ecosystem robust (Alex Murray, Dennie Kim, and Jordan Combs, 2022). The second application is NFTs. The main difference between NFTs and native and non-native tokens is that NFTs are interchangeable (fungible) and can be fractionalized. Also, each NFT is owned by a single user at a time, and NFTs can be engineered to save data and tracked with a high degree of specificity, which is not the case for native and non-native tokens. That's why NFTs are considered a significant disruption in the digital assets' domain, as using NFTs becomes a means for proving the legitimacy of digital ownership. Thus, NFTs are widely used for the exchange of numerous creative products, including videos, digital artwork, music, text- based work, and collectibles (K. B. Wilson et al., 2021). The third application is DAOs which are virtual organizations totally managed by protocols instead of human administrators. These protocols are encrypted and implemented through smart contracts that exist in a blockchain. These smart contracts facilitate the main principles of an organizational structure. This is to increase security, governance, and transparency while lessening the ability to violate or manipulate the rules or regulations. Unlike conventional organizations, smart contracts permit DAOs to systematize a set of procedures if specific circumstances are fulfilled, without human interaction with the system (Fabrice Lumineau et al., 2021). The fourth application is the metaverses, which are online massive multiuser 3-D platforms. Such platforms will make it possible for users to create their avatars and build their own virtual worlds. Also, users will be able to trade and exchange goods, such as virtual costumes and properties, against cryptocurrencies, as well as exchange NFTs. Moreover, it is expected that Meta (formerly Facebook) will bring AR/VR technologies into its metaverse, which might encourage corporates to have a presence on this platform as an extension of their existence on social media platforms (Alex Murray, Dennie Kim, and Jordan Combs, 2022). Therefore, Web3 is expected to profoundly impact media, gaming, and entertainment industries. This technology will enable new experiences for users and open doors for interoperability between the different applications and platforms. Also, Web3 DeFi technology could autonomously execute analogous functions for traditional financial organizations, including transaction handling and asset management, with different degrees of security and governance (Anutosh Banerjee et al., 2022).

Bioengineering

Bioengineering represents the intersection and convergence of biological technologies and information technologies. This branch of science and technology is expected to have a great socioeconomic effect and is characterized by four main domains that are biomolecules, biosystems, biomachine interfaces, and biocomputing. Biomolecules are the process of mapping and engineering intracellular molecules, such as DNA, RNA, and proteins for studying omics, including proteomics, and genomics. Biosystems are systems that are designed for diagramming and constructing complex biological organizations, processes, and interactions, such as cells, tissues, and organs. Biomachine interfaces are for linking the nervous systems of living organisms to machines. Biocomputing is for employing cells and cellular components for storing, retrieving, and processing data (Michael Chui et al., 2020). The domains of biomolecules and biosystems have witnessed substantial development over the last decade. The virtual-vector gene therapy has been used for the perpetual substitution of poor-functioning genes to handle genetic diseases, where modified viruses act as drug-delivery vehicles of genetic sequences, which represents hope for incurable diseases, such as cystic fibrosis, and even can treat diseases before they are symptomatic. This technology is projected to be the base of treating more than 10,000 diseases triggered by a single gene, such as hemophilia, or by an amalgamation of genes, such as cardiovascular. Furthermore, this technology will be the instrument for treating cancer at all stages and preventing aging. Moreover, mRNA therapy will produce synthetic mRNA to be converted into protein to handle missing or mutated genes; a technique that was used for generating COVID-19 vaccines, as well as utilized for providing personalized treatment for viruses like HIV (Mengmeng Zhang et al., 2022). Additionally, tissue engineering technology has been utilized to cultivate meat by growing small samples of animal cells inside a disciplined ecosystem for matching traditional meat qualities (Michael Chui, Roger Roberts, and Lareina Ye, 2022). For biomaterials, drop- in technology is used for substituting fossil-fuel-derived chemicals with biochemicals without altering existing production procedures. This is for developing cost-effective materials with insignificant production interference and presenting environmentally friendly substitutes, such as bioethanol-based polyethylene, instead of conventional chemicals that have a high carbon footprint. This technology will greenly transform large industries, such as the textile industry, by using bio-textiles, such as mushroom leather and spider silk, as well as the cosmetic industry, by making personalized products that fit with individuals' skin microbiomes (Tom Brennan et al., 2021).

The economic impact of emerging technologies and why should policymakersand business leaders pay attention to these technologies?

The progression of emerging technologies is shaping the future of the economy. Applied AI is expected to add around $15 trillion to the global Gross Domestic Product (GDP) by 2030. This is due to many reasons that include the exponential innovation growth in this sector by 30x over the last few years, as the number of filed patents witnessed a compound annual growth rate of 77% over the period 2015-2021. This is fueled by private investment in AI-based startups and projects that reached almost $95 billion in 2021. Subsequently, there is remarkable progress in the training speed of AI models doubled since 2018 which helped public and private enterprises to increase their AI adoption by approximately 56% over the same period. Applied AI will create a new landscape to boost productivity by reducing expenditure while enhancing efficiency, as well as reveal novel business models due to automation and acceleration which will unlock new business capabilities. Using swiftly generated 3-D models, which are developed by applying reproductive procedures that combine 3-D visuals based on singular or multimodal directives will leverage the design and production process in various industries, such as retail, textile, and automotive. Furthermore, applied AI will assist the executives within the enterprises to reach agility and resilience by optimizing the workflow dynamically through multitasking learning to give precedence to the most relevant tasks, during the production process. Applied AI will be able to employ numerous sensor inputs to execute tasks, such as in the case of autonomous driving. Likewise, applied AI will help executives to forecast and recommend prospective products related to a customer's activities based on prior customer data. Applied AI will also help sectors like the financial and eCommerce sectors to reduce operational risks by identifying possible illegal activities, such as unauthorized credit card transactions and account logins to decrease cases of fraud (Michael Chui, Roger Roberts, and Lareina Ye, 2022) (Lei Wang et al., 2021).

The next-generation communication systems are expected to add around $2 trillion to the global GDP by 2030, due to the improvement of operational activities resulting from utilizing advanced connectivity, being the key enabler for a radical digital transformation. Moreover, these technologies will present a vehicle to include more than 200 million people, around the world, in the digital society for the first time. The manufacturing sector will benefit most from the advancement of communication systems, as it is projected that these technologies will add more than $270 billion to this sector by 2030. Furthermore, these technologies are expected to add approximately $130 billion to the service industry, such as healthcare and education, and $96 billion to the public administration sector (Stefano Suardi and Pau Castells, 2022).

Edge computing will be a complement to the growing cloud computing market. Cloud computing is neither public nor private anymore, but it has become a hybrid. The hybrid computing model is expected to optimize the operational cost of the top fortune 500 companies by $1 trillion by 2030. The rapid development and utilization of services, such as Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS) are leading the growth of this sector by almost 25% CAGR to reach $300 billion by 2030. Moreover, the global expenditure on edge computing is expected to be around $250 billion in 2025, with a CAGR of 10%. Edge computing will offer both public and private enterprises an agile and resilient mechanism to accomplish better data autonomy and security with minimum latency. Edge computing will assure compliance with laws and regulations related to data sovereignty, as edge computing will allow better control of data by minimizing data dependency on public clouds. Moreover, edge computing will enhance data security measures, and improve the digital trust factor among individuals and enterprises, as processing data only on the public cloud is always skeptical due to the mental image of having a possibility of data breaches because of using shared infrastructure. As well, edge computing's low data latency will open the doors to building neuromas use cases that are dependent on real-time data processing, such as autonomous driving, and smart factories, logistics, and utilities (Auday Al- Dulaimy et al., 2020) (Aaron Bawcom et al., 2022).

The size of quantum technologies use cases is expected to be $300-700 billion in industries, such as aerospace and defense, pharmaceuticals, healthcare, finance, automotive, and chemicals. The size of investment in startups operating in this domain doubled from 2020 to 2021 to reach almost $1.7 billion, and the market size is projected to reach $44 billion by 2028, which is growing at a CAGR of 30 % since 2021. This domain of technology will make impossible computing tasks possible. Scientists and engineers are working on enhancing quantum stand-alone processors that are capable to deal with more sophisticated computing tasks for process optimization in different industries, build improved models of the properties of small molecules for producing new products, especially in pharmaceuticals and chemicals domains, and have a better sampling of data to shorten the time required for AI training tasks. Therefore, there are several advantages for early movers that include establishing the ecosystem early and setting the industry standards for this fresh field. Based on that, enterprises should be ready for the quantum technology age by starting to build teams in this domain, and recognizing use cases that will be benefiting from this technology to keep the enterprise ahead of the competition (Alexandre Ménard et al., 2020) (Matteo Biondi et al., 2021).

Web3 will form new business models based on the elimination of middlemen. This will be done by coding the current roles into autonomous smart contracts. Thus, Web3 will present broader economic prospects by shifting the accumulation of value in the direction of end-users and suppliers away from intermediaries, as Web3 is opensource that allows users to access, generate and possess data and digital assets globally without the interference of those intermediaries. It is expected that Web3 will witness rapid advancement due to its modularity nature, which will encourage building a global network of developers who would lead the next wave of innovation in this domain by increasing the rate of developing the Web3 applications. Furthermore, the innovative applications of Web3 will necessitate developing new infrastructure and means to be able to scaleup for addressing the projected services. This also will open new vista for creating various middleware software tools and development platforms, which is accelerating the investment in this domain to reach almost $40 billion in 2022. Web3 will help to unify the user experience, as it will allow transactions from omnichannel to single channel and integrate the digital identity of the users throughout the different platforms and applications seamlessly, by adding a common decentralized blockchain data layer. Based on that, Web3 will establish new business models for the entertainment and gaming industry, as players can gain digital assets that can be monetized through peer-to-peer and value change networks or exchanged across various Web3 gaming and metaverse platforms. Likewise, Web3 will impact the retail industry in different ways, as users will have better control over their data ownership, and retailers will be able to develop new techniques for customer acquisition, engagement, and retention, based on the personalization of offerings. Also, Web3 will make it possible to build native digital assets and digital twins of physical items that could be used for new product development and brand identity. The financial sector will also benefit from Web3, as this economic sector will be more efficient on both cost and operational levels by using smart contracts, and mitigating the risks associated with credit provision (Alex Murray, Dennie Kim, and Jordan Combs, 2022) (Chohan, 2022) (Anutosh Banerjee et al., 2022).

For bioengineering, it is estimated that the yearly economic value of this domain will be $2-4 trillion by 2030. There are more than 400 technically viable use cases recognized across different industries. This field will give an opportunity to tackle global challenges, including challenges related to healthcare, production, and the environment. Bioengineering will open venues to develop more advanced healthcare solutions and novel treatments and cures for a variety of diseases that represent a challenge to humankind for ages, including monogenic and polygenic diseases, cancer, and elderly diseases. This domain will also make the production techniques more sustainable and environmentally friendly, while achieving cost reduction, as well as a mechanism for producing renewable energy resources with low carbon emissions. Bioengineering will assist in addressing global food shortage, by increasing access to more sustainable high-value food sources and disrupting the food supply chain. Also, this domain will boost the development and production of cost-effective, high-quality, and eco-friendly biomaterials and chemicals for usage across different industries (Ananya Gupta et al., 2021) (Tom Brennan et al., 2021) (Michael Chui, Roger Roberts, and Lareina Ye, 2022).

Based on the above, the following table illustrates the anticipated impact of these emerging technologies on different industries.

Table 1: Impact of Emerging Technologies on Industries; Source: Adapted from Technology Trends Outlook 2022. McKinsey

Industry/Technological Trend	Applied AI	Next-Gen Comm Sys	Edge Computing	Quantum Tech	Web3	Bio-engineering
Aerospace and defense	□	□	□	□	□	□
Agriculture	□	□	□	□	□	□
Automotive and assembly	□	□	□	□	□	□
Aviation, travel, and logistics	□	□	□	□	□	□
Chemicals	□	□	□	□	□	□
Construction and building materials	□	□	□	□	□	□
Consumer packaged goods	□	□	□	□	□	□
Education	□	□	□	□	□	□
Electric power, natural gas, and utilities	□	□	□	□	□	□
Financial services	□	□	□	□	□	□
Healthcare systems and services	□	□	□	□	□	□
Information Technology and Electronics	□	□	□	□	□	□
Media and entertainment	□	□	□	□	□	□
Metals and mining	□	□	□	□	□	□
Oil and gas	□	□	□	□	□	□
Pharmaceuticals and medical products	□	□	□	□	□	□
Public and Social Sector	□	□	□	□	□	□
Real Estate	□	□	□	□	□	□
Retail	□	□	□	□	□	□
Telecommunications	□	□	□	□	□	□

High Impact	□

Therefore, public and business leaders should track the landscape of technology. They should know when to invest in these emerging technologies and when to employ such technologies within their institutions and enterprises to become sustainable, self-dependent and resilient. Such technology may be acquired through internal R&D efforts or external venture or tactical and strategic alliances. According to the technology performance parameters, If the technology is still in its embryonic stage, decisionmakers should monitor it closely, and if the technology is in the early stage of growth, but its pace of development is high, they need to invest selectively. If the technology is approaching maturity, decisionmakers should build it systemically, and if it is closer to its physical limits, they should disassociate from it (Khalil, 2000), as illustrated in the following figure:

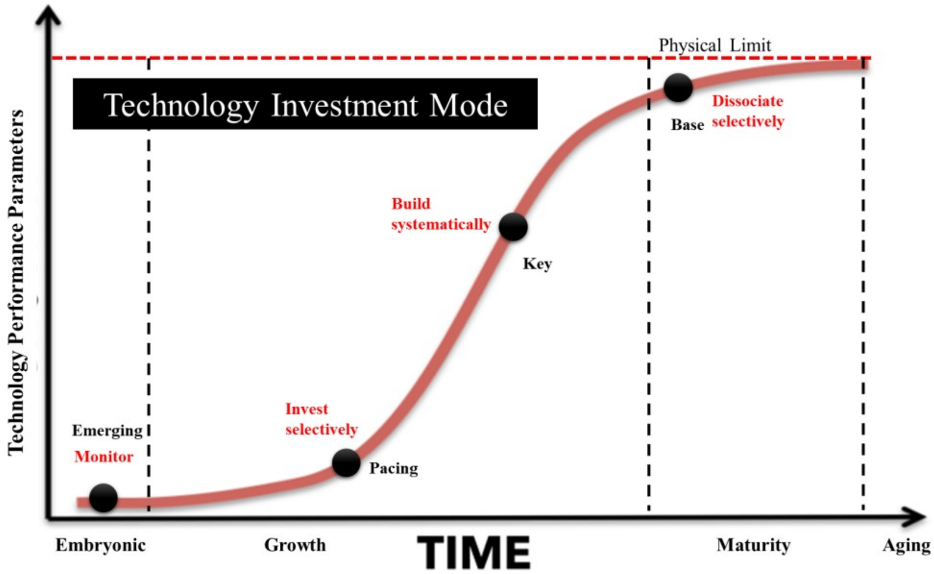

Figure 1: Technology Investment Mode; Source: Adapted from Tarek Khalil, Management of Technology: The Key to Competitiveness and Wealth Creation. McGraw Hill, 2000.

Conclusions and Recommendations

In this study, we investigated six major technology trends that are Applied AI, next- generation communication systems, edge computing, quantum technologies, Web3, and bioengineering. Applied AI, next-generation communication systems, edge computing, and bioengineering trends are based on established and mature technologies and have a multitude of feasible industrial applications. Therefore, it is anticipated that they will realize a considerable growth in the near future. On the other hand, trends such as quantum technologies and Web3 are still in the emerging development phase and might take time to reach the maturity phase; however, they can avail major disruption to different industries and reshape their business models.

In all cases, policymakers and business leaders should keep an eye on the future. They need to assess and analyze the emerging technological trends and forecast their probable implications on their businesses and organizational structure. Therefore, policymakers and business leaders should be acquainted with the pace and the direction of technological advancement and define a strategy on both mid and long terms to cater such technological disruption.

Both public and business leaders should track the progress of the emerging and disruptive technologies to plot the investment strategies needed to capitalize on the benefits of the implementation of such technologies. Such a step is very critical to the competitiveness of the enterprises and institutions, and even to their survival. Public and business leaders should also identify the strengths and weaknesses with respect to their organizations' technological readiness and benchmark their organizations against their best-in-class peers. Then, this should be followed by developing an integrated path for embedding these emerging technologies in their core operation and production units to have better offerings for their beneficiaries, while adjusting their business models accordingly. Public and business leaders should build a mechanism that fosters organizational innovation with respect to developing new working models, better utilization of the power of technology and its use models, as well as taking advantage of the power of data, to keep their organizations sustainable, agile, and resilient to match the dynamics of the technology progression and the markets. This is simply the role of management of technology.

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Leveraging technology in protecting traditional knowledge: the case of India and Kenya

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Abstract: The contemporary age of the 21st century belongs to the knowledge economy and technological age. Knowledge economy brings in the role and contribution of Intellectual Property (IP) in greater respect. Within the IP domain, two fundamental keywords are technology development and innovation which hold relevance. This century, in parallel terms, also draws in the significance of climate, culture, tradition and its co-existence with that of human beings. To utilize the resources to the possible extent to develop and innovate, a country cannot afford to leave behind its sociocultural identity, especially those of developing countries. Such countries are a huge reservoir of rich traditional knowledge (TK) in form of cultural heritage. These contents are precious in terms of existence, development, management, and building a scientific temperament. India and Kenya are developing countries with rich heritage content within their jurisdiction. Technology plays a crucial role in advancing the measures to protect these heritage contents held by indigenous communities in form of TK. The objective of this study is to explore the measures of TK protection with the role of technology in strengthening the protection of TK in the technological age. The authors have followed an exploratory research methodology. World Intellectual Property Organization- Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (WIPO-IGC) meetings held over the domain of TK protection and attached meeting documents have been extensively studied and relevant data have been extracted. A comparative approach is undertaken to understand the difference in approaches taken by India and Kenya to protect TK in their national jurisdiction.
Keywords: Management of Technology, Intellectual Property, Traditional Knowledge, Developing Countries, WIPO IGC.

Introduction

Human history has a glorious past with rich accounts of cultural content. These contents include art and craft, music and folklore, songs and stories, tools and techniques, medical know-how and traditional medicines. These contents are recognized by terms such as ‘indigenous knowledge’ (IK); ‘traditional knowledge’ (TK). Though IK is a subset of TK, they are often used synonymously. Accordingly, UNESCO holds that IK is local knowledge unique to a given culture or society. It forms the basis for decision-making in local contexts of agriculture, health care, food preparation, education, natural resource management and a host of other activities in rural communities. With the onset of the 21st century marking the technological era, this knowledge over time started wide-spreading and was used commonly not only by respective communities but a quantum of the population that had access to these contents. This scenario did not pose any significant problem to the local and indigenous communities which were acting as the custodian of such knowledge. Technology made these contents accessible and its misappropriation has further posed severe issues. Knowledge of these communities was beings used without due acknowledgement. These kinds of knowledge attract the role of Intellectual Property (IP) as with the horizon of the time, the communities put innovation into these contents and transfer it to the younger generations. IP refers to the creativity of human intellect in the form of inventions, literary and artistic works, designs, performances, plan varieties, names, signs, and symbols. Various forms of IP protection include patents, copyright, trademark, design, geographical indications, and plant varieties depending on the relevant subject matter.

IP protection requires certain prerequisite conditions, based on the subject matter in question, to be fulfilled. These are the general requirements for seeking protection. The subject matters of TK, genetic resources (GRs), and traditional cultural expressions or expressions of folklore (TCEs) do not find a suitable fitting into the existing protection regime created under the IP system. This is one of the major challenges that WIPO-IGC has been instituted and tasked with to deliberate on the matter and build consensus among the stakeholders towards an international instrument like TRIPS to protect TK. The rich endowment of such knowledge and biodiversity plays a critical role in health care, food security, culture, religion, identity, environment, trade and development of the indigenous and traditional communities along with the nation. IP system often considers these traditional contents into the public domain, therefore allowing their free use by anyone without any restriction. There is strong opposition against this "public domain" approach.

With the development of technology, the frequency of misappropriation has increased multifold. Such a scenario warrants the content to be protected and properly managed for the benefit of the community at large, with the intervention of technology to achieve the goal effectively. The technological intervention has alternate aspects attached to it. One aspect advances and strengthens the protection of TK and the other favours misuse and piracy of the cultural content. In reference to this, the present study objective is to explore the technological standards/measures adopted towards effective management, preservation and protection of traditional knowledge. To meet the abovesaid objective of the study, the following research questions become crucial,

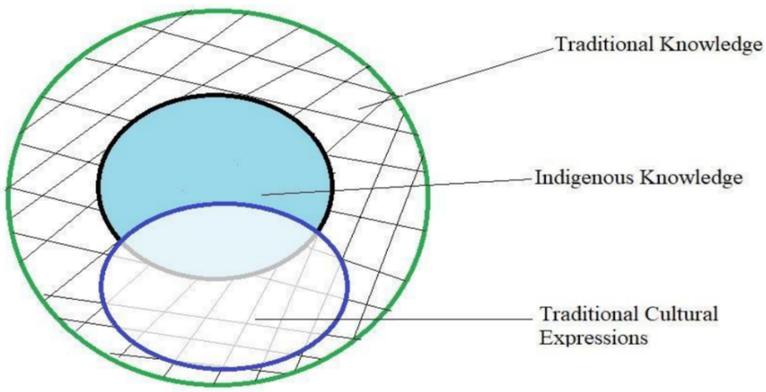
- R.Q.1 What are the existing technology initiatives adopted in the preservation and protection of TK?
- R.Q.2 How India and Kenya have utilized technology to preserve and protect TK?

The authors have followed exploratory research methodology to fulfil the said objective of the study. The data has been collected through a range of secondary sources dealing with TK protection along with the incorporation of technological measures. India and Kenya are developing countries with rich traditional knowledge content within their jurisdiction. The efforts and initiatives adopted by these countries still have a long way to go due to the intrinsic challenges faced while protecting such content. Technology may contribute to turn these challenges into opportunities to act and succeed.

Theoretical Background

WIPO acknowledges that there is not yet accepted definition of the term 'TK' against which all probable connotations of the term are deliberated. WIPO attempted to deliver a working description of the term (WIPO, 2018). Simply put this subject matter incorporates several contents of knowledge along with traditional cultural expressions, including distinctive signs and symbols associated with traditional knowledge (Figure 1). TK encompasses a large body of knowledge. It incorporates 'information' like trees and plants that grow well together; 'practices and technologies' like bone setting methods; 'beliefs' like holy forests that form vital watersheds; 'education' like apprenticeships and 'communication' like folk media (Sen et al., 2006). As per the WIPO-IGC glossary, "Protection" refers to the protection of TK against some form of unauthorized use by third parties which takes two forms. These two forms are positive protection and defensive protection. Positive protection underlines not only preventing others from gaining illegitimate access to such knowledge or using them for commercial gain without equitably sharing the benefits with the custodian communities but rather enabling the custodians to build up their enterprises based on their TK. Defensive protection can be understood as a set of measures to ensure that there are no illegitimate or unfounded IP rights over TK subject matter and related genetic resources of any traditional and indigenous community. This form of protection includes measures to pre-empt or invalidate such IPs that illegitimately claim pre-existing TK as inventions.

Figure 1: Traditional Knowledge System (Prepared by the authors)



Most of the contents of TK systems are influenced by rapid population growth, modern technology and development, globalization, and educational systems to a great extent (Padmasiri, 2017). Girardi et al., (2015) describe the loss of traditional knowledge as a global reality in this era. Subba Rao (2006) critically views the prevailing situation as traditional knowledge is at risk of becoming extinct due to rapidly changing natural environments and fast pacing economic, political, and cultural changes at a global scale. TK incorporates several characteristics within itself (Figure 2).

Figure 2: Characteristics of TK (Source: Ghimire, 2021)

While digital technologies enable materials to be easily repatriated, widely distributed and annotated indefinitely, these technologies present challenges to indigenous communities who wish to preserve traditional cultural protocols for displaying, disseminating, and reproducing these new cultural materials (Bell, 2013). Challenges identified in the collection and management of TK include language barriers, funding, technological challenges, and intellectual property rights (Sraku-Lartey et al., 2017). In the present age, technology is at the core of human activities, there arises a need to introduce it to complement the TK preservation which mainly comprises “oral tradition” and is facing challenges of becoming extinct. However, Lodhi et al., (2010) find that the introduction of technology must be minimalistic but geared towards user-friendliness, more context-sensitive and representative of the local communities.

Doubtlessly Information and Communication Technology (ICT) in general has enormous potential to improve the availability and accessibility and dissemination of IK while adding value to the IK system. ICT plays a significant role in improving the availability of indigenous knowledge systems and enhancing their blending with modern scientific and technical knowledge (Adam et al., 2010). Incorporation of new and innovative high-quality 2-D and 3-D scanners along with collaborative interactive software tools, high-speed networks and emerging grid technologies would enhance communication and the sharing of these contents and provide for infrastructure according to the need towards the implementation of preservation programs (Hunter, 2005). Many indigenous communities wish to maintain control over the circulation of certain types of knowledge and cultural materials based on their own cultural structures (Christen, 2009). Digital technologies and the Internet have merged to produce both the possibility for greater indigenous access to material collections held in collecting institutions, as well as a new set of tensions for communities who wish to monitor these materials and thereby limit their access and circulation (Bell, 2013). It is widely acknowledged that tacit indigenous knowledge can be managed through the application of relevant ICT tools (Ngulube, 2005).

Biopiracy, misappropriation and non-authorized use are among the driving forces that have brought the discussion about these subject matters to international fora. These contents are misappropriated for economic gain and even patent rights are obtained with no consent of the holders of such knowledge and with no benefit sharing in return. Specific to the Indian experience attempts to obtain patents through misappropriation of TK came to light for the first time when a patent application was filed for turmeric in the United States Patents Office (USPTO) (Ruiz, 2002). This application was challenged on the conditions of non-fulfilment of novelty and non-obviousness by the Government of India (precisely the Council of Scientific and Industrial Research, CSIR). The references utilized to support the opposition were from ancient Indian scriptures along with an article from an Indian medical journal about the use of turmeric for the claimed purposes for many centuries (Swamy, 2014). Consequently, the USPTO revoked the patent after such opposition. A similar attempt to obtain a patent over neem, which is used as an insecticide and pesticide, was attempted in European Patent Office. The basmati patent was similarly filed on the pretext of being a new variety. These controversial patent applications relating to neem, turmeric and basmati are representative in nature. There is a looming threat over these age-old rich cultural assets held by the local and indigenous communities which have remarkable tacit knowledge relating to almost all segments of human life and the effective management of resources (Ragavan, 2001).

A number of countries are using different ICT to majorly develop digital libraries of TK both to use the knowledge in current community projects and to prevent misappropriation of the knowledge through commercial patents (Hunter, 2005). Many indigenous communities are creating local TK databases, either formally or through Indigenous Knowledge and Cultural Centers (IKCs) created especially for this purpose (Figure 3). The digital content is put together and presented within these centres is either locally recorded, donated, or repatriated from outside private and public collections owned by museums archives, community members, and other organizations.

Figure 3: Approaches to Navigating Content in TK databases (Source: Hunter, 2005)

Methodological Procedures

This research took the form of an exploratory study. The research paper uses the case study method because it allows for a comparative study of different systems that attempted to preserve traditional knowledge in digital formats. The case study includes the protection initiatives of two countries namely, India and Kenya. While choosing the appropriate country to get a comparative analysis of protection measures towards TK, we also carried out a comparison of general and some key socio-economic data available in World Bank (World Bank Data, 2020). UNESCO list of World heritage properties inscribed by state parties' data is also taken into consideration for these two countries (UNESCO, 2021). We also based our decision to consider these countries in the research study due to factors leading towards TK protection through several parameters of constitutional provisions, IP legislations favoring TK protection, associated policies and other measures. One of the anchoring factors towards the inclusion of Kenya in our study is the sui-generis system of protection of TK which only a few countries practices and among them, Kenya falls closer to India.

Range of secondary sources have been considered to compare different measures within the context of digital preservation. The relevant legal measures of both countries have been considered to analyze the extent and nature of protection. WIPO-IGC meeting document held over the domain of TK protection has been extensively studied and textual data have been extracted (Saunders et al. 2019). Textual data relating to initiatives adopted by the respective countries to protect and preserve TK have been obtained from secondary sources. To carry out the present research, the authors have adopted the manual content analysis method. In this process a coding scheme is developed on the themes which have guided our analysis in the discussions section. The coding is generated from the data by reviewing the content and identifying common themes and patterns. The codes are analyzed leading to the interpretation of the results which is entailed in discussions. We have added sample content analysis in the results section of the paper (Table 2).

Results

In the age of digitization and technical advancement, traditional folklore has secured itself into digital dominion through the emergence of depositories, digitalization, and online libraries. The objectives and ends of efforts of digitalization are the preservation of folklore promoting open access and making information accessible online ensuring cross-cultural exchanges; the creation of databases by indigenous communities for preserving their knowledge and to fight biopiracy by outsiders (Kansa, 2009). There lies a stark difference in the methodology to protect these contents in India and Kenya. In this light, the approach taken by Kenya with enacting the sui-generis system of TK protection can be regarded as a positive protection mechanism. India's Traditional Knowledge Digital Library (TKDL) is said to be a defensive protection mechanism. It would be appropriate to consider that countries which rely on digital libraries on TK towards its protection can be said to be adopting the defensive mode of TK protection.

India

With the aim to protect TK and allied subject matters, India is moving ahead with certain initiatives to create online libraries and digitalized databases of TK. Before discussing these initiatives, the perusal of Constitution of India, 1950 becomes important. The Constitution is the supreme law of the land being 'grundnorm'. It incorporated fundamental rights available to individuals of the nation. One of the most widely interpreted provisions in the Constitution is Article 21, which provides for the fundamental right to life and personal liberty. This provision has a large number of liberal interpretations and relying upon the same; it can be used as a measure to argue in favor of protecting the rights of TK holders. Article 29 (1), grants protection of the cultural rights of minorities as a fundamental right. However, this fundamental right is available to only such communities that are falling within the scope of minorities protected under the section that can safeguard their rights. One of the fundamental duties under Article 51A (f) requires the preservation, respect, and safeguarding of the rich heritage of the Indian culture by every citizen of India.

One of the first initiative was the institutionalization of TKDL in 2001 after the controversial patent filed in different jurisdictions over the knowledge which resided within Indian society. The TKDL intends to remove barriers based on language and format for the existing TK of Ayurveda that is accessible to the public in India. While developing the library, the Indian government anticipated that this step will be able to successfully defend India's rich TK and speed up the invalidation of existing patents on inventions based on TK that do not meet the criteria for patentability when compared to traditional knowledge as prior art (Table 1). The retrieval of TK which is already in the public discourse is facilitated by using classification tools such as the Traditional Knowledge Resource Classification (TKRC) and posing the information available in several languages including English, French, German, Spanish and Japanese. The digital library does not instil any specific rights to indigenous communities over their knowledge. However, it enables the protection of such TK from misappropriation by breaking the barriers of language and access (Gupta, 2000). Health Heritage Test Database comprises literature (non-patent and patent) on over fifty medicinal plants endemic to South Asia and their traditional uses in the codified knowledge systems of traditional medicine in South Asia.

Table 1: India's Defensive protection to TK (Source: "Inventory of Existing Online Databases Containing Traditional Knowledge Documentation Data" WIPO IGC, 2002)

Objective	Functionalities	Specifications	Example Databases
Defensive protection	Data search and retrieval integrated with other forms of non-patent literature	Integration of TK data with existing databases and services used in prior art searches;	Health Heritage Test Database (India) integrated with WIPO IPDLs and PCT Search Engine
		Text-based search and retrieval	Health Heritage Test Database (India)
	Translation to and from local languages	Automated translation	TKDL (India)
	Bibliographic references	Data fields and standards for bibliographic references	TKDL (India) and Health Heritage Test Database (India)
	Security Measures	Security protocols (e.g., firewalls, using SSL (Secure Socket Layer), if the database is accessible through Internet websites)	TKDL (India)

The National Mission for Manuscripts (NMM) was established in 2003 by the Ministry of Tourism and Culture, GoI. The mission agenda is to document, preserve and digitalize the rich number of manuscripts of India which is our wealth. These rich manuscripts have a wide variety of aesthetics, calligraphies, illuminations, illustrations, languages, scripts, textures, and themes. As per Manuscript Resource Centres (MRC), 42.03 lakhs of Manuscripts have been documented. In the process of the digitization project, approximately three lakhs ancient and traditional manuscripts (2.61 Crore pages) have been digitized (NMM, GoI).

A comprehensive mission 'National Mission on Cultural Mapping and Roadmap (NMCMR)' was launched by the GoI in 2017. The mission comprises three objectives. Firstly, to create awareness across the country about India's rich cultural heritage. Secondly, a program to identify rich cultural artists and promote them. Thirdly, the establishment of a National Cultural Workplace (NCWP), a centralized web portal with an enriched database and demography of several cultural assets and resources including all art forms and respective artists (PIB, 2017). One important part of this Mission is towards the adaptation of technology to the possible extent. Development of high-quality e-content, for loading onto 'NCWP' in all disciplines and subjects, at various levels using the best available authoring tools and making the fullest use of animation and multimedia technologies.

The establishment of the Indira Gandhi National Centre for Arts (IGNCA) in 1985 is one such approach towards maintaining a repository of traditional content along with other initiatives. An initiative taken by the centre is to digitize the expressions of traditional culture like artworks, audio, books, manuscripts, video etc. The Indian National Trust for Art and Cultural Heritage (INTACH), a Non-Governmental Organization established in 1984 acts towards creating awareness and protection of the tangible as well as intangible heritage of India. The organization aims to develop policies and regulations and make legal interventions that would result in the protection of India's heritage when necessary. Another effort in this regard is the setting up of the National Folklore Support Centre (NFSC). This centre put efforts into documenting and is involved in creating archives with the help of the traditional communities.

Kenya

Kenya, an African nation has adopted a sui generis system of protection for TK (The Act, 2016). The Constitution of Kenya obligates the state to support, promote and protect the IP rights of the ‘people of Kenya’ [Article 40(5)] and to protect and enhance the IP and ‘indigenous knowledge’ associated with biodiversity and ‘genetic resources of the communities’ [Art. 69(1)(c) & (e)]. It recognizes culture as the foundation of the nation and cumulative civilization of the Kenyan people and nation [Art. 11(1)] and requires the State to promote IPRs of the people of Kenya [Art. 11(2)(c)]. It also enjoins parliament to enact legislation, to ensure that ‘communities receive compensation or royalties for the use of their cultures and cultural heritage’ [Art. 11 (3)(a)]. The sui generis Act of 2016 broadly discusses several key aspects linked with the protection of these traditional subject matters. This legal document of Kenya offers to protect TK through the system of sui generis mode and does not rely on existing IP legislations or other legislations touching indirectly upon the TK. Article 2 of the Act provides the definition of the term ‘traditional knowledge’ and outlays a broad description of the term (Article 2, the Act of 2016). The law attempts to maintain a balanced approach by granting some exceptions and limitations to bridge the gap between the private need and the public need of the contents of TK. The Act produces a well-devised and broad approach to the protection of TK. The Act hardly puts emphasis on the incorporation of technological measures in the protection regime. There is no direct provision stating the obligation of the government to bring in the role of appropriate technology to preserve and protect the knowledge of indigenous communities.

Another enabling document being traced to the intervention of technology with the protection regime is the policy of 2009 intended for TK, TCEs and GRs. The Millennium Development Goals (MDGs) and Vision 2030 have both served as sources of inspiration for the policy. The policy seeks to construct a system that goes beyond merely recording and preserving previously created TK that might be in danger of vanishing. It not only envisions a system that aids in the promotion and adoption of innovations built on the ongoing use of tradition, but also emphasizes the importance of preserving what already exists as a vital and effective tool for encouraging ongoing traditional innovation and creativity to aid in national development. The policy acknowledges the lack of a comprehensive database on these subject matters. TK systems are dispersed in various media and communal structures. The policy further aims to encourage the recording, utilization, and sharing of these traditional contents while putting in place systems to recognize, safeguard, and benefit the sources and custodians; establish a registry of inventions in which communities can register their traditional innovations; mobilize and harness grassroots technological innovations and traditional knowledge values and institutions (The Policy, 2009).

Kenya Industrial Property Institute (KIPI) includes a TK and GR unit with the responsibility to develop a TK database for Kenya; develop a simplified classification system of Kenya’s traditional knowledge products and processes based on the hierarchical structure of the International Patent Classification. The Unit has been authorized with the duty to promote documentation and preservation of rich TK of Kenya; provide a means of patent search procedures and identification of prior art. It identifies individuals and communities entitled to sharing of benefits and exclusive rights on accessed TK and GR and provides the means for recording the existence of traditional knowledge over which positive rights have been recognized (KIPI TKU). The unit has embarked on the creation of the database of TK as a priority for Kenya in liaison with the ICT Division (KIPI TKU).

Table 2: Sample Content Analysis

Raw Data	Code/Construct
……. most widely interpreted provisions in the Constitution are Article 21, which provides for the fundamental right to life and personal liberty. This provision has a large number of liberal interpretations and relying upon the same; it can be used as a measure to argue in favour of protecting TK holders. Article 29 (1), grants protection of the cultural rights of minorities as a fundamental right. One of the fundamental duties under Article 51A (f) requires the preservation, respect, and safeguarding of the rich heritage of the Indian culture by every citizen of India.	Constitutional Provision (India)
……… protect the IP rights of the 'people of Kenya' [Article 40(5)] and to protect and enhance the IP and 'indigenous knowledge' associated with biodiversity and 'genetic resources of the communities' [Art. 69(1)(c) & (e)]. It recognizes culture as the foundation of the nation and cumulative civilization of the Kenyan people and nation [Art. 11(1)] and requires the State to promote IPRs of the people of Kenya [Art. 11(2)(c)].	Constitutional Provision (Kenya)

A case study relates to the Maasai tribe of Kenya entails a success story. WIPO undertook a mission in 2006 to explore and identify the needs and explore assistance possibilities for the community with the International Labour Organization (ILO). National Museum of Kenya with WIPO launched a pilot program with the community. Several community members were trained on how to use recording equipment. WIPO helped the Maasai community in protecting, preserving and documenting their cultural contents with the incorporation of technological measures (Image 1). It qualified the community to document and preserve their cultural traditions along with managing their IP interests. This project enabled them to create their own IP in forms like community databases, photographs and sound recordings. The project even empowered the Maasai community to control these contents in digital formats relating to their histories, and their own stories, and turning themselves into IP owners.

Image 1: Snapshots from Maasai Tribe Project (Source: WIPO)

Comparison of India and Kenya

Table 3 puts up the comparative approach taking into account different measures being forwarded by both countries towards the protection of TK. Several parameters have been taken to present a more holistic overview of the protection system in their jurisdictions.

Table 3: Comparison of India and Kenya on select parameters of TK protection

Subject Matter	**India**	**Kenya**
Constitutional Provisions	No explicit constitutional provision; a fundamental duty [Article 51A (f)]	Contains provisions relating to the protection of TK [Article 11, Article 69].
IP Legislations	No IP legislation available for TK protection	No proper setup under the IP system
Policies	IPR Policy, 2016; No TK policy.	IPR Policy, 2009; TK Policy, 2009.
Sui generis system	No sui generis system of protection	Protection of Traditional Knowledge and Cultural Expressions Act, 2016
Databases	TKDL, Health Heritage Test Database	No database
Other measures	NMM, NMCMR, IGNCA, INTACH, NFSC	KIPI, Maasai Tribe project.
Method of Protection	Defensive Protection	Positive Protection
1. Manuscripts	✔	✕
2. Photos and Images	✔	✔
3. Videos	✔	✔
4. Audio Files	✕	✔
5. 3D Objects	✕	✕
6. Stories	✕	✕
7. Annotations	✔	✕

Discussion

In recent times, stakeholders to TK have come up hand in hand for the preservation and protection of the traditional contents. They have been voicing for effective protection regime to be established to safeguard these contents. These traditional subject matters also encompass the domain of innovation into them as with the passing generations, the future generations put their intellect into the pre-occupied knowledge. Innovation attracts the role of the IP where such protection considers these traditional contents into the public domain and therefore allows its free use without any restriction. There is strong opposition against this "public domain" approach as such consideration puts an existential threat on these valuable contents and often leads to their misappropriation and misuse. These underlying issues lead to the fact that the IP regime cannot answer the call for effectively protecting these contents. Indian IP laws do not offer effective protection to the subject matter of TK nor the country has a sui generis system of protection. Defensive protection through TKDL is one of the milestones India has achieved in protecting its rich TK, but it still has a long way to go. While Kenya has relied on a different set of measures through the sui generis system of protection but it has still to appreciate the role of technology in protecting TK.

Our exploratory study contributes to the existing theory by identification of the criteria which must be utilized to choose the appropriate protection regime i.e., positive or defensive protection. The study based on two countries data clearly shows that the country can decide whether they want to protect the TK using sui generis system like that of Kenya or create a digital library by incorporating TK as prior art like that of India. The important proposition we are proposing is, countries should look into the dimensions enumerated in Table 4 and may come up with hybrid mode of protection by incorporating elements of positive as well as defensive protection depending on the nature of TK. The complex subject matter of protection measures has its answers in legislative intervention or technological intervention or an integrative approach of both interventions is the question that remains. The application of new technologies continues to be severely hampered by a lack of digital literacy and skills, which is especially acute in rural regions, particularly in developing nations.

Table 4: TK Protection Regime Constituents

S. No.	Criteria	Traditional Knowledge-Rich Countries
1.	Constitutional Provisions	Shall contain constitutional provisions intended towards the protection of TK.
2.	Policies	Necessary to have TK-related provisions in the IPR policy of the country.
3.	IP Legislations	IP legislation must include explicit and separate TK provisions offering protection to the subject matter of TK.
4.	Sui Generis Systems	These systems are a must for having a positive protection regime.
5.	Mode of Protection	A positive protection system as it offers broad scope. This will help in protecting the TK of countries that have a rich heritage.
6.	Databases	An extensive database
7.	Other Institutional Measures	To provide a holistic protection regime, other necessary institutional measures are needed. The role of NGOs, civil society, and others can be clearly stated in the TK policy document and other corresponding legislation and policy documents if any.

Conclusions

TK is a valuable asset for the indigenous and local communities as well as for the country too. Its effective and proper management is the key responsibility of the state. The subject matter of TK itself presents complexities due to the nature of the subject matter being intergenerational. There is no hesitation in realizing that technology especially ICT hold significant potential for supporting the recording, management, dissemination and long-term preservation of TK. The development in technology has also resulted in an increased frequency of misappropriation and misuse. Such a scenario warrants the content to be protected and properly managed for the benefit of the community at large, with the intervention of technology to achieve the goal effectively. Codified and fully disclosed TK systems adopt defensive protection through the compilation and disclosure of databases like India's TKDL. TK systems which are uncodified and undisclosed medicine systems exclusively need positive protection. To this, database creation and its effective management become crucial with the application of ICT tools. One important aspect is the security measures, which must also be taken into account along with these databases to ensure data protection. TK has a huge potential to transform many lives, and it may be applied to a large extent to solve societal issues. Although some of the obstacles are technological, many of the more challenging ones are social, political, or economic. Overcoming these hurdles will require a lot of time, patience, financing, resources, support, training, and a combined effort by Indigenous communities, academicians, institutions, and the government.

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Article 2, The Act of 2016, TK is defined as "any knowledge either originating from an individual, the local or traditional community that is the result of intellectual activity and insight in a traditional context, including know-how, skills, innovations, practices, and learning, embodied in the traditional lifestyle of a community; or contained in the codified knowledge systems passed on from one generation to another including agricultural, environmental or medical knowledge, knowledge associated with genetic resources or other components of biological diversity, and know-how of traditional architecture, construction technologies, designs, marks, and indications".

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World Intellectual Property Organization (WIPO) https://www.wipo.int/tk/en/tk#:~:text=Traditional%20knowledge%20(TK)%20is%20knowledge,its%20cultural%20%20or%20spiritual%20identity "Traditional knowledge is knowledge, know-how, skills and practices that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity.

WIPO, 2018 The glossary prepared by WIPO IGC during its deliberations defines TK as "a broad description of subject matter, generally includes the intellectual and intangible cultural heritage, practices and knowledge systems of traditional communities, including indigenous and local communities." https://www.wipo.int/tk/en/resources/glossary.html

INNOVATION ECOSYSTEMS I

May 1st: 3h10 pm – 5h pm

Chair

Bibiana Martins (Unisinos, Brazil)

Papers

Engagement with different types of ecosystems for radical innovation: The role of ambidexterity

Filipe Marinho Barcellos, Leonardo Augusto Vasconcelos Gomes

Ecosystem typologies, worldviews and value creation: Evidence from an innovation ecosystem

Marcelo Ferreira de Castilho, Carlos Olavo Quandt

Building an innovation ecosystem: Encqor's strategy

Anas Ramdani, Catherine Beaudry, Mario Bourgault, Polytechnique Montreal, Canada

Innovation ecosystems challenges: To create value for the region and return for its participants

Angélica Duarte Lima, Tatiana Cabreira de Severo Pasquini, Mariza Costa Almeida, David Nunes Resende, Regina Negri Pagani

Engagement with different types of ecosystems for radical innovation: the role of ambidexterity

Abstract ID#145

Filipe Marinho Barcellos, Leonardo Augusto Vasconcelos Gomes (University of São Paulo)

Purpose

The pursuit of more radical innovations is fundamental to any established firm pursuing survival and growth. In the current competitive context, a company alone does not have all requirements (e.g., resources) for this kind of innovation, therefore being nudged to engage with external actors and achieve ambidexterity at the ecosystem level. The literature so far has recognized three types of ecosystems: (1) innovation, (2) entrepreneurial, and (3) knowledge ecosystems. While maintaining business-as-usual activities in place, a firm can create, engage with, or influence the three types of ecosystems through different mechanisms with unique processes for developing more radical innovations, yet the current literature does not clarify how. Thence the question that guides this research arises: How can the literature on ambidexterity and ecosystems be bridged?

Literature Review

An ecosystem is a group of independent, interdependent, heterogeneous, loosely connected actors that share a common output at the system level (Gomes et al., 2022). The actors participating in ecosystems may be mature companies or startups, universities and research institutes, the government and regulatory authorities, and other types of organizations that are connected informally (instead of formal supplier-customer contracts) and interdependently while coherently sharing a common output.

The innovation ecosystems are the meta-organizations centered on a focal value proposition, whose main output is value creation for customers. The actors involved are engaged in a necessary role for the product or service development, rollout, and distribution (Altman et al., 2022).

In its place, the entrepreneurial ecosystems are not centered in a value proposition, but they are configured by a group of new ventures trying to bring about new business models and defined customers, through experimentation and sharing individual results within the ecosystem (Baaziz, 2019). This is facilitated due to the predominantly regional configuration.

Radical innovations (RIs), also known as strategic or breakthrough innovations, are brought to create brand new product lines, transform markets, reinvent customer interactions, deliver unmatched solutions to real-life problems, and enrich value to customers. They are the foundation for long-term success for an organization (O’Connor et al., 2018).

The ability to harmonize the mainstream operations and incremental innovation mechanisms with strategic innovation projects is part of the core of ambidexterity studies in large firms (Lin et al., 2013). At the firm level, authors discuss whether RI should be undertaken within the same organization (O’Connor et al., 2018) or through the separation of exploration and exploitation units aligned with a business leadership capable of balancing these demands (O’Reilly & Binns, 2019). Other articles take the analysis of this phenomenon to individual, project, or portfolio level and its activities such as uncertainty identification and mitigation, RIs portfolio and stakeholder management (O’Connor et al., 2018), managing radical innovation projects from the discovery of ideas, through their incubation and finally to acceleration. Still, it is unclear how ambidexterity is managed given an ecosystem context; that is to say, how do firms maintain business as usual activities while also innovating more radically in a situation where it is necessary to manage distributed creation of value in a metaorganization whose actors are hierarchically independent.

Methodological Procedures

A systematic literature review is applied employing bibliometric and citation analysis, as well as content analysis. Based on bibliometric indicators and content analysis, it is shown how fragmented and dispersed the literature on these topics is, as well as the trends and gaps in the literature. Furthermore, content analysis is applied for investigating and interpreting a subject of research through an objective, systematic, and quantitative content description. The combination of bibliometric and content analysis helps to recognize literature trends, the most frequently discussed topics and fields, and gaps that may exist within the literature.

Findings

The literature shows a connection between the entrepreneurial ecosystem and the knowledge ecosystem by the interchange of knowledge and ideas for new possible technologies and applications. It can also be deduced that the established firms must succeed in orchestrating all ecosystems simultaneously to achieve sustainable success in radical innovations. We present a summary of identified mechanisms and their purposes, and if they are related to innovation, entrepreneurial or knowledge ecosystems. We also propose a conceptual framework based on the content analysis. What the literature shows is a connection between the entrepreneurial ecosystem and the knowledge ecosystem by the interchange of knowledge and ideas for new possible technologies and applications.

Implications

There are some implications for theory and practice. First, a bridge between ambidexterity and ecosystems literature is built through the identification and understanding of three different groups of mechanisms for engaging and transforming different ecosystems (knowledge, entrepreneurial and innovation). Secondly, our findings indicate that a firm must make use of primarily knowledge ecosystem mechanisms to nurture the discovery of new possible radical innovations, while mechanisms related to entrepreneurial ecosystems are related to incubation of these discoveries, and innovation ecosystems are connected to acceleration (go-to-market) of the innovation.

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Ecosystem typologies, worldviews and value creation: evidence from an innovation ecosystem

Abstract ID#318

Marcelo Ferreira de Castilho, Carlos Olavo Quandt (Pontifical Catholic University of Paraná)

In the business literature, ecosystems are often described in terms of interactions of collaboration and competition, or "coopetition", aiming to achieve value creation for themselves and in relation to other ecosystems. Rivalry underlies the existence of predators and prey (Moore, 1993) under a logic of improvement or even compromise, through the possibility of coexistence between collaboration and competition. Tsujimoto et al. (2018) present four perspectives on ecosystem typologies: ecological (industrial ecosystems concept); business ecosystem (organizational edges concept); platform management; and network of actors (concept of social networks). Following this, a typology of ecosystems composed of four categories is proposed: Territory, Platform, Networks, and Adaptive.

The territory type refers to synergistic processes of learning within a geographic area, in the sense of concentration by affinity and similarity in a physical or virtual context. It is based on the neoclassical economic assumption of competitive strategy and scarcity, whereby partners act opportunistically when in proximity, seeking to capture opportunities through resource sharing, collective learning, and social capital.

The platform type refers to interdependencies by leveraging complementarities to overcome competition and capture value. It involves coopetition as a strategy to strengthen structures that support alignment efforts among participants. The platform type is similar to the territorial view for its coordination and governance mechanisms that sustain co-evolution, specialization and complementarity in the construction of multilateral relations. This involves three competition fields: 1) between newly emerging and established platforms; 2) rivalry or competition between different platforms vying for the same market space; and 3) internal competition for value capture among the members of a platform.

The network type refers to the agility of multi-actor collaborative networks in continuous reconstruction and reformatting. The network type addresses the challenges of self organization around the construction of shared meaning in constant adaptation to change (Roundy et al., 2018).

The adaptive type refers to a holistic, often unpredictable system in a multidirectional process of social integration and differentiation, based on the indeterminacy of flows and on emerging dialectical tension. Similar to the network type, it addresses the challenges of building shared meaning, but it seeks to integrate interaction flows in ambiguous and complex configurations, dependent on dynamic relationships (Austen, 2018).

Multi-actor relationships in ecosystems are possible because they are immersed in a diversity of worldviews, in parallel with the assumptions of subjectivity, objectivity, and intersubjectivity (Cunliffe, 2011). Subjectivist assumptions refer to human autonomy to create socially constructed contextual meanings. A subjective worldview is about how participants experience, give meaning to, interpret and make sense of their reality. Objective assumptions refer to an objectified external reality, which the observer seeks to qualify from a measurable reference. Intersubjective assumptions refer to a state of relating; what emerges is constantly changing and lived in a fluid, relational, responsive quality, embodied in multiple and changing meanings. The three types of worldviews may be connected with the ecosystem typologies, as follows:

The Territory type of ecosystem is closely connected with an Objectivist world view: Support structures and alignment of shareable resources are developed around a belief in the stability and perpetuity of multilateral relations. A stable relationship with the 'object' is established independently, for a joint articulation between private and collective interests. The Platform ecosystem is linked to an overlay of the Objectivist worldview with a Subjectivist worldview. It involves the alignment of actors in multilateral relationships around a belief in human autonomy to create socially constructed meanings. A contextualized relation of the 'object' is established through mutual dependencies in search of the resignification of divergences. The Network type of ecosystem can be linked to a Subjectivist worldview overlaying an Intersubjectivist worldview. It displays a contextual and provisional collective understanding around a belief in collective experimentation and interpretation of meanings. The network expresses an emerging multi-actor relationship, established in the articulation of self-organized structures in search of shared meaning. The Adaptive ecosystem expresses an Intersubjectivist worldview. Co-evolutionary relationships develop in indeterminacy and fluidity around a belief in continuous contextualized adjustments, based on exchanged signals. Relationships are developed adaptively around a mission, with a provisional significance built on reflexivity.

This study analyzed the meanings of rivalry, competition, and collaboration in the case of an innovation ecosystem. It explored the integration of such factors for value creation, in light of the different worldviews that emerge in the ecosystem literature. It was found that the case reflects an adaptive worldview, serving the purpose of transforming society in a holistic sense that reflects the non-separation of what is inside and outside. This ecosystem can also be seen as a multi-actor worldview, which embeds a networked systemic consciousness. It is also possible to observe a Territory aspect in the case study, from the evidence of delimitation of threats and identification of opportunities based on a belief in the stability of multilateral relations, focusing on expanding influence and occupation of space. The Platform aspect is seen in the articulation of the business chain and the alignment of actors in multilateral relationships around a platform leadership position. The Network angle is present in its systemic awareness and multi-actor complexity, leading to contextualized, provisional collective understanding. The Adaptive characteristic is evident in the ecosystem's purpose of transforming society, reflecting a sense of integration of internal and external elements. Guided by innovative entrepreneurship, the ecosystem is well integrated into its socioeconomic context and contributes to its development.

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Building an innovation ecosystem: encqor's strategy

Abstract ID#356

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Purpose

The deployment and introduction of 5G technology will offer many advantages and distinct features from previous generations not only in the telecom world but also for many vertical sectors. SMEs from different sectors can seize this opportunity to develop new innovative solutions or take advantage of 5G to develop disruptive solutions to target new markets.

Since 2018, the ENCQOR 5G project (https://www.encqor.ca) in Canada has raised awareness, mobilized and helped mainly SMEs to prepare for the deployment of 5G in the Quebec-London corridor. This initiative will enable Canada to accelerate the transition to 5G and unlock the potential of smart cities, e-health, autonomous vehicles, and the Internet of Things. ENCQOR's objective is to create, mobilize and consolidate an ecosystem that attracts heterogeneous actors such as SMEs, industrial actors, and universities at both the national and international levels. Since its creation, ENCQOR has attracted more than 800 SMEs working in various fields such as transportation, agriculture, augmented reality, mining, etc. As of March 31, 2021, 15 higher education institutions in Quebec and Ontario were collaborating with ENCQOR in various 5G projects.

Positioned as the starting point of the 5G ecosystem in Canada, the ENCQOR 5G project is an ideal case study to analyze the construction of a new ecosystem. This study aims to answer the following research question: What are the factors that enable the emergence of an innovation ecosystem? The general objective of this research is therefore to develop a better understanding of the dynamics, mechanisms and challenges concerning the emergence of an innovation ecosystem based on the ENCQOR 5G project.

Literature review

This study is based on the model developed by Cohendet, Grandadam and Simon (2010) to analyze the ENCQOR ecosystem. According to the authors, local innovation dynamics are based on interactions between three levels:

Upperground: Creative firms and other organizations: research laboratories, universities, cultural and artistic centers as formal organizations contribute to the creative process through their ability to finance and unite different ideas, and to test new forms of creativity on the market.

Underground: Includes creative, scientific, technological, artistic and cultural activities taking place outside of any formal organization or institution based on production, exploitation or dissemination.

Middleground: Provides the necessary soil for the informal structures of the Underground to be born and develop, as well as for the trust necessary to transfer ideas from the Underground to the formal organizations of the Upperground.

Methodological procedure

The methodology employed for this article is a case study based on semi-structured interviews of the various stakeholders involved in the ENCQOR 5G project. These interviews allow for an in-depth analysis of the existing dynamics within the ENCQOR project through key testimonies from the various participants. A total of 26 semi-structured interviews were conducted: 11 interviews with the founding and mobilizing organizations of ENCQOR and 15 interviews with businesses and SMEs that participated in one of the program components. The interviews (lasting from 40 min to 130 min) were recorded, transcribed, coded and then analyzed using InVivo.

We participated in several formal and informal events and meetings organized by ENCQOR to gain a more in-depth understanding of the project and the program participants. We also relied on other secondary data sources such as ENCOQR's annual reports, partner websites, documents shared by partners, and media articles to complement and provide context for the interview analysis.

In analyzing the interviews, we focused on understanding the roles and interactions of the upperground organizations, particularly the founding partners and the engagement partners. Subsequently, we identified and analyzed projects, places, spaces, and events at the middleground level that benefit underground actors. For each of the three strata of the model, we identified the challenges constraining the emergence of the 5G ecosystem.

Findings

Upperground or Rebuilding and expanding the existing network – The emergence of a 5G ecosystem did not start from scratch as several ENCQOR founding partners had already collaborated before the arrival of 5G. This highlights the importance of using the existing network of organizations to build a "new" ecosystem. The success of their collaboration on past project motivated them to continue their partnership in the field of disruptive technologies such as 5G. Government funding played a key role in the creation and development of the ecosystem: their contribution was not limited to project funding, but ensured, through the establishment of KPIs, the smooth running of the project/ecosystem. For instance, the ecosystem faced several challenges: Slow program set-ups with governments; Legal issues and contract-based challenges; Complex governance.

Building an attractive middleground – An innovation ecosystem must attract several organizations to emerge and last over time. To fulfill this mission, the construction of a middleground capable of attracting a wide range of organizations is necessary. ENCQOR's attraction mechanisms for SMEs that want to test or develop their 5G products are summarized below:

a) Free access to an iPaaS platform;

b) Funding for stand-alone and co-development projects with core partners; • Technical and human capital whose mandate is to provide free technical support to new members;

c) Appropriate governance and IP management to create a climate of trust between the multinationals (main partners) and the SMEs, by setting up an NPO whose mandate is to ensure that the SMEs keep their intellectual property when using the platform;

d) Project selection committees that are independent of multinationals to ensure a fair and transparent distribution of government funds;

e) Events, projects and activities to raise awareness and attract organizations to the platform (Bootcamp, discovery tours, challenges, etc.)

These mechanisms remain insufficient to attract, engage and retain the larger number of organizations needed to create an ecosystem. Among the several challenges highlighted in this regard, our results found identifying organizations likely to use 5G is difficult especially in non-telecom verticals, keeping SMEs in the ecosystem and encouraging them to collaborate with new players to have a snowball effect that will expand the 5G ecosystem, or KPIs not adapted to the innovation ecosystem concept.

Implications

The results could help companies, governments and managers understand the key factors for building an innovation ecosystem

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Innovation ecosystems challenges: To create value for the region and return for its participants

Abstract ID#293

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Purpose

This paper seeks to identify the main aspects of two challenges faced by innovation ecosystems: the return of the value generated to the region of the innovation ecosystem and to its participants; and the types of relationships developed in these ecosystems.

Literature Review

From Moore's (1993) business ecosystem, different analogies emerged, such as knowledge-based ecosystem, entrepreneurial ecosystem, innovation ecosystem, among others. An important aspect in the development of innovation ecosystems is the creation of value. To achieve it, it is necessary to rely on the participation of different agents, such as: companies, government, universities, non-governmental organizations (NGOs) and other resource providers, who play different roles (Adner & Kapoor, 2010). However, the value created not often return to the region where it was created to the benefit of its own participants. Another problem is also the way in which this value is distributed among these participants, so the types of relationships are a critical factor to be studied (Assefi, Resende & Amorim, 2020).

Methodological Procedures

A literature review was performed using the methodology Methodi Ordinatio (Pagani et al., 2015). The method is based on three parameters: number of citations, the impact factor, and the year of publication. The search in the Scopus, Science Direct and Web of science databases resulted in a portfolio with 70 articles relevant to the topic, which were analyzed and served as base for the conclusions.

Findings

It was observed that there is a growing interest for the theme due to the number of publications, leading us to the conclusion it is of great important, not only to the academia, but also for regions searching innovation in its environment. Although the literature presents studies and models that seek to understand and strengthen the relationship between the players in the innovation ecosystem, the topic still needs further research. Furthermore, it was also observed that the literature does not present a consensus regarding all the different terms used towards this phenomenon, and this research is an attempt to fill this gap.

Implications

Local and regional development has proved to be dependent on innovation process. Therefore, understanding the innovation ecosystems phenomena and all the relationships developed by its agents is crucial to manage a local and regional development process. This is the major contribution of this paper, which might serve as a guide for public policies towards fostering these innovation ecosystems.

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DIGITAL INNOVATION I

May 1st: 3h10 pm – 5h pm

Chair

Aline Jansen (Federal University of Rio Grande do Sul, Brazil)

Papers

Digital technologies and SMEs: Help to adopt or help to use? Evidence from UK

Jevgenija Golubova, Nick Theodorakopoulos, Mark Hart

Digital infrastructure for data preparation for LGPD implementation: Example of brazilian digital innovation

Marcelo Tsuguio Okano, Henry de Castro Lobo dos Santos, Edson Ursini

Where is the current research on blockchain value creation? Systematic review on value and impact

Daniel Lanes Pereira, Marcirio Silveira Chaves

Proposal of a method for diagnosis about organizational entrepreneurship, degree of innovation and maturity of digital transformation in projectified organizations

Débora Mendonça Monteiro Machado, Cristina Dai Prá Martens, Cláudia Terezinha Kniess

Digital transformation in agribusiness: Smartphones use by organic and agroecological farms

Aline Castro Jansen, Antonio Domingos Padula

Digital technologies and SMEs: help to adopt or help to use? Evidence from UK
Abstract ID#195

Jevgenija Golubova, Nick Theodorakopoulos, Mark Hart (Aston University)

Purpose

UK's productivity and digital technology (DT) adoption lag behind other countries with SMEs lagging even more (Valero et al., 2021). Academics and practitioners tend to agree that DTs benefit firms and increase business productivity (Canhoto et al., 2021): with British SMEs making up 99.9% of private sector businesses, considerable focus is on increasing DT adoption. This study's purpose is to identify factors affecting SMEs' DT adoption by using an example of SMEs in the West Midlands region, the second most populous English region. Key research questions are: why and how SMEs adopt DTs, what prevents/constrains and what drives/enables them.

Literature Review

This study draws on the body of peer-reviewed, industry and policy evidence on SME digital adoption, which mostly uses the technology–organisation–environment (TOE) and diffusion of innovation (DOI) theories. The studying of barriers to adoption is more prevalent than studying drivers. Plus, studies vary widely in methodologies and DT types, making it difficult to synthesise the most commonly experienced barriers and enablers of DT adoption by SMEs (Costa & Castro, 2021; Ramdani et al., 2013). Crucially, the question of why and how varying factors (alone or together) help or hinder SMEs over time is understudied. The level of DT usage is also barely considered, and prevalent theories do not typically integrate barriers with enablers. This results in a lack of understanding on SME DT adoption and, subsequently, on ways to improve it.

Methodological Procedures

A mixed-methods study using 117 quantitative surveys and 27 qualitative in-depth interviews with established SMEs conducted in the summer of 2022. The study included a range of DT types and business sectors. Survey data was analysed descriptively and inferentially using significance testing. Qualitative data was analysed thematically (COREQ) to contextualise quantitative data, explore interactions of different factors, and trace change over time.

Findings

Every firm reported adopting at least one DT (five on average). The most used DTs were online marketing through social media, accounting and remote working (all over 80%), while Industrial Internet of Things and AI/ML were the least used (approx. 10%). Despite high usage, intensity and perceived sufficiency, over 80% of SMEs were interested in using more DTs. We found this to be related to an interest in AI/ML technologies, and the need to better utilise and integrate DTs. Despite firms differing in business characteristics, they showed remarkable similarities in DT use (e.g., 76% of SMEs adopted certain DTs due to COVID-19). While almost 9 in 10 firms experienced barriers to using DTs, no barriers prevented the adoption. Impact on usage was limited with just a few firms reporting efficiency losses due to barriers. Plus, no firms abandoned their DTs. The most commonly reported barriers - lack of in-house digital skills/knowledge (61%), lack of funding (57%), and lack of external advice/guidance (42%) – were more complex than theorised (e.g., external advice and in-house skills were cited as enablers in another context within the same firm, funding issues were associated with return on investment). Enablers of DT adoption (such as relative advantage) varied among firms. They were found to help retain DTs rather than drive to start using them; though external advice was often instrumental in adopting specific software. Factors driving adoption were related to growth, key business or industry requirements, and COVID-19 (with variations depending on DT type). Moreover, SMEs expected to experience the same barriers in the future but not the same enablers: future enablers were associated with past barriers (e.g., availability of funding if SMEs experienced lack of funding in adopting DT). In the summary we discuss implications of reasons for identified barriers, enablers and their interaction to DOI and TOE theories, as well as policy implications given the complexity of barriers and enablers in the SME adoption journeys. We also identify and discuss five profiles of DT adoption: knowledgeable starters (those implementing certain DTs at business launch), gradual adopters (who implement new DT as business grows), users (in need of maximising their DT value), advanced users (requiring DT integration and automation rather than new DT), and super users (digitally high-skilled firms continuously progressing their DT use). We summarise DT needs of these profiles and discuss ways in which business support interventions could address them.

Implications

This study valuably contributes to both the academic and policy evidence bases. It adds to the evidence of various constraining and enabling factors of DT adoption as per DOI and TOE theories. It enriches these theories singularly and taken together by explaining how, if at all, SMEs get affected by these factors and their interaction over time. The study provides a segmentation of firms based on their DT adoption journey and needs, which could be used for designing better targeted business support interventions by the practitioners. The key limitations are absence of firms that do not use DT (it is unclear if high DT adoption in SMEs is the new norm), and the geographical restriction to UK West Midlands (mitigated by a mixed-methods approach). Future work opportunities include undertaking qualitative comparative analysis to determine causes of specific adoption patterns and/or SME profiles; following up with respondents to observe DT barriers, enablers and trends over time in the post-COVID world; and testing representativeness of findings nationally and internationally.

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Digital infrastructure for data preparation for LGPD implementation: example of Brazilian digital innovation

Abstract ID#198

Marcelo Tsuguio Okano (Paulista University); Henry de Castro Lobo dos Santos, Edson Ursini (State University of Campinas)

Purpose

New digital technologies are innovating in several areas of companies and industries, allowing manual processes and routines to be automated and new functions to be created intelligently for decision making.

These new requests for the use of technologies come from various stakeholders, whether internal or external, such as government, suppliers, market and customers and need their own digital infrastructure. In this article, we analyzed what the LGPD (General Data Protection Law, in Portuguese) required of digital infrastructure for the preparation of data for its implementation.

According to Tilson et al. (2010), digital infrastructure is a shared, infinite, heterogeneous, open and evolving socio-technical system that includes the installed base of infrastructure resources and their user, operational and design communities.

For Berawi et al. (2020), the use of digitalization provides new ways for companies to create added value for business and the modernization of companies, combining digital technologies, physical resources and the creativity of individuals, is an essential step in the innovative transformation of businesses that can constitute a competitive advantage and a digital innovation.

Digital Innovation (DI) is challenging both theories and practices in organizational research, and scholars are calling for more research on this. ID management research can be classified substantially under innovation management research, which revolves around organizations. Therefore, the central issue of ID management is still the interaction between ID and organization (Xie et al., 2020).

The purpose of this article is to present how two large Brazilian companies had to prepare their digital infrastructures to meet the LGPD in data preparation and how this represents a digital innovation.

Literature Review

Bogers et al. (2021) consider that digital innovation is changing the way products and services are developed, produced and used. For example, innovations using digital technologies allow the “sharing” of inputs or resources, such as cars, tools and accommodation. These innovations are revolutionizing traditional markets, including media and entertainment, car rental and sales, hotels and hospitality, and even temporary jobs.

Xie et al. (2020) in the article “Digital Innovation in Organizational Research: A Systematic Review” define two points of view on how Digital Innovation has been classified in the academic literature, the first classification sees it as the use of digital technology/IT in a wide range of innovations and the second classification sees it as a kind of recombination of physical and digital.

According to Nambisan et al. (2017) digital innovation is the use of digital technology during the innovation process and can be used to describe, in whole or in part, the result of innovation.

Digital infrastructure can be defined as the basic information technology and organizational structures, as well as the related services and facilities necessary for the functioning of a company or industry. These infrastructures can be defined as global, national, regional, industrial or corporate infrastructure depending on the entity being supported or enabled (Tilson et al., 2010).

Ndubuisi et al. (2021) show a strong positive effect of digital infrastructure on employment in the service sector and reveal that the effect of employment in the service sector of digital infrastructure depends on a country's institutional and economic conditions. As an example, the positive effect of digital infrastructure on employment in the service sector increases as institutional quality increases, while poor macroeconomic conditions (measured by the inflation rate) decrease the effect of digital infrastructure on employment in the service sector.

According to da Silva Sousa et al. (2022), the General Data Protection Law (LGPD) came into force on August 1, 2021, bringing rules for the use, collection, conservation and distribution of user data, which can be used privately or publicly.

Methodological Procedures

The research methods used were the bibliographic research to build the theoretical framework with the themes digital innovation, digital infrastructure and LGPD and the multiple case study to analyze two large Brazilian companies, which we will call Alpha and Beta, which had to prepare their digital infrastructures to meet the LGPD in data preparation. The research instrument was a script of interviews with open and closed questions and professionals who participated in the implementation of LGPD in companies were interviewed.

Findings

The research presented as results the digital infrastructures of the Alpha and Beta companies for the preparation of data for the LGPD, the data information such as amount of source of researched data, amount of researched data, types of data (structured and unstructured), amount by data types, daily and total execution time, and details of procedures and operations.

Implications

The results and analyzes presented in the research lead to the conclusion that new digital technologies increasingly require their own and autonomous digital infrastructures to prepare the required scenarios such as the LGPD, as the existing digital infrastructures meet the daily needs of companies and do not are prepared for the new requirements.

These new digital infrastructures can be considered digital innovations, as according to Nambisan et al. (2017), digital innovation is the use of digital technology during the innovation process and can be used to describe, in whole or in part, the result of innovation, which in this case is the preparation of data to implement the LGPD.

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Where is the current research on blockchain value creation? – Systematic review on value and impact

Abstract ID#228

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Purpose

The growing interest and use of Blockchain, question on where the current research on blockchain value creation is, beyond technology, is needed to expand academic understanding and future research on this broader topic.

Context

Blockchain is the fundamental technology underlying several business applications and cryptocurrencies like Bitcoin since it´s invention in 2008, while its practical implementation occurring in 2009. Currently, blockchain technology receives a lot of public attention from practitioners and scholars where the technology has key characteristics of decentralization, persistency, anonymity, and auditability, which give blockchain a strength for several applications beyond cryptocurrencies. Lu Yang (Lu, 2019) defines blockchain as a novel application model that combine uniqueness and innovation of computing technologies such as distributed storage, decentralization and independent peer-to-peer transactions, automatic and intelligent consensus mechanisms, programable smart contracts and dynamic encryption algorithms. Large number of novel business models and use cases have emerged and this work will answer where is the current research on Blockchain value creation to business models, how they are being measured and how can we advance in this topic.

Objective and Research Questions

The objective of this work is to review the state of research on blockchain value creation answering three research questions:

RQ1: What is the value of Blockchain use in Business Models from Integrative Model of IT Business Value Perspective

RQ2: Which value creation Lens have been used to research Blockchain Business value?

RQ3: What are the current research gaps in Blockchain value creation and the future research directions?

Literature Review

Blockchain is the core technology of cryptocurrencies and was originally conceptualized by Nakamoto (2008) to support transactions in Bitcoin. The definition of Blockchain is vast including a tamper-resistant, decentralized database of transactions, a technology with key characteristics as decentralization, persistency, anonymity, and auditability (Zheng et al., 2017) and a fully distributed system for cryptographically capturing and storing a consistent, immutable, linear event log of transactions between actors (Risius & Spohrer, 2017). The characteristics of blockchain are mentioned by scholars and practitioners as game changer for many business models. Yuthas (2021) argues that "despite the increasing sophistication in identifying beneficial use cases, there are currently no frameworks that provide guidance for envisioning or evaluating the strategic opportunities and innovations that blockchains could enable" (Yuthas, 2021). While it is easy to find sources that support blockchain's potential to disrupt all business activity (Swan, 2015), it is much harder to find material that explains how they can offer value to businesses (Morkunas et al., 2019). On support to value research, IT Business value research examines the organizational performance and impacts of information technology and how IT can be applied to improve organizational performance (Melville et al., 2004). The Integrative Model of IT Business Value perspective from Melville et al (2004) use resource-based view of the firm as a principal theory base. The authors arguments that IT is valuable, but the extent and dimensions are dependent upon internal and external factors, including trading partners, competitive and macro environment (Melville et al., 2004).

Methodological Procedures

The proposed methodology for this paper is a Systematic Review of 49 articles written in the last 10 years.

Discussion

In this work we analyzed a relevant number of papers on blockchain value creation and identified dozens of values which had been confronted to Integrative Model of IT business Value perspective and 28 theoretical paradigms being used to extract the essence of Blockchain value in business models on different industries. Not only established theories like RBV, and TCE but practical models as Canvas and Value Focused Thinking. Our paper aggregates studies of value creation from different industries, from Supply Chain to Healthcare and Financial Services which help to create a broader understanding of how blockchain value creation is being researched. 3 Limitations, Value of the Paper and Future Work: Many publications have arisen since Risius and Spoher (2017), stated on their work about a research framework for blockchain, that has predominantly focused on technological questions of design and features, while neglecting application, value creation, and governance (Risius & Spohrer, 2017). Studying 49 papers, this work creates a vast set of information on blockchain value creation using an Integrative Model of IT Business Value to analyze works on different lens of perspectives to measure the impact of blockchain on business models, while unveiling many lenses and industries that blockchain is being used. The major limitation of this work is the lack of empirical evidence that could corroborate with our findings.

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Proposal of a method for diagnosis about organizational entrepreneurship, degree of innovation and maturity of digital transformation in projectified organizations

Abstract ID#290

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Purpose

Propose a method of diagnosing organizational entrepreneurship, the degree of innovation and the maturity of digital transformation for projectified organizations.

Literature Review

Entrepreneurship is conceptualized as the creation of new organizations, new products, production methods, markets, new sources of supply and forms of organization (Schumpeter, 1982). At an organizational level, entrepreneurship has the aspect of Entrepreneurial Orientation (EO) used to identify and explore new business opportunities, differentiation and innovation. EO, according to Miller & Friesen (1983), is composed of three dimensions: innovativeness, which refers to the search for creative, unusual or new solutions to organizational problems and needs; risk taking, which is the willingness to commit resources to projects, ideas or processes whose outcomes are uncertain; and, finally, proactivity, referred to as the engagement in prospective actions aimed at exploring opportunities. Lumpkin and Dess (1996) expanded the dimensions of EO, adding competitive aggressiveness, characterized by the ability to respond to competitors, and autonomy, which refers to decision-making in the Organization independently. Therefore, innovation emerges as a concept underlying entrepreneurship, described by Schumpeter (1982) as the process that introduces new products or services capable of generating changes in the market, being fundamental for the creation of value and for the growth in the Organization. According to Autio, Kenney, Mustar, Siegel and Wright (2014), these processes provide conditions for organizational innovation. Organizational innovation, according to Tidd, & Bessant (2020), is conceptualized as new ways for companies to change, being driven by the ability to see connections, identify opportunities and take advantage of them. Harryson, Dudkowski, & Stern, (2008) complement this definition by stating that organizational innovation is the propensity of an Organization to change through the exploration of new ideas and also through the use of new technologies. The integration of digital technologies in the Organization's operations and functions change the way they operate and deliver value to customers (Lusch, & Nambisan, 2015). Thus, the integration of innovation with technologies transforms the mindset and behaviors of Organizations (Gregory, Kaganer, Henfridsson, & Ruch, 2018) potentially giving rise to Digital Transformation (TD). In this context, the projects are used as a tool to assist the proper creation of a product, service or exclusive result. These Organizations are designated as projectified, that is, they contain some level (low, medium or high) of project use (Shinoda, Maximiano, & Sbragia, 2015). Therefore, the lack of studies that approach organizational entrepreneurship, innovation and digital transformation together, and a theoretical gap when it relates to projectified organizations.

Methodological Procedures

This study is qualitative in nature, with an exploratory approach. The first step is to identify, in a practical context, the problem identified in the literature, which is the lack of studies that address entrepreneurship, innovation and digital transformation together. Step 1 consists of verifying in the practical context the existence of the theoretical gap, for this, three semi-structured interviews were carried out in relation to organizational entrepreneurship, the degree of innovation and the maturity of the digital transformation, according to the developed script, with empirical data collection called as "Identification of the problem in empirical context". The second stage consisted of developing a research instrument to assess organizational entrepreneurship, the degree of innovation and the maturity of digital transformation in projectified organizations, Initially, a research instrument on organizational entrepreneurship, the degree of innovation and the Maturity of Digital Transformation was proposed, based on instruments identified in the literature, later the process of back translation of the Maturity of Digital Transformation was carried out because the instrument was in the language English. Subsequently, the 3 instruments were organized into a single file for evaluation. The third step was the evaluation of the research instrument, and consequent improvements to the instrument. The fourth stage developed the analysis of the data obtained with the application of the instrument.

Findings

The development of the organizational data collection instrument used to measure the degree of organizational entrepreneurship, innovation and maturity of the digital transformation in projected companies, made possible the first result that consists of the practical confirmation of the lack of joint studies on the constructs of these studies in designed organizations. The second result was the theoretical model for diagnosis and the development of the evaluation method and recommendations for the strategic alignment of companies.

Implications

The study advances joint studies in the area of entrepreneurship, innovation and digital transformation in companies designed with a theoretical model. For the practical scope, the study includes an applicable and adaptable method in organizations to help in the strategic alignment and source of data for decision making.

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Digital transformation in agribusiness: Smartphone use by organic and agroecological farmers

Abstract ID#112

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Purpose

In order to facilitate the sale of organic and agroecological products, and also to improve processes in rural businesses, the use of Information and Communication Technologies (ICTs) is spreading, in particular, smartphone using, which is the digital tool most widely adopted in the modern world, and especially by rural producers (Min et al., 2020). Thereby, this study aims to describe the usage behavior of organic and agroecological farmers regarding smartphone applications.

Literature Review

The primary sector actors seek solutions to support rural business management, facilitate communications and provide food productivity increasing through sustainable technologies (Pivoto et al, 2019). In the pandemic scenario of 2020 e 2021 due to COVID-19 disease spreading (OMS, 2020), organic and agroecological agriculture are becoming more expressive, with consumers searching healthier foods that improve their immunity (Lage et al., 2020; Organis, 2021).

Literature about technology adoption models and the variables that compound them was reviewed and the authors decided to use the Unified Theory of Acceptance and Use of Technology (Venkatesh et al, 2003) as the basis of this study. The UTAUT was created by integrating the contributions of different models and theories about technology acceptance and it explains user intentions to use an information system and their usage behavior. However, it was necessary to propose some adaptations for the agricultural context (Mikhailov et al., 2021).

Methodological Procedures

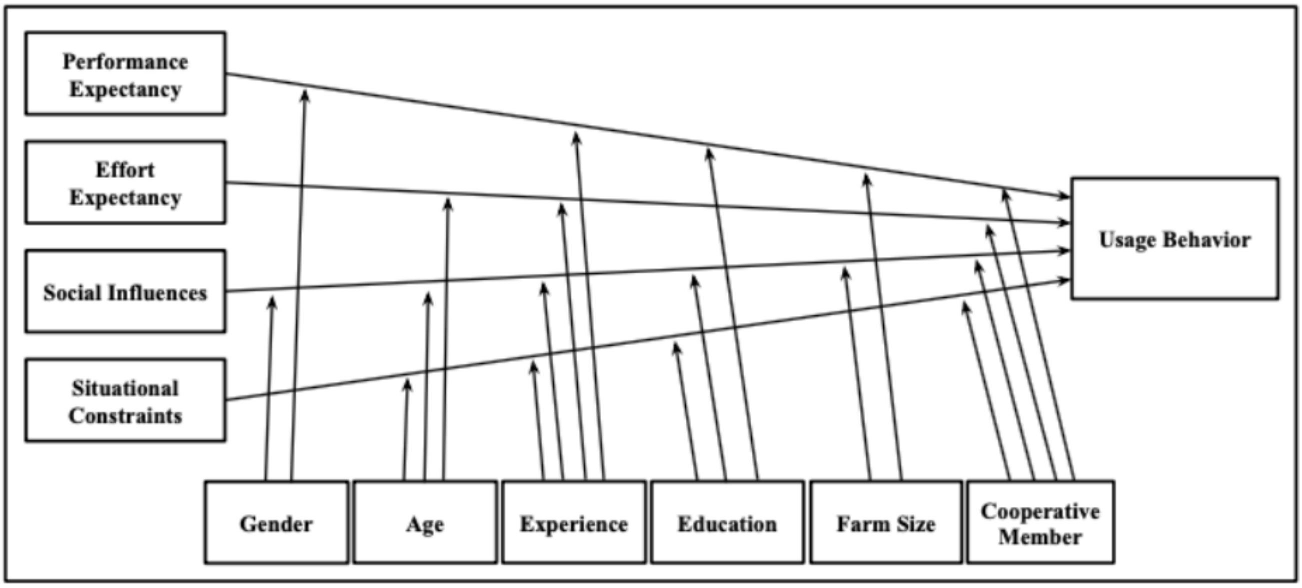
To achieve this paper objective, a quantitative method study was chosen. questionnaires were applied by telephone to organic and agroecological farmers who expose their products in agricultural street markets of Porto Alegre (Rio Grande do Sul/Brazil), obtaining 157 valid responses.

The data were analyzed using structural equation modeling with partial least squares estimation (PLS-SEM), according to Hair et al (2016). The model developed and tested is composed of four independent variables: 'performance expectancy', 'effort expectancy', 'social influences' and 'situational constraints'; a dependent variable: 'use behavior'; and six moderating variables: 'gender', 'age', 'experience', 'education', 'farm size', 'cooperative member'.

Findings

From the theoretical framework used and the statistical analysis performed, it was possible to validate the proposed analytical structure and all four hypotheses formulated about the relationship between exogenous and endogenous variables were supported. In the case of control variables, six hypotheses were rejected, however, it is noteworthy that each one of them moderates the relationships between at least two exogenous constructs and the endogenous one. Findings reveal that the behavior of smartphone use by organic farmers has 66.5% of its variance explained by the independent variables (Figure 1).

Figure 1 - Framework for analysis of organic and agroecological
farmers' usage behavior of smartphone



Participating in agricultural street markets' WhatsApp groups and making payments virtually are the features most accessed by producers on smartphones, while business management and traceability applications still have low adoption rates, according to the results of this research. The organic and agroecological farmers also indicate drivers of smartphone use, which are the communication becoming more accessible, the possibility of making online sales and the increase in agility in business tasks. In the other hand, related to limitations on smartphone adoption expressed by those surveyed, the factors associated with data reliability and security were listed, besides the difficulty of accessing the Internet in most rural areas.

Additionally, this paper identified that the adoption of digital technologies by organic and agroecological agrifood producers and their usage behavior are linked to their outcomes expectations and how much effort they need to employ so they can explore the benefits of digital tools. Furthermore, it also depends on relevant actors indicating the use of the technology and to situational influences, such as global crises, alterations in legislation or major changes that impact the business. Finally, all of these elements are moderated by control variables, such as age, gender, experience in agriculture sector and education, that are general factors, and some of which are specific to agriculture, such as farm size and cooperative membership.

Implications

This paper brings some insights, such as the behavior changing of organic and agroecological rural farmers could create opportunities for AgTechs (startups developing technological solutions for agribusiness sector) and other technology providers to insert themselves more effectively in the primary sector of the economy. However, a limitation on this study is the survey being applied only with farms from Porto Alegre/RS and its metropolitan area, because, being a capital, it is understood that its citizens are more adapted to digital tools. Therefore, as a suggestion for a future study, the analytical framework can be applied with farmers from small towns.

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INNOVATION IN EMERGING ECONOMIES I

May 1st: 3h10 pm – 5h pm

Chair

Silvio Bittencourt da Silva (Unisinos, Brazil)

Papers

A region-specific theory of innovation in emerging economies

Brett Anitra Gilbert

Entrepreneurship and innovation: Capabilities and links of Mexican firms in emerging contexts

Nidia López-Litra, Rebeca Teja-Gutiérrez, Verónica Loera-Suárez

ICT, innovation and absorptive capacities: Micro-level evidence from Colombia

Castillo Juan Carlos

The role of legal orders in strengthening existing innovation ecosystems in emerging countries: A study of brazilian laws and regulations

Silvio Bittencourt da Silva

A Region-Specific Theory of Innovation in Emerging Economies
Abstract ID#151

Brett Anitra (American University, Kogod School of Business

Emerging economies account for a significant portion of global population and have great need of innovation to improve conditions for local citizens. These economies have been seeing high levels of economic development in short periods of time (Siqueira & Bruton, 2010). Economic growth and development require innovation (Kaplinsky & Kraemer-Mbula, 2022), which in developed countries, typically derives from business R&D and locally and non-locally generated knowledge (Camagni & Capello, 2013; Filippopoulos & Fotopoulos, 2022; Hervas- Oliver, Parilli, Rodríguez-Pose & Sempere-Ripoll, 2021). However, in emerging economies, firms engage in little R&D because they face high resource constraints (Siqueira & Bruton, 2010), which lowers their ability to invest in R&D. Consequently, emerging economy firms tend to be less embedded in structured R&D (Fagerberg, Srholec & Verspagen, 2010). Still, we know that innovation happens in these regions (Alhusen et. Al., 2021).

Emerging economy firms tend to be more market driven innovate without R&D (Alhusen et al., 2021). Therefore, R&D based indicators, which are commonly used in advanced economies, do not effectively capture innovation in emerging economy firms (Hervas-Oliver et al., 2021). Moreover, despite knowledge that innovation happens in emerging economies, but without significant R&D, our collective knowledge about the drivers of innovation in emerging economy contexts is limited. Developing understanding of innovation in these regions will require perspective from the region-specific attributes of emerging economies. Emerging economies are diverse not only in geographic and population size, but also in their available resources, human capital and levels of government support among other factors.

This paper introduces a theory of innovation in emerging economies. Grounded in the logic that innovation emerges from different pathways (Filippopoulos & Fotopoulos, 2022; Gilbert & Campbell, 2015), and therefore, does not unfold the same way across emerging economies, the paper associates the types of innovation and the associated drivers that are unique to as well as common across Asia, Africa and Latin America (Allard & Williams, 2020). It focuses on differences between policy, industry structure, market, and human capital and how these differences produce different types of innovations.

For example, understanding innovation in Asia must consider what happens in India and China separately from what happens in other Asian countries. The sheer size of India and China offer capabilities that cannot be matched by other emerging economies, and which, therefore, make it different to advise other countries on how to improve their innovation efforts. Likewise, Brazil is likely to have innovation advantages due to its size, that other Latin American countries may not have or easily replicate. Similarly, innovation that is happening in Kenya, Nigeria and South Africa may not be easily replicable in Francophone or Lusophone Africa. And none of these countries may have the advantages that Eastern European countries might due to their cultural and geographic proximity to Western cultures. A region-centric theory of innovation in emerging markets will help to identify the distinctiveness of innovations that originate within emerging economies, and the factors that attributed to this development.

Contributions

This paper will make several contributions to the literature. First, as we know businesses are important for innovation, understanding the diverse ways in which businesses innovate across emerging economies will offer insights for increasing these activities within these regions. This research will address a call to understand microlevel processes for how innovation unfolds in emerging economy firms (Sigueira & Bruton, 2010). Second, this research will highlight types of innovations that are associated with emerging economies, and thus, provide insights with respect to more appropriate measures for assessing innovation in these countries. This will enable the field to move away from the measures that are used to assess innovation in advanced economies when those measures are known to exist at low levels if they exist at all in emerging economies (Filippopoulus & Fotopolous, 2022). Thus, this research will offer the field measures that are more appropriate given the emerging economy context. Third, as we know that research has not been equally distributed across emerging economies, this research will highlight areas where additional research is needed to enhance understanding of innovation in emerging economies.

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Entrepreneurship and innovation: capabilities and links of Mexican firms in emerging contexts

Abstract ID#167

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Entrepreneurship and innovation made by micro, small and medium business that operate in emerging contexts in most cases respond to survival needs. Therefore, it is necessary to recognize that, for its study, such activities must be characterized based on criteria that consider this condition.

This research applies its own capacity taxonomy proposal, suitable for this type of firms, to analyse the management, innovation and entrepreneurship routines of a group made up of 11 Mexican companies, as well as the links they have made with different actors in a locality.

The frames of reference that were considered in this investigation are the following:

a) Micro, small, and medium companies. (Albuquerque, 2007; Gibson and Van der Vaart, 2008; Secretaría de Economía, 2009; Hashim and Abdullah, 2000; OECD, 2010).

b) Business capacities related to entrepreneurship, management, and innovation. (Levitt and March, 1988; Prahalad and Hammel, 1990; Nonaka and Takeuchi, 1999; Dogdson, 1993; Lazonick, 1993; Amit and Shoemaker, 1993; Collis, 1991 and 1994; Ventura, 1996 and Makadok, 2001; Zahra et al., 2011).

c) Company-society linkage. (Schartinger, Rammer, Fischer and Fröhlich, 2002; Correa, 2001; Zeng, Xie and Tam, 2010; Gortari de 2001, Jasso and Ortega 2007; and Ortega, 2005).

The research is qualitative and is based on a case study (Yin, 1993; 2003; Stake, 1999; Eisenhardt, 1989) in its modality of multiple holistic case (Yin, 2003) composed of 11 firms. Based on the following categories of analysis, an ad hoc questionnaire was constructed to apply an in-depth interview with the companies:

a) Business skills (entrepreneurship, management, and innovation)

b) Links made by firms with other agents.

c) Sources of information or knowledge.

The data collected was analyzed and interpreted through a combination based on the technique of discourse analysis and the identification strategy of emerging concepts (Pichón-Rivière, 1960).

Summary of results

Entrepreneurs give more importance to management skills than to entrepreneurship and innovation; older companies dominate practically the basic management skills, but not those that require more knowledge; their skills have been acquired in the university, in other training organizations and in their own company.

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ICT, innovation and absorptive capacities: Micro-level evidence from Colombia

Abstract ID#179

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Purpose

This research aims to evaluate the extent by which innovation and absorptive capacities are positively influenced by the adoption of information and communication technologies (ICT) inside the plant. Unlike existing research, our study does not solely focuses on the monetary resources that are devoted for the scaling-up of those technological facilities. More importantly, we pay strong attention on the development of three particular firm-level ICT capabilities that are also attached to such investment: the ability to perform online transactions (e-commerce), the competence to utilize internet tools at the workplace (e-integration) and the adoption of intranet and extranet networks to ease interaction across key partners (e-communication).

Literature Review

The empirical firm-level evidence studying the link between ICT, innovation and absorptive capacity remains rather scant and solely limited to the analysis of their indirect effects through indicators of performance. For instance, Marsh et al. (2017) indicate that firms with strong absorptive capacities are more likely to experience those positive productivity gains that are derived from the adoption of ICT and their corresponding spill-over effects. Roberts et al. (2012) also show that ICT investment represents a valid alternative to acquire and build absorptive capacities especially for the case of small firms that lack the critically relevant resources to properly disseminate knowledge and undergo this objective. Although these latter studies provide novel micro-level empirical insights, a higher number of quantitative analysis addressing the direct link between ICT adoption, innovation and absorptive capacities are deemed as highly necessary to better understand the current set of challenges being faced by manufacturing firms on their objective to build robust and resilient competitive advantages and rapidly adapt to existing digitalization trends.

Methodological Procedures

Our three proxies for ICT capabilities, as well as our variable accounting ICT investment, are first included as explanatory variables within a probit regression analysis on the elements that shape firms' propensity to innovate (execute R&D). These latter group of ICT and R&D related variables are then integrated as independent regressors in the context of a two-stage econometric analysis that deals with those micro-level factors configuring absorptive capacities. Such instrumental variable approach is performed considering potential endogeneity concerns on the relation between innovation (as an explanatory variable) and absorptive capacities (as a dependent variable). Our preferred instruments (i.e., indicators on cooperation related funding for innovation that can be granted either from domestic or foreign sources) are found to be exogenous and strong, thus suggesting that the IV estimates here obtained are unbiased and do not suffer from large standard errors.

Following the ideas from Cohen and Levinthal (1990), absorptive capacity can be defined as the ability possessed by a given firm to build long-lasting competitive advantages and rapidly adapt to changes in the environment. Absorptive capacities are thus herein conceptualized as the ratio of the lagged total factor productivity value (TFP) reported by a given firm with respect to the corresponding maximum industry-level lagged TFP. In our view, such TFP ratio serves as an accurate measure of firms' absorptive capacity because it underscores the existence (or the lack thereof) of an efficiency gap in comparison with the industry leaders operating in the market. A small TFP gap will then signal the ability of the establishment to profitably perform under the same competitive conditions as those encountered by firms with superior technology and skills.

These quantitative analyses are performed through the lenses of a novel Colombian micro-level dataset. By relying on various sources of official information, our research generates a single dataset for Colombian manufacturing that jointly reports industrial and innovation statistics together with data on ICT-related variables at the establishment level over a ten-year span (2008-2018).

Findings

Our general results suggest that innovation and absorptive capacities are differently affected by ITC capabilities. On the one hand, the probability to spend on R&D is argued to increase with the existence of each electronic competence (e-commerce, e-integration and, ecommunication). Firms that perform e-sales and e-procurement, that seek to engage a higher number of workers to utilize internet tools on their daily activities and that aim to strengthen cooperation through a higher use of intranet and extranet communication platforms are more likely to also spend monetary resources on innovation.

Nevertheless, when further exploring the impact of this same group of variables on our indicator for absorptive capacities our research then concludes that e-communication entails the sole ICT capability playing an active role in shaping the emergence of such competitive edge. The underlying reason for this can be related to the fact that the use of intranet and extranet network technologies not only reinforces means of communication between internal and external partners of companies, but also facilitates the dissemination of tacit knowledge and even encourages an increasing collaboration among those different entities, through the sharing of strategic data and information that could otherwise not be safely transferred.

Implications

These quantitative findings have strong policy implications for other emerging economies that seek to induce a profound digital transformation of their manufacturing base. In line with our results, effectively coping with the challenges and threats posed by the ongoing fourth industrial revolution does not merely entail devoting higher monetary resources on the improvement of existing ITC infrastructure. Pursuing a proper nurturing of special skills inside the plant is also necessary to successfully assimilate and internalize the different set of digital tools that are made possible by such investment.

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The role of legal orders in strengthening exisiting innovation ecosystems in emerging countries: a study of Brazilian laws and regulations

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Abstract: This article explores the relationship between a specific type of societal organization (innovation ecosystems) and legal orders (laws and regulations) in Brazil, considered an emerging country, in order to answer the following research question: what is the role of legal orders in strengthening existing innovation ecosystems in emerging countries. For this purpose, the normative legal drafting method was used and the model was adopted in which three components of significance are measured: the essence, extension and practicality of the law, in addition to evaluating legislative effectiveness by measuring three other components: public awareness of the issue, the gap between the intentions of legislators and the implementation of the law, and the existentiality of the gap. The so-called Legal Framework for Science, Technology and Innovation (Marco Legal da Ciência Tecnologia e Inovação – MLCTI, in Portuguese) was taken as the unit of analysis. The findings show that Brazilian legal systems represent a series of "legislator's intentions" aimed at making the country more competitive and better positioned in the global scenario of science, technology and innovation. However, they are out of step with advancing global economy, technology or societal needs and failed to focus on interaction between players.
Keywords: emerging countries, innovation ecosystems, innovation policy, legal orders, national innovation systems.

Introduction

The National Strategy for Science, Technology and Innovation that was in force until recently (ENCTI 2016-2022) placed as a condition for Brazil to take a leap forward in scientific and technological development and increase the competitiveness of products and processes the existence of a National Science, Technology and Innovation System – NSTIS robust and articulated. Represented by a wide range of actors with diverse roles qualified in three groups (political actors, development agencies and operators of Science, Technology and Innovation - STI, the political and social effort to bring them together occurs since the middle of the last century, but with few and occasional results over time.

In this sense, the Brazilian government has implemented a series of measures to stimulate innovation in the country, such as regulatory measures and tax, credit and direct financial support incentives, among others. On the normative front, the Legal Framework for Science, Technology and Innovation (Marco Legal da Ciência Tecnologia e Inovação – MLCTI, in Portuguese) sought to create incentives and bring academia closer to market needs. However, the results in terms of innovation are still not very significant. This performance is reflected in international rankings. In the 15th edition of the Global Innovation Index 2022 ranking, a publication that evaluates the performance of the innovation ecosystem of 132 economies, prepared by the World Intellectual Property Organization – WIPO and partners, Brazil occupies the 54th place; global leadership is Switzerland, followed by the United States and Sweden.

The MLCTI aimed to favor a more dynamic environment for innovation in the country, with greater legal security for the actors involved in the face of a history of insecurities and discontinuities that imply significant risks for the country's competitiveness. In this direction, the discussion was raised to the constitutional level and the revision of existing laws and decrees was promoted, respectively in the form of Law No. 13,243/2016 and Decree No. 9,283/2018 together they evaluated and discussed the legal and regulatory regime, including its operational dimension. It gave rise to conditions for the integration, simplification and flexibility of activities directly and indirectly related to innovation, such as making efforts to build and strengthen innovation ecosystems.

According to the MLCTI, innovation ecosystems are spaces that add infrastructure and institutional and cultural arrangements, which attract entrepreneurs and financial resources, constituting places that enhance the development of the knowledge society, comprising, among others, scientific and technological parks, cities smart centers, innovation districts and technology hubs.

Thus, this article aims to explore the relationship between a specific type of corporate organization (innovation ecosystems) and legal orders (laws and regulations) in Brazil, considered an emerging country, in order to answer the following research question: which the role of legal orders in strengthening existing innovation ecosystems in emerging countries.

To answer the proposed research question, in addition to this introductory section, the text presents the theoretical background; next, the methodological procedures; then the results, discussion and conclusions; and, finally, the adopted reference.

Theoretical Background

Within the scope of this research, which aims to explore how the relationship between a specific type of corporate organization (innovation ecosystems) and legal orders (laws and regulations) occurs (Goldoni, 2022).

Laws and Regulations

Laws and regulations play a crucial role in strengthening innovation ecosystems through the traditionally recognized existing functions proposed by Kono & Kagami (2015). First, laws and regulations can be a tool to increase the individual capacity of each player. Second, contracts and property can be protected by laws and regulations. Third, laws and regulations are needed to develop and manage infrastructure, including financial systems, information systems, traffic systems, distribution systems, production systems, and legal systems for innovations. Conflicts of modes are fatal for innovations, because if the modes of the players do not match, the modes can be adjusted by autonomous in the ecosystem to which they belong. But, we could not rely on the autonomous tuning functions of an ecosystem, and we might have to use mechanisms and powers outside the ecosystem. Here, there is the potential usefulness of laws and regulations, although the previous analysis neglected this aspect. In this direction, the General Theory of Law is used in which Kelsen (2005) established a correlation between the different matrices of norms existing in the legal system of a sovereign country. The Federal Constitution emanates the commands that form the state and must be observed by the entire legal system. The Laws establish general and abstract rules for everyone to fulfill the obligations and provisions contained in their statements. Decrees are acts of the Executive and Legislative Powers to regulate within their scope the rules set forth in the Law and the Constitution. Finally, each body or public entity will formulate and publish administrative acts that must be applied internally to ensure compliance with the Federal Constitution, laws and decrees.

More critically, perhaps, in emerging countries that are characterized by a lower level of economic development and have relatively immature legal, political and financial institutions, which results in an ambiguous and uncertain business context (Kuhlmann & Ordóñez-Matamoros; 2017; Guimón, 2018).

Recent studies that promote reflections on new trends and challenges in innovation policies reinforce this understanding (Edler & Fagerberg, 2017; Diercks, Larsen & Steward, 2019; Akcigit, Hanley & Serrano-Velarde, 2021; Janssen 2022). The traditional logic of innovation policy has been expanded to contribute more explicitly to addressing societal challenges (Tödtling, Trippl & Desch, 2022; Bergek, Hellsmark & Karltorp, 2023).

Innovation Ecosystems

Innovation is considered an efficient socioeconomic development strategy, and innovative activity has been encouraged all over the world. Innovation is ubiquitous in all parts of the economy. The paths through which innovation can be achieved, however, have not been clearly and satisfactorily identified in studies on innovation policies. The current understanding of innovation, how many types of innovation there are and how which innovation can be achieved, has not been clearly identified. Building an innovation ecosystem has emerged as a promising approach and has recently attracted more and more interest from scholars and practitioners (Gu, Hu, Zhang & Hou, 2021).

There are different perspectives for innovation ecosystems in the literature, such as the link with open innovation, value creation and capture processes in innovation ecosystems, and the need to properly orchestrate them (Yaghmaie & Vanhaverbeke, 2019).

An emerging perspective is adopted that highlights the entrepreneurial role of the State in the institutional formation of market relations, society and the State itself, which has been referred to as 'legal institutionalism', born in reaction to two dominant currents of studies, positivism legal and natural law (Deakin, Gindis, Hodgson, Huang & Pistor, 2017). The entrepreneurial state debunks the myth that private companies are solely responsible for innovation and the growth of economies (Mazzucato, 2011; Mazzucato, 2015, Mazzucato, 2018; Dosi, Lamperti, Mazzucato, Napoletano & Roventini, 2021). However, innovation is not limited to technological activities only, but includes organizational and transactional improvements, and is largely a process of recombining local and imported knowledge, shared through multiple forms of collaboration. There are distinct varieties of innovation ecosystems, which can have their types demarcated by accounting (and distinguishing) their conceptual and objective boundaries (Rinkinen & Harmaakorpi, 2019; Beaudry, Burger-Helmchen & Cohendet, 2021; Zheng & Cai; 2022).

Methodological Procedures

Using the normative legal writing method (Taekema, 2018), we conducted a literature study based on secondary data and primary legal materials (laws and regulations) to study the role of legal orders in strengthening existing innovation ecosystems in Brazil to determine whether laws and regulations are meaningful and effective. To answer this question, we adopted the model proposed by Akirav (2018) in which three components of significant significance are measured: the essence, extension and practicality of the law. The model also assesses legislative effectiveness by measuring three other components: public awareness of the issue, the gap between legislators' intentions and the implementation of the law, and the existentiality of the gap.

The MLCTI is adopted as the unit of analysis, which covers the constitutional provisions related to the study (especially those resulting from Constitutional Amendment No. 85/2015), Law No. 10,973/2004 (updated by Law No. 13,243/2016) and Decree No. 9,283/2018. These legal orders establish measures to encourage innovation and scientific and technological research in the Brazilian productive environment.

Its most relevant themes are addressed in this study: the innovation policy of scientific, technological and innovation institutions, environments that promote innovation, legal instruments, accountability, budget changes, economic subsidy, technological bonus, minority participation in the capital of companies and investment funds by the Union, the other federative entities and their entities, public purchases, the technology ordering contract, the importation of goods for research, and the transfer and dissemination of technology.

Results

The inclusion of innovation in the Brazilian political agenda is recent, starting around the 2000s. However, the main milestone of this movement is Law No. with emphasis on the articulation of public and private entities.

From the regulation of the Innovation Law and the subsequent enactment of other laws related to STI, representatives of academia and the public and private sectors understood that the Innovation Law still needed adjustments so that it served the purpose of promoting innovation, either in the sense of removing obstacles, some of them created after the enactment of the Innovation Law in 2004, or in the sense of giving greater effectiveness (ie, enforcement) to some of the initial objectives of the Law itself.

Then, in 2011, the creation of a National ST&I Code was proposed, which contemplated the robustness and complexity of a compendium of laws related to STI, but after rounds of hearings and public consultations on the House Bill – PLC nº 2177 of 2011, the proposal for a code was abandoned in favor of a more specific strategy aimed at modifying the Federal Constitution and revising the Innovation Law, as well as changing other rules related to STI.

It resulted in Constitutional Amendment No. 85 of 2015 (which founded the MLCTI in Brazil), and Law No. 13,243 of 2016.

Constitutional Amendment No. 85 of 2015 inserted the role of the NSTIS in the Federal Constitution. According to article 219-B of the Federal Constitution, the System "will be organized in a collaboration between entities, both public and private, with a view to promoting scientific and technological development and innovation". It gives greater prominence to State policies related to the STI theme, opening the opportunity for regulation that could give greater centrality to the sector's affairs by the entities of the Federation.

The changes introduced by Constitutional Amendment No. 85 of 2015 sought to stimulate scientific and technological development and innovation. One of the main objectives was to boost national research and the creation of technological solutions that improve the performance of the productive sector. Changed several constitutional devices to improve the articulation between the State and public and private research institutions. In addition, it expanded the range of entities that can receive support from the public sector for research. In addition to universities, professional and technological education institutions may be supported. It also established, as a new function of the State, the stimulation of articulation between the entities of the sector, both public and private, in the execution of research activities, scientific and technological training and innovation. The State will also promote the activities of these institutions abroad. To improve the exchange of knowledge, the text allows the cooperation of the spheres of government (Union, States, Federal District and municipalities) with public and private bodies and entities. With the aim of making the achievement of established scientific goals more feasible, the amendment grants greater freedom in the management of resources destined for research, by allowing their relocation or transfer from one programming category to another without the need for prior legislative authorization.

In this direction, regulatory adjustments were made, of which Decree No. 9,283, of 2018, amending the Innovation Law (Law No. 10,973, of 2004, already modified by Law No. o. 13,243 of 2016 (art. 24, paragraph 3, and art. 32, paragraph 7, of Law No. 8666, of 1993), art. 1 of Law No. 8,010 of 1990, and art. 2, caput, item I, letter "g", of Law nº 8,032, of 1990. It created mechanisms to integrate Scientific and Technological Institutions – STIs and encourage investments in research, such as: simplifying the signing of agreements for the promotion of research public and procedures for importing goods and inputs for research; the internationalization of scientific and technological institutions and increase the interaction between STIs and companies; increase the promotion of innovation ecosystems; diversify financial instruments to support innovation, allow greater sharing of resources between public and private entities; and to generate new incentives for the realization of technological orders and flexibility in the reallocation between budgetary resources. However, until now, the need to recompose eight vetoed items remains. The Senate Bill - PLS n.º 226/2016 is still in Congress and aims to restore the vetoes, as there is an understanding that they prevent the Law from operating in the fullness of its conception, disregarding action proposals that structure the NSTIS to operate according to the potential of the country.

It is worth highlighting the main thematic axes of Constitutional Amendment No. 85 of 2015 that can provide a foundation for eventual more technical systematic approaches and a more effective application of infraconstitutional legislation (Soares & Prete, 2018): (i) raising the theme of Science, Technology and Innovation as a State policy, its implementation no longer subject to the discretion of a specific Government; (ii) adoption of the term "Innovation" together with "science" and "technology" representing the organicity and interdependence between science, technology and innovation; (iii) constitutional adoption of the triple helix theory, used to explain how the Economy of the Knowledge Era is a result of the integrated and synergistic action of the Public Power, Public and Private Institutions of Teaching and Research and the Productive Sector; (iv) deconcentration and decentralization of powers for the purposes of local and regional regulatory densification of the STI system: capillarization, flexibility and local adequacy; and (v) reflection on whether education, given its articulation with the purposes of innovation, would not receive additional functions, in addition to being combined with other topics under the aegis of the state, with health, for example. In this direction, its most relevant themes can be highlighted (Portela, Barbosa, Muraro & Dubeux, 2019): the innovation policy of scientific, technological and innovation institutions, environments that promote innovation, legal instruments, accountability, budgetary changes, economic subsidy, technological bonus, minority participation in the capital of companies and investment funds by the Union, other federative entities and their entities, public purchases, technological order contract, import of goods for research , and technology transfer and diffusion.

The innovation policy of scientific, technological and innovation institutions is required by article 15-A of the Innovation Law as a reflection of the consensus that efforts for the necessary boost to innovation in Brazil depend on the participation of STIs and their greater insertion in national and local development policies. In addition to the Innovation Policy, each Public STIs, and recommendably private STIs, must set up or join a Technology Transfer Offices – TTOs, as provided for in article 16 of the Innovation Law.

Innovation-promoting environments, as well as technology transfer activities, were raised to the condition of principle of measures to encourage innovation and scientific and technological research in the productive environment, in accordance with item VII of the sole paragraph of article 1 of the Law of Innovation. Its relevance derives from the understanding that it is necessary to ensure conditions for integrated action between public power, private initiative and academia.

The legal instruments of partnership that started to be based on norms that consider them in a systemic way and that take into account the nature of research activities in Brazil. Thus, the legal and infralegal provisions introduced by Law No. 13,243 of 2016 and Decree No. 9,283 of 2018 were prepared based on two business elements: (i) the legal object of the research and (ii) the type of obligation existing in the legal relationships of Research, development and Innovation – RDIR.

Accountability has taken on a new standard. Instead of focusing on financial execution, the new model is focused on the search for research results, really aiming to produce new knowledge, and not so much directing a significant part of the efforts to the fulfillment of formalities.

The budget changes were ruled by the MLCTI to meet the particularities of the area of science and technology, admitting, with certain limitations, three new rules: (i) reallocation of credits by the

Executive Branch, without the need for legislative amendment through a bill submitted to the National Congress; (ii) certain flexibility so that the researcher, through simple communication to the granting institution, can change the limits of expenses foreseen within the scope of each project for which he is responsible; and (iii) explanation of the possibilities for STIs to use support foundations to capture and manage resources from private sources.

The technological bonus, a type of subsidy to micro-enterprises and small and medium sized companies, intended for the payment of sharing and use of technological research and development infrastructure, contracting specialized technological services or technology transfer, as long as they are complementary to services.

Minority participation in the capital of companies and investment funds by the Union, the other federative entities and their entities, with the purpose of developing innovative products or processes that are in accordance with the guidelines and priorities defined in the STI and industrial development policies of every sphere of government.

Public procurement was revisited to provide greater legal certainty and modernize legislation in the area, consisting of (i) admitting the use of a faster and more flexible bidding model for STIs, called the Differentiated Public Procurement Regime – RDC; (ii) the extension of the possibility of exemption from bidding for the acquisition of products for research and development, including engineering works; and (iii) waiver of delivery of documentation by contracted companies in certain types of contracts.

The technological ordering contract that refers to contracting research and development for the creation and application of an innovative technological solution not available on the market, to be used or appropriated by the State, in the presence of technological risk, and may cover the subsequent scale acquisition of the final product generated, in order to meet a specific public demand.

The importation of goods for research must be done quickly to avoid damage to RDI activities. For this reason, Article 11 provides that import processes and customs clearance must have priority treatment and will observe simplified procedures.

The transfer and dissemination of technology by public STIs were disciplined through contracts, such as the Intellectual Property Assignment Agreement - IP, IP Licensing Agreement and Technology Transfer Agreement, with specific nuances in each of these types.

However, over the last few years it has been possible to observe a series of gaps in the Brazilian STIS and in the developments of the MLCTI.

According to the Technical Note "Reflections on NSTIS from the Center for Management and Strategic Studies – GEE, the need to reformulate the very frame of its conception is perceived, which seems to start from the idea of being possible to build an a priori structure, ready and finished with the prior definition of all participants and their roles, showing, when viewing the current map of the NSTIS, that one is facing a formulation of an operationally viable model, just pressing the "on" key. The Federal Court of Auditors - TCU, in its Judgment 1237/2019, detected the absence of a structure to coordinate federal policies to promote innovation. For example, it found that the ENCTI 2016-2022 does not meet the requirements to be considered as the central axis of the country's growth recovery strategies. It cannot be considered a long-term innovation strategy, which would cover a period of 10 to 20 years. In fact, it has been a considerable challenge, if we take into account the results of the Innovation Survey - PINTEC covering the 2015-2017 triennium, as they suggest that, despite Brazil being the ninth largest economy in the world, it lacks a watchful eye and for the STI area in face of the challenges faced by Brazilian companies. However, there is a profusion of movements within the ITC that deserve special attention. Subsequent to Judgment 1.237/2019- TCU-Plenary, the then Ministry of Science, Technology, Innovation and Communications - MCTIC, supported by the Civil House of the Presidency of the Republic, began efforts to build a policy with the purpose of establishing objectives and guidelines that guide , systemically and universally, the role of federative entities regarding the theme of innovation. As a result of work started in 2019, led by MCTIC through the Secretariats of Entrepreneurship and Innovation – Sempi and of Financial and Project Structures – SEFIP, with the participation of other NSTIS actors, Decree No. 10,534 of 2020 the National Innovation Policy – PNI and provides for its governance. In view of this, the TCU decided to act concomitantly by monitoring the formulation of the PNI, at the then MCTIC and at the Civil House of the Presidency of the Republic, using as a basis the findings and deliberations of the aforementioned judgment.

Monitoring the PNI aimed to contribute to the policy formulation process, so that it serves as an effective instrument to guide the State's actions to promote innovation in Brazil. In this sense, we sought to verify in the PNI proposal the presence of previously non-existent aspects in the ENCTI 2016-2022 that greatly impact the State's capacity to guarantee that the resources destined to the promotion of science, technology and innovation reach the results desired by the government itself and by society. The study found that the preliminary proposal for the PNI had weaknesses that could harm its ability to strategically guide action.

TCU also carried out an operational audit (TC 014.856/2021-2) with the objective of evaluating the level of implementation of the MLCTI in the 69 federal universities. TCU inspection had some specific objectives, such as verifying whether innovation policies were formalized and whether they are up to date. We sought to identify the degree of effective implementation of the incentives provided for in the MLCTI and the difficulties for its adoption. The audit also examined the operational capacity of the units involved in policy management and innovation production, mainly the TTOs and the departments that carry out research. It concluded that the level of implementation of the new MLCTI by most Brazilian federal universities is still low. It was identified by the TCU that about half of the federal universities do not have updated innovation policies, in accordance with the provisions of the new MLCTI, with 14 universities not even having formalized policies. In addition, the TCU audit found that factors external to educational institutions may be hindering the creation of TTOs. Such as budget difficulties, lack of skilled workforce, lack of innovation culture and inadequate infrastructure.

TCU also carried out an audit (TC 027.088/2020-0) to assess the governance structure in the promotion of federal public incentives for CTI in charge of the Financier of Studies and Projects - Finep in the last five years. The work evaluated the federal public incentives in CTI in charge of Finep, as well as the performance of the current Ministry of Science, Technology and Innovation - MCTI as a conducting body of public policy, carried out mainly with resources from the National Fund for Scientific and Technological Development - FNDCT. The FNDCT aims to finance innovation and scientific and technological development in the country and constitutes the most important instrument available to the MCTI to support these areas, when only budgetary expenditures are considered. The audit found the need to develop a long-term strategic reference for the use of FNDCT resources and the inadequacy of monitoring the execution of actions in terms of performance by Finep. The audit also found the need for continuous realignment of strategies in the management of the FNDCT, with lessons learned from the evaluation of results, and the need for continuous availability of information on monitoring indicators and evaluation of results. As a result of the work, the TCU determined, among other measures, that the Board of Directors of the FNDCT establish and prepare long-term strategic planning for the use of FNDCT resources, in line with the strategies of the subject contained in the related regulations.

In a survey on the 'Perception of Foundations on Bureaucracy' conducted by the National Council of Foundations to Support Institutions of Higher Education and Scientific and Technological Research – Confies in 2021, it was shown that the reduction of bureaucracy for research and development activities, its main motto of the law, did not materialize. Of a total of 147 responding researchers, 54% assessed that bureaucracy had increased in recent years, even with the Legal Framework in force. Another 25% said the situation remained the same — no worse and no better. Among the support foundations (which intermediate contracts between funding agencies and research institutions), 61% said that bureaucracy increased and 32% that it remained the same. The MLCTI removes a series of knots and barriers that hindered (or even completely prevented) cooperation between public and private institutions for scientific purposes. The problem is that these changes were not incorporated satisfactorily into the day-to-day activities of control bodies (such as attorneys' offices and courts of accounts) or development agencies, which finance projects, or even universities and research institutes, where research is carried out. are made.

Discussion

Following the model proposed by Akirav (2018), it was possible to reflect on the essence, extent and practicality of the MLCTI to determine its significance. In essence, the MLCTI promotes the encounter between two antagonistic operational dynamics: the formal hierarchical and bureaucratic logic of the State and the relatively informal flexibility of the high technology economy. Thus, the MLCTI presents an articulated set of actions to produce an improvement in the management model of legislative elaboration adequate to the Brazilian reality, capable of articulating and harmonizing public policies and normative acts. However, in terms of its practicality, in order to achieve all its effects and effectively become the daily routine of the actors who operate the NSTIS, it also needs to be regulated at the state and municipal level, in addition to each agency and public entity formulating and publishing administrative acts that must be applied internally to ensure compliance with the Federal Constitution, Laws and Decrees, ensuring their extension to create a favorable environment for innovation and scientific research in Brazil.

Likewise, the model proposed by Akirav (2018) allowed reflecting on the public awareness of the subject, the gap between the intentions of legislators and the implementation of the law, and the existentiality of the gap of the MLCTI to determine its legislative effectiveness. In fact, the changes that culminated in the MLCTI were the result of the growing awareness of the Brazilian political class regarding the articulation of the Brazilian scientific community with the National Congress for the adequacy of the Brazilian Constitution and the pertinent legislation to the challenges of STI in Brazil. However, there is a gap between the intentions of legislators and the implementation of the MLCTI, since the level of its implementation is low, especially in Foundations that do not observe an improvement in "bureaucracy" and in Public Universities, one of the main actors of the Brazilian STIS, regarding the implementation of policies for innovation and consolidation of the TTOs. The existentiality of the gap is evidenced in four aspects. Conception of the Brazilian STIS. Absence of structure to coordinate federal policies to promote innovation. Low level of implementation of the new MLCTI in Foundations at federal universities. Inefficiency in the use of FNDCT resources.

The MLCTI demonstrates significance, but its effectiveness falls short of the expectations of legislators and the scientific community, and must be continuously improved.

Conclusions

The conclusions obtained in the research demonstrate that the Brazilian legal systems represent a series of "legislator's intentions" aimed at making the country more competitive and well positioned in the global scenario of science, technology and innovation. However, they are out of step with advancing global economy, technology or societal needs and failed to focus on interaction between players.

It is suggested that the role of legal orders in strengthening existing innovation ecosystems in emerging countries, taking the Brazilian case as a reference, would be to facilitate procedures and partnerships for research activities that allow the different actors of the NSTIS to relate to each other in a similar way. a less hierarchical and bureaucratic form and closer to the relatively informal flexibility of the high-tech economy. However, for this role to be fulfilled, it is essential to ensure its effective implementation, translating the legislator's intention into action and, therefore, in obtaining results. It is necessary to ensure the integration of the NSTIS, but as long as the MLCTI is deployed at all levels and effectively implemented based on an adequate allocation of resources in accordance with an agenda appropriate to the country's ambitions.

In this direction, to strengthen the existing innovation ecosystems in Brazil, demand must be at the center of a challenge-oriented innovation policy that is not limited to technological activities, but includes multiple forms of collaboration and conflict resolution modes in a wide range of ways. variety of innovation ecosystems characterized by their boundaries and goals. A mission-driven policy agenda would have the potential to increase the effectiveness of Brazil's innovation policies, as well as helping to rebalance public finances, not through spending cuts but by focusing on strategic investments and future revenues. Such missions expressed in the public discourse of scholars and professionals would be the adequate guide to assign objective values to legal orders aimed at strengthening the existing innovation ecosystems in Brazil. Therefore, we should not assume the idealization of the institutional capacities of the legislators, without opposing with the empirical information available in order to guarantee that the legal orders of a business state make the business context less ambiguous and uncertain.

This finding leads to the main theoretical implication of this study, which involves obtaining new insights into the role of legal orders in strengthening existing innovation ecosystems in emerging countries, indicating the growth of the conceptual and analytical apparatus around this relationship that characterizes a field of evolving research that can be explored based on the model proposed by Akirav (2018), in addition to raising new elements that complement the understanding of significance and effectiveness, such as the achievement of results, which would bring the debate closer to the Economic Analysis of Law – EAD. In this case, the application of the analytical and empirical instruments of Economics would be applied, in order to try to understand, explain and predict the factual implications, as well as the logic (rationality) of the legal system itself.

Furthermore, we consider the inclusion of the debate on significance and effectiveness in the formulation of innovation policies as an implication for public policy makers, when considering the provision of mechanisms that ensure compliance with the role of legal orders in strengthening innovation ecosystems, whether through systematic monitoring of alignment between the planning and reality and the results obtained for the necessary route adjustments.

Finally, it is important to note the limitations of this study. The findings are specific in relation to the body of literature used and the Brazilian context. The possibility of expanding the body of literature, its connection with different scientific theoretical bases or the conduction of empirical investigations in this field in other emerging countries or comparatively in developed countries, could result in additional observations on the role of legal orders in strengthening ecosystems of innovation.

Special attention should be given to future studies on how the topic is addressed in the formulation and implementation of innovation policies, as well as whether it is linked to other literature references, including adherent scientific theoretical bases and with the potential to expand the capacity for reflection on the findings obtained.

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INNOVATION EVALUATION AND IMPACT I

May 1st: 3h10 pm – 5h pm

Chair

Mario Sergio Salerno (University of São Paulo, Brazil)

Papers

How can the performance of circular business model design be measured? A systematic literature review

Rodrigo Bruno Santolin, Andrea Urbinati, Valentina Lazzarotti

Success Factors of technology-based startups

Tiago Paz Lasmar, Ana Paula Paes Leme Barbosa, Mario Sergio Salerno, Edivan Alexandre Ferreira

Living labs and the innovation learning process: A literature review using the template analysis

Murilo Marques, Elaine Mosconi, Luis Antonio de Santa-Eulalia

Predicting incremental technological change based the technological life cycle

Juan Andrés Niño Peñalosa, Luciano Gallon, Jorge Manrique, Santiago Quintero Ramirez

How can the performance of circular business model design bemeasured? A systematic literature review

Abstract ID#184 | Full paper ID#529

Rodrigo Bruno Santolin (Federal Institute of Rio Grande do Sul, Carlo Cattaneo University);
Andrea Urbinati, Valentina Lazzarotti (Carlo Cattaneo University)

Abstract: One of the great challenges for companies doing the transition towards a circular economy lies in the management and measurement of their circular business models. This fieldof research is still at an embryonic stage with instruments that need to be validated and expanded. A performance measurement system can be understood as a holistic approach to themanagement and control of organizational performance. It is a broad concept that has the aimof aligning individual actions and interactions, thereby binding together the various parts of theorganization according to the company's vision and strategic ambitions. No performance measurement systems to measure the degree of circularity of circular business models were found in previous studies. Starting from the above premise, this research aims to answer the following research question: how can the performance of circular business model design be measured? To bring the answer, the paper makes use of an extensive Systematic Literature Review (SLR) at the intersection between the research fields of performance measurement and circular business models and synthesizes the results in a novel framework. The research is stillin development, so there are no definitive results. However, they are going to have practical implications serving as a guideline for companies that are starting new circular economy practices and those that are adapting their traditional business models towards the circular economy paradigm.

Keywords: measurement, circular economy, circular business model

Introduction

Circular Economy (CE) is a fundamental avenue towards sustainable development that retains the value embedded into products and materials through the principles of reducing, reusing, recycling, and recovering (Ghisellini et al., 2016; Kirchherr et al., 2017). This achievement is projected through new and innovative circular business models that are designed to create, transfer and capture the value of the products and materials (Centobelli et al., 2020; Nußholz, 2018; Pieroni et al., 2019; Ranta et al., 2021; Urbinati et al., 2017). Into this logic, the adoptionof circular business models can be considered the 'How' (i.e. the pathway), while the reachingof sustainable development under the triple bottom line approach (i.e., the environmental, social, and economic performance) can be considered the 'Why' (i.e. the goal) to be persecuted(Corona et al., 2019; Geissdoerfer et al., 2017; Nobre & Tavares, 2021; Schroeder et al., 2019).

The transition to a more circular and sustainable economy faces an important challenge in the performance management of a circular business model in order to address the path towards sustainability (Sassanelli et al., 2019). Most of the already existing circularity measurement systems take into account only the material perspective (e.g. recycling rates or waste volumes),in which is better when more material or product is maintained in circulation (Blum et al., 2020; Stucki et al., 2023). However, they don't consider the existence of different strategies designed (e.g. sharing platforms, product service systems, long service life) under the perspective of novel circular business models and their value dimensions (Moraga et al., 2019;Reich et al., 2023; Saidani et al., 2019). In this sense, is important to posit that measuring onlythe circularity of materials is insufficient to pursue the path towards sustainability. The researchgap is evident and is going to be addressed in this paper.

Different firms have different circular business models that are strategically focused on different value dimensions (Centobelli et al., 2020; Kaipainen et al., 2022; Urbinati et al., 2017). The performance measurement systems used to measure these circular business modelsneed to consider the company's strategy in terms of value creation (e.g. design for X practicesor upgradability of products), value transfer (e.g. effective commercial initiatives), and value capture (e.g. take back systems or product-service-systems). When firms adopt systems centred only on indicators that measure the flow of materials, the approach is limited and can, sometimes, lead to an increase in the rate of material circulation that can be mistakenly interpreted as positive (Blum et al., 2020). Instead of it, the fundamental is to optimize on the one hand the minimization of social and environmental impacts within the value dimensions, and, on the other hand, the maximization of the firm's economic performance, leading to a sustainable development. In this case, it is important to have systems that go beyond measuringcircularity.

Considering the above posited, the paper aimed to answer the following Research Question:

How can the performance of circular business model design be measured?

For performance we intend to address the circularity and sustainability aspects (i.e. making a simplification exercise, the word 'performance' could be replaced by 'circularity' and 'sustainability'). In order to achieve this target, we conducted a systematic literature review that aim to collect the most important papers in order to subsidize the development of an integrative management system that consider the value dimensions of circular business models coupled with the triple bottom line of sustainability. In this way, the performance of different circular business models designs can be assessed, considering metrics not limited in the material flow.

Methodology

To answer the Research Question we developed a Systematic Literature Review which is considered a secondary study with clear and replicable methodology, with thoroughness and rigor, that allows scholars to identify, evaluate, select, and synthesize studies on a particular specificity (Fink, 2010; Snyder, 2019). It is a mixed methodology that integrates qualitative and quantitative analysis (Brewerton & Millward, 2001). Our Systematic Literature Review was conducted according to the objective process proposed by (Tranfield et al., 2003) considering the different theories and perspectives inherent to the business and management fields coupled in our target (i.e. our research question).

Based on the premises posited above, the study was conducted using a review protocol that was built considering three main phases:

- Data selection: Encompass the definition of the keywords and databases to be adopted,the filters designed to collect the papers, and the definition of exclusion criteria.
- Descriptive analysis: A descriptive statistics of the papers selected are presented.
- Content analysis: The found literature is analysed in depth and the research gap is fulfilled with the development of a framework that synthetise the measurement systemdesigned for assess the degree of circularity of circular business models.

Data Selection

The first step of this SLR was to identify the relevant and eligible literature on the aspects under investigation. Many studies, as example (Mongeon & Paul-Hus, 2016; Singh et al., 2021; Waltman, 2016) presented that the overall Scopus database coverage of academic journals is higher than other databases and only a small percentage of relevant journals are not indexed there. For this reason, we used only the Scopus database to retrieve all the relevant content. Furthermore, the material search phase was strategically conducted in the first week of the year2023, in order to cover all articles published until the end of the year 2022.

The research tried to bring together papers dedicated to the combined analysis of 'circular economy', 'sustainability' and 'measurement systems', not limited to metrics to measure the circularity of products, but seeking to holistically integrate all value dimensions of a circular business model. To pursue this, it taking into account a combination (i.e. the Boolean operators“and” and “or”) of terms limiting the research in the title, abstract or keywords of the articles published in peer-reviewed journals in English language. Synonyms of terms were extensivelyresearched and analysed, resulting in the initial query ‘TITLE-ABS-KEY (("circular economy" or circularity) AND (sustainability or "sustainable development") AND (performance OR indicator OR score OR index OR metric OR measure*)) AND (LIMIT-TO(DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO(SRCTYPE , "j"))’. The initial sample of articles was therefore equal to 1.718.

As next step, this initial query was validated, on the one hand, through a focus group composed of five researchers operating in the umbrella of management field (i.e. supply chain, sustainability, performance measurement systems, circular economy and network analysis). Onthe other hand, by comparing our query with additional keywords used by the papers with thehighest number of citations (i.e. trying to comparing with the highest quality papers). At this stage, it was found that many articles referred only to environmental issues, focused on an environmental approach, which was not the main objective of our research. Hence, the query used was partially modified with the insertion of a new limitation, including only papers published in the ‘Business, Management and Accounting’ subject area. It is important to mention that this cannot be understood as a review bias, as it is about directing the focus of theresearch to its objective. In addition, some highly cited papers were not included in our researchdue to the use of the word “measure” and “measures” as keywords. To solve the problem, we included an asterisk after the word “measure*”. At the end, the query generated was ‘TITLE-ABS-KEY (("circular economy" or circularity) AND (sustainability or "sustainable development") AND (performance OR indicator OR score OR index OR metric OR measure*)) AND (LIMIT-TO (SRCTYPE,"j")) AND (LIMIT-TO (DOCTYPE,"ar")) AND (LIMIT-TO (SUBJAREA,"BUSI")) AND (LIMIT-TO (LANGUAGE,"English"))’ that resulted in 419 papers found.

Advancing in the data selection criteria we performed a manual coding to select the papers that may better address our research question. Clearly explaining, articles that address measurement systems (i.e. indicator, score, index, metric, tool) at the micro level of the circular economy were included. We considered all papers that could contribute to holistically integrate all valuedimensions of a circular business model, singly or in an integrated way. The micro level can be understood as the company level (i.e. encompasses the circular business models) and considers all company’s stakeholders (Merli et al., 2018; Yuan et al., 2006). Articles with different focus were excluded. The first step of the manual coding was the reading of the titlesand abstracts of the papers. The exclusion criteria were applied to those who did not align withour research question (Urbinati et al., 2022). In this stage 94 papers remained for the next analysis.

In the second selection criteria, a full paper analysis was conducted to check the focus of the full text of the articles. Two researchers, plus a third one in case of uncertainty, read the full text of the papers and checked the inclusivity criteria stated above. This resulted in in the maintenance of 77 papers.

As additional selection criteria, we considered a hand searching and citation tracking (Booth, 2016). In this way, we found papers that were aligned with our research question but were notselected through the databases and search terms chosen. In this step we included more 4 papers.At the end, the total sample of our research was 81 papers, as shown in the Table 1.

Phases	Actions	Number of papers
Step 1	Definition of the initial query	1718
Step 2	Initial query refinement	419
Step 3	Abstract and title analysis	94
Step 4	Full paper analysis	77
Step 5	Additional hand searching and citation tracking	4
Total sample	Step 4 + Step 5	81

Table 1. Steps of the systematic literature review

Data Analysis

This subsection provides a descriptive overview of the selected papers. The 81 papers were analysed considering the following perspective:

- Papers over time
- Papers and citations across journals

Papers over time

The distribution of papers over time highlights the topic's novelty. In Figure 1, it is possible tosee that interest in the topic has increased significantly from the year 2021 onwards. This showsthat although the circular economy is still an evolving concept, its best practices are already being implemented and it has demanded the development of measurement systems.

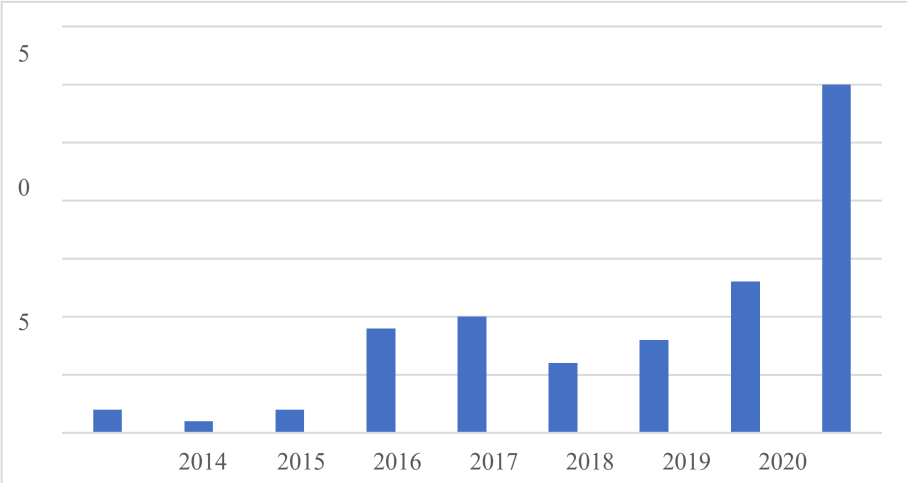

Figure 1. Distribution of papers over time

Papers and citations across journals

The distribution of papers across journals is shown on the Table 2 and highlights the large variety of journals publishing articles on the interest of this research. The journal with the highest number of papers included was the ‘Journal of Cleaner Production’.

Journal	*Number of papers*	*Total citations*	*Citations per document*
Omega (United Kingdom)	1	631	631
Journal of Cleaner Production	53	4306	81,25
Benchmarking	1	50	50
British Food Journal	1	1	1
Business Strategy and the Environment	6	215	35,83
Cleaner Logistics and Supply Chain	1	8	8
Corporate Social Responsibility and Environmental Management	2	11	5,5
International Journal of Logistics Management	1	1	1
International Journal of Mathematical, Engineering and Management Sciences	1	3	3
International Journal of Production Economics	3	52	17,33
International Journal of Production Research	2	1	0,5
International Journal of Productivity and Performance Management	1	13	13
Journal of Business Research	1	3	3
Journal of International Studies	1	19	19
Management Decision	1	47	47
Operations Management Research	1	2	2
RAUSP Management Journal	1	0	0
Technological Forecasting and Social Change	1	0	0
Technology in Society	1	1	1
WSEAS Transactions on Business and Economics	1	6	6

Table 2. Distribution of papers and citations across journals

Theoretical Framework

Our literature review showed that none of the selected articles makes a holistic analysis of the measurement of the entire circular business model dimensions (i.e. considering value creation,

Value transfer and value capture). A feature that can be seen in the existing literature is which the focus of measurements on the circular economy field is the development and application of indicators to measure the potential degree of circularity of products (i.e. limited to the value creation). Intending to advance in the theoretical development of the field, after the data selection, we inductively propose the holistic framework, shown on Table 3. It is based on a combination of managerial practices adopted for achieve circular economy, the already existent performance measurement systems for assess circularity and the consolidate literature on circular business models and their value dimensions.

Circular Business Model Dimensions (Osterwalder et al., 2005; Urbinati et al., 2017)	**Value Creation**	**Value Transfer**	**Value Capture**
Managerial practices (Centobelli et al., 2020; Franzò et al., 2021)	-Product design for circularity (to products and processes) -Upgradability of products -Resources and Energy Efficiency -Waste Management -Interventions on key activities	-Effective commercial and promotion initiatives -Communication of circularity through all channels - Offering the right value to the right customers - Management of changes in customer habits	- Building and maintaining relationships with customers to promote take back systems - Shift from product selling toward product-service system (PSS) - Extend the product life cycle
Abundance of performance measurement found in the literature	High	Low	Medium
Types of performance measurement found in the literature	MCI, VRE, EVR, CPI, PLCM, CEI, OSR, Longevity, PLCM, NTUM, CIRC		LCA, MFA, eDIM

Table 3. The framework of results

The following subsections provide a detailed description of the framework and its mains constructs.

Contextual factors

The performance measurement of a circular business model must go beyond of the borders of material analysis. An assessment of a circular project needs to consider its value creation withhigh circularity of material (Elia et al., 2017), a good channel of value transfer for the customers(Franzò et al., 2021) and an efficient system of value capture, extending the product life cycle(Ranta et al., 2018). These are the expectation of value of all companies' stakeholders that should be satisfy by circular business models design (Ellen MacArthur Foundation, 2013). Atthe end, the value dimensions have some tangible and intangible components that can be combined to develop an integrative performance measurement system.

In order to better understand the contextual factors, we first present what are the main managerial practices for each value dimension. These practises were collected from (Centobelliet al., 2020; Franzò et al., 2021) and summarize the state-of-the-art of the field. In the sequence,based on the recurrence of existent performance measurement systems identified on literature,we classify the results within each value dimension into 3 different groups: i) High (i.e. more than 10 different performance measurement systems); ii) Medium (i.e. from 3 to 10 different performance measurement systems); and iii) Low (i.e. less than 3 different performance measurement systems). At the end, we present the main results with the different performancemeasurement systems found in the literature. These results are better explained on the next paragraphs.

Performance measurement for Value Creation

The value creation considers the creation (adaptation) of a product/service that, in accordance with the principles of circular economy, is able to preserve economic and environmental valuealong the time. It needs to have an efficient usage of resources and the possibility to close loops(Nußholz, 2018). Examples of Value Creation can be the Design for X practices (e.g. ecodesign), upgradability of products, resource and energy efficiency (Centobelli et al., 2020;Urbinati et al., 2017).

This value dimension is the one with higher number of performance measurement found on the literature. Generally they are associate with an analysis of the level of materials/products circularity. We can present the results as follow: OSR (Old Scrap Ratio) from (Graedel et al., 2011); Longevity from (Franklin-Johnson et al., 2016); MCI (Material Circularity Indicator) from (EMF, 2015b); PLCM (Product-Level Circularity Metric) from (Linder et al., 2017); CPI (Circular economy Performance Indicator) from (Huysman et al., 2017); CEI (Circular Economy Index) from (Di Maio and Rem, 2015); VRE (Value-based Resource Efficiency) from (Di Maio et al., 2017); EVR (Eco-cost value ratio) from (Scheepens et al., 2016); NTUM(Number of Times of Use of a Material) from (Matsuno et al., 2007); CIRC (Material Circularity Indicator CIRC) from (Pauliuk, 2018); Displacement from (Zink et al., 2016); SCI(Sustainable Circular Index) from (Azevedo et al., 2017); GRI (Global Resource Indicator) from (Adibi et al., 2017).

Performance measurement for Value Transfer

Value transfer recalls all those elements related to the customer segmentation and customer relationship that are traditionally included into the value proposition (Geissdoerfer et al., 2018).One of the great challenges of the circular economy is to form a consumer base that is aware and intends to purchase circular products. This must be measured through the ability of a company to carry out the value transfer (Shao & Ünal, 2019). It should receive due attention from studies, considering the smaller number of scientific researches on it. As an example of metrics, we could consider investment in advertising campaigns, development of spaces to increase the user experience, customer fidelity mechanisms, investments in education and awareness (Franzò et al., 2021). For a company perspective is fundamental transfer the value of this product to its consumers.

Performance measurement for Value Capture

Value capture can be achieved through capitalizing additional revenue sources and intangibles, reducing costs and changing their structure, and through value preservation (Nußholz, 2018; Ranta et al., 2018). From a circular economy perspective, value capture must also allow companies to preserve natural resources and societal wellbeing (Geissdoerfer et al., 2018). Generally this concept is linked to take back practices, Product Service System and reverse logistics. A common approach to measure this dimension is the adoption of LCA (Life Cycle Assessment) as posited by (Scheepens et al., 2016) because it considers the entire life of the product from cradle to grave. Other relevant performance measurements of the Value Captureare: the eDiM (ease of Disassembly metric) from (Vanegas et al., 2018) and the Material FlowAnalysis (MFA) from (Wit et al., 2019).

Performance measurement for Value Sharing: the inclusion of a social dimension

An important challenge to be pursuit for circular business models is the achievement of some social benefits. In this way, the firms can accomplish their circular business models with the sustainable development. The triple bottom line is the most common approach of sustainability (Elkington, 1998), and have the economic and environmental aspects already included into thecircular business models, being necessary to include the social dimension. For this reason, wepropose the inclusion of Value Sharing (Porter & Kramer, 2019) as a new dimension of circularbusiness models, in order to advance under the social aspects. As measurement system for it, we can adopt job creation, gender equity, investment on qualification as some important features to be considered.

An integrative performance measurement system for circular business models

A performance measurement system is a process through which the organization aligns its mission, goals, and objectives with available resources (e.g. manpower, material, etc), systems,and set the priorities (Ferreira and Otley, 2009). One of the most recognised model is BalancedScorecard (Kaplan & Norton, 2007). In the Figure 2 we shown a framework developed for thisresearch, that intend to be a guideline to construct a holistic and integrative performance measurement system able to measure the circular business model in a sustainability perspective.

The performance measurement system considers the achievement of circular economy as the main target. To reach on this point, an integrative analysis must include the value creation, value transfer, value capture and value sharing in a combined approach. In this way, emerges the Figure 2 that need to be better developed with the inclusion of some key performance indicators for each dimension, in order to permit a good measurement of the circular businessmodel of a company.

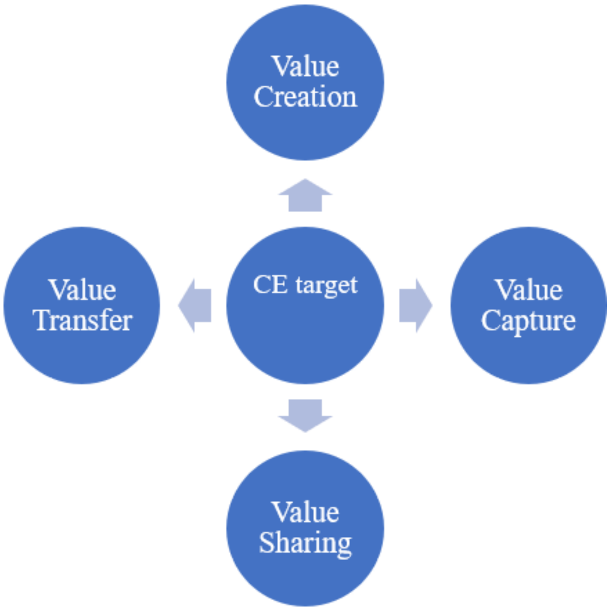

Figure 2. The performance measurement system for circular business models.

Conclusions

Only a performance measurement system that considers all the value dimensions of a circular business model can be efficient to assist a company in the process of implementation of circular economy. Thus, this work proposed to present the minimum criteria that should be consideredfor the development of this system considering all dimensions of value.

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Success factors of technology-based startups

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Abstract: Due to the economic potential of Technology-Based Startups TBS), studies have been carried out to understand the phenomenon and the successful antecedents of these ventures. The literature shows several publications discussing critical success factors in startups, but such factors are considered in isolation. We used a survey with 330 TBS designed to support comparative configurational method analysis to enable discussion of causality between factors that boosted or inhibited the company's development. We analyzed the database with 19 variables using Coincidence Analysis. Results indicate that success in technology development, associated with the development of internal competencies or the alliance for R&D, are platforms for business development. It is evident that success in technology development is a central factor for business success, but it alone is not enough. Access to investment appears in one of the configurations as a minimally sufficient condition for a technology-based company to succeed in business. The novelty of the present study is to verify possible combinations of success factors, which we now call causal conditions, as they are understood as possible conditions to achieve business performance. Understanding these combinations can help entrepreneurs and development support institutions reduce the mortality rate of TBS.
Keywords: High Technology companies; Key Factors; Performance; Comparative Configurational Methods.

Introduction

The role of Technology-Based Startups (TBS) in economic development through job creation and local innovation received attention from researchers and government sectors (Malerba & McKelvey, 2020; Mustar et al., 2006; Ratinho et al., 2015). Due to their potential economic studies have been carried out to understand the phenomenon and the successful antecedents of these ventures (Djokovic & Souitaris, 2008; O'Shea et al., 2008; Pasayat et al., 2023; Shane, 2004). Although essential, the prospects of new ventures are very uncertain, with most of them failing during their first five years of existence (Sarasvathy et al., 2013), and generally fail to generate high growth firms (Brown & Mason, 2014).

The failure rate is associated with the difficulty of crossing the so-called "valley of death" that separates the discovery of technology from its commercialization. One of the difficulties is the development and technological maturation (Van Gelderen et al., 2005). In addition, there are aspects related to the recognition that the idea or research has commercial value, communication of the project potential through a business case, acquirement of the resources necessary to realize that potential, and the use of those resources to reduce risk throughout development (Markham, 2002). Another challenge commonly faced by TBS is the lack of legitimacy in the eyes of potential resource providers, including employees, customers, and financiers, called 'liabilities of newness' (Söderblom et al., 2015).

According to Söderblom et al., (2015), the low success rate of TBS led governments to develop strategies to support the small businesses. And yet, even where governments have increased the availability of financing and management support for the Valley of Death phase, the challenge of crossing it and securing the first significant commercialization investment persists (Brown & Mason, 2014; Ellwood et al., 2022; Rasmussen, 2011).

Given that context, it is essential to identify the antecedents of the success or failure of TBS, and many studies have this proposal. Santisteban et al., (2021) identified a total of 1.013 potential studies with this theme and 21 success factors of TBS in the state-of-the-art article. Song et al., (2008) carried out a meta-analysis of the success factors of this type of enterprise.

Empirical studies examine success factors such as absorptive capacity, the perceived performance of a product or service, the quality of a product, customer satisfaction, staged financing, the support of a business incubator, innovation and entrepreneurship ecosystem, the dynamic capability of absorptive capacity and innovative entrepreneurial culture. Aspects related to the political and market reliability of the new business are also studied as factors that impact the success (Liu & Wang, 2022; Modolo et al., 2021; Santisteban et al., 2021; Söderblom et al., 2015).

However, there is still a gap in the academic literature. Despite this effort, there is a need to understand how these success factors behave combined and not just observed independently. According to Song et al., (2008), numerous studies focus on success factors for new technology-based ventures, but the empirical results are often controversial and fragmented. The literature shows several publications discussing critical success factors in TBS, but the problem is that such factors are considered separately.

Based on the demand for an integrated analysis, this study aims to point out necessary and sufficient factors for the success of technology-based startups, understanding why some companies could reach a specific performance expectation while others were not. Specifically, we studied companies that received financial government support from the Fapesp (The São Paulo Research Foundation), a Brazilian funding agency, through the Pipe Program (Innovative Research in Small Business). According to Salles-filho et al., (2022), studies related to the impact of the PIPE program on companies are relevant, considering the evolution of the program and the diversity of companies that are financed. In this way, this study contributes to understanding aspects that influence initiatives that aim to help companies pass through the valley of death of innovation. With this understanding, this initiative can be improved.

The present analysis sought to answer the following question: what are the success factors in Pipe-Fapesp beneficiary companies? In other words, from the set of Pipe beneficiary companies, why did some companies reach a confident performance expectation? The identification of success factors in nascent companies was raised in previous research, in particular, in research that consolidated several studies and presented a meta-analysis of what was or was not positively related to the performance. However, although the list of factors helps to highlight important points to be considered in the management of companies, it does not inform how such factors combine. In this sense, the novelty of the present study lies in verifying possible combinations of these factors, which we now call causal conditions, as they are understood as possible conditions to achieve a certain effect, in this case, a certain measure of performance.

Another foundation to justify this research is the need for studies of this nature in the context of countries such as Brazil. According to Modolo et al., (2021), it is essential to understand which factors contribute to the improved performance of innovations in Brazilian TBS, as these companies lack public funding and face constant difficulties and challenges heightened by the reality of a developing country and few public policies to encourage innovation.

Theoretical Background

We use the theoretical background to build the survey for collecting data. The reviewed literature resulted in a list of success factors and a description of how these factors were measured in previous questionnaires. The base text for identifying success factors was a (Song et al., 2008) survey published in the International Journal of Product Management that carried out a meta-analysis of success factors in new technology-based companies. Twenty-four success factors were identified in the literature, of which 16 were considered in this research. In order to identify how to measure these factors, research already carried out were tracked, which served as the basis for the construction of the questionnaire. Following the structure proposed by (Song et al., 2008), success factors were grouped into variables related to the market and opportunities of the business, the entrepreneurial team, and resources used by the TBS. The variables related to TBS performance were also defined.

Success factors

The market and opportunity category describes characteristics, such as environmental dynamism, environmental heterogeneity, and competitive strategies. The entrepreneurial team category encompassed characteristics of the TBS team, including experience and capabilities, both as individuals and as a team. The resources category united a broad scope of factors, comprising resources, capabilities, and characteristics of the TBS as firms. Such resources included financial resources, alliances, and partnerships. Table 1 shows the definitions and references of the variable used in the configuration analysis.

Table 1 - Definitions and references of the variable

Variable	Definition	Reference
Market and Opportunity		
Competition Intensity	Strength of interfirm competition within an industry	(Chamanski & Sigmund, 2001; Miller, 1987)
Environmental Dynamism	The high pace of changes in the firm's external environment	(Miller, 1987; Shaker A. Zahra & Bogner, 2000)
Internationalization	The extent to which a firm is involved in cross-border activities	(Bloodgood et al., 1996)
Low-Cost Strategy	The extent to which a firm uses cost advantages as a source of competitive advantage	(S A Zahra & Covin, 1993)
Market Growth Rate	The extent to which average firm sales in the industry increase	(Bloodgood et al., 1996; Lee et al., 2001)
Marketing Intensity	The extent to which a firm pursues a strategy based on unique marketing efforts	(Li, 2001; S A Zahra & Covin, 1993)
Product Innovation	The degree to which new ventures develop and introduce new products or services	(Eisenhardt & Schoonhoven, 1990; Li, 2001; Stuart & Abetti, 1986)
Entrepreneurial Team		
Industry Experience	Experience of the firm's management team in related industries and markets	(Marino & De Noble, 1997; Mcgee et al., 1995)
Marketing Experience	Experience of the firm's management team in marketing	(Marino & De Noble, 1997; Mcgee et al., 1995)
Prior Startup Experience	Experience with the firm's management team in previous startup situations	(Marino & De Noble, 1997; Mcgee et al., 1995)
R&D Experience	Experience with the firm's management team in R&D	(Marino & De Noble, 1997; Mcgee et al., 1995)
Resource		
R&D Alliances	The firm's use of R&D cooperative arrangements;	(Mcgee et al., 1995; Shaker A. Zahra & Bogner, 2000)
R&D Investments	The intensity of the firm's investment in internal R&D activities	(Shaker A. Zahra & Bogner, 2000)
Supply Chain Integration	A firm's cooperation across different levels of the value-added chain (e.g., suppliers, distribution channel agents, or customers)	(Gemünden et al., 1996)
University Partnerships	The firm's use of cooperative arrangements with universities	(Chamanski & Sigmund, 2001; Shaker A. Zahra & Bogner, 2000)
Government Support	Extent to which the company used public resources	Authors

Performance assessment

There are different definitions of success for startups, and no consensus exists in the literature. It can be related, for example, to high financial performance, increase in sales and profits, develop high-quality products or services, the TBS market share and the number of clients (Santisteban et al., 2021).

Considering the different maturity stages of startups and their different operating contexts, it is difficult to define a performance indicator that coherently meets the entire database. For this reason, in this study, performance-related variables comprise measures of meeting business expectations, technology development expectations, and investment expectations (the measure of access to investment was already part of the meta-analysis variables). These variables were not consolidated, as each could have explanatory importance for success. Table 2 shows the definitions of the variable used in the configuration analysis that gets de performance perception of the TBS from the respondents.

Table 2 - Performance Variables

Variable	**Definition**
Performance	
Investment success	Extension in which the company has managed to get investment to continue with the project
Business Success	The extent to which the startup has been successful in meeting expectations regarding business development
Technology Success	The extent to which the startup has been successful in meeting expectations regarding technology development

Methodological Procedures

We conducted the research with TBS supported by Fapesp (The São Paulo Research Foundation), a Brazilian funding agency, through the Pipe Program (Innovative Research in Small Business). Pipe Program aims to support the execution of scientific and/or technological research in small companies and foster entrepreneurial projects with high knowledge intensity and innovative potential.

We used a survey with 330 responses from these companies. The survey was designed to support Comparative Configurational Methods (CCMs) to enable discussion of causality between factors that boosted or inhibited the company's development. Charles Ragin introduced CCMs in 1987 (Ragin, 2009). First introduced by the Qualitative Comparative Analysis (QCA), CCMs later adopted new approaches such as the Coincidence Analysis (CNA) (Baumgartner, 2009).

According to the CNA approach, the searched result is at least one solution in Boolean syntax that can be interpreted causally if, and only if, it corresponds to a minimally necessary disjunction of minimally sufficient conjunctions of values of factors for the phenomenon of interest (Baumgartner & Ambühl, 2018). Two indicators are important for understanding the results: the degrees of consistency and coverage. Consistency values are the degree to which empirical evidence is consistent with the theoretical relationship of the sets. Coverage values are evidence of the importance of conditions (Ragin, 2009).

We analyzed the database with 19 variables using the Coincidence Analysis (CNA) method. It is important to emphasize that comparative configurational analyses aim to detect certain phenomena' formal causes. Such analyzes are based on theories of causal logic. They do not explain correlations but make it possible to perceive which variables lead to a particular phenomenon, including which variables must be absent for the phenomenon to occur. Thus, unlike statistical analyses that measure the correlation between independent variables, comparative configurational analyses aim to explain a given phenomenon's causes (Whitaker et al., 2020).

The collection instrument was developed from the literature review and the results insights of a qualitative stage. The qualitative stage consisted of conducting in-depth interviews with a sample of 16 Pipe beneficiary companies. Based on the qualitative stage, we identified Pipe's impacts on the perception of the interviewed companies, and in the literature review, we identified critical success factors in previous studies. Thus, the questionnaire was developed based on the variables identified in these sources and organized as follows: i) company qualification, ii) impacts of the Pipe on the company, iii) assessment of success factors, and iv) performance assessment.

During the development stage of the instrument, we carried out pre-tests in three stages: i) with researchers for content evaluation; ii) with people with experience in surveys to adjust the questionnaire and research presentation, including FAPESP personnel; iii) with companies from the Pipe base, prioritizing those already interviewed, to facilitate dialogue. Validation with companies from the Pipe base was carried out synchronously online with four companies. The participants answered the questionnaire and could discuss any doubts and suggestions with the researchers. We collected data from an online questionnaire prepared on the SurveyMonkey platform. The average response time was 19 minutes. The Board of Fapesp's Scientific Technical Council sent a previous email introducing the research team. Then, we sent an email inviting the Pipe beneficiary companies to respond to the questionnaire, whose link was available in the body of the email. Two reminders were sent to non-responding companies after 5 and 11 days of sending the first email. One thousand one hundred ninety-one emails were sent, of which 162 were returned (recipient not found). Between 07/20/2022 to 08/22/2022, 425 were answered. Of these, 332 confirmed that they were managers of the companies and answered all the questions. However, two presented inconsistencies in the answers and were excluded from the final analysis. Thus, we evaluated 330 complete responses, which constituted the sample considered for the analyzes carried out in this study.

For the configurational analysis, we selected thirteen variables from the list of success factors in the article by (Song et al., 2008), three performance variables and three variables originating in the qualitative stage (the result of a factorial analysis of 9 variables). A list of these nine impacts was considered in the survey, with each impact represented by a question (item). The respondent should inform the degree of disagreement or agreement with the presence of the impact on their company. However, some impacts have conceptual similarities, which suggests a grouping of items to improve the analysis and interpretation of data. Therefore, we performed an exploratory factor analysis (EFA) to identify whether and how these nine items were grouped. We performed exploratory EFA in the R software with the psych (Procedures for Psychological, Psychometric, and Personality Research, version 2.2.5) and Lavaan (Latent Variables Analysis, version 0.6-12) packages. With this analysis, we consolidated the three factors (Z, PA, and PB) in the database for the configurational analysis. Each factor was composed of the average of its items and later transformed into configurational data, following the same approach as the other variables, as explained below.

The selection criterion was that the variables from the survey that could be transformed into a configurational crisp-set (0 or 1) database. In addition, we decided not to include demographic variables, such as age, company size, and the number of managers, as they increased processing complexity without adding explanatory potential about decisions, team profile, or business environment and resources. Initially, we performed descriptive statistics to better understand the data for all variables, increasing the sensitivity to interpret responses. Subsequently, the configurational analysis with the selection of variables mentioned above. We used configurational analysis through the CNA, frscore package in R, version 0.2.0. We chose to use the CNA to carry out the analysis of configurations given advances in the development of this.

The data collected in the survey were transformed into a database for configurational analysis, which means defining the rule of belonging of the cases in the sets of conditions to be considered in the configurational analysis. In this transformation, each causal condition assumes a value between 0 and 1 (total absence of the condition or total presence of the condition. We used a crisp-set database calibrated by the direct method. Table 3 shows the variable used in the configurational analysis and how it was calibrated.

Table 3 - Variables and Calibration

Cod	Description	Calibration
D	Industry Experience	Time average greater than or equal to 3 years (1); less than 3 (0)
E	Marketing Experience	Greater than or equal to 1 person (1); Less than 1 (0)
F	Prior Startup Experience	Greater than or equal to 1 person (1); Less than 1 (0)
G	R&D Experience	Greater than or equal to 1 person (1); Less than 1 (0)
K	Competition Intensity	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
L	Environmental Dynamism	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
M	Low-Cost Strategy	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
O	Marketing Intensity	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
P	Product Innovation	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
Q	Government Support	Nº of supports - Less than or equal to 2 (0); Greater than 2 (1)
S	Supply Chain Integration	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
T	R&D Alliances	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
U	University Partnerships	No = 0; Yes = 1
AK	Technology Performance	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
AI	Investment Performance	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
AJ	Business Performance	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
Z	PIPE's impact on the credibility	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
PA	PIPE's impact on internal competencies	Likert (1, 2 or 3 = 0; 4,5,6 = 1)
PB	PIPE's impact on external competencies	Likert (1, 2 or 3 = 0; 4,5,6 = 1)

Results

Sample Characteristics

The analyzed sample can be characterized as being from companies in transition stages, from product development to market entry and consolidation, a stage commonly known as "valley of death." They are companies of independent entrepreneurs, men or women, who have high levels of education and have other market experiences prior to the creation of the company, mainly in technical areas of engineering, exact sciences.

Despite the average age being close to 10, these companies still do not have significant numbers in employed personnel and revenue. It is possible that the complexity of the products that are being developed, mostly with intellectual property and related to the manufacturing industry, as well as operating in a market in formation, in which there is little demand, cause that companies' growth takes place in longer development cycles, for example when compared to information technology startups.

Due to these characteristics, these companies seek different forms of support throughout their development, such as financial investment, mainly support in state programs, and programs offered by support networks, such as incubation and mentoring, seeking knowledge and expertise related to the development of the business. Regarding product development, they seek alliances mainly with universities and research centers, which may or may not have been the origin of technology development.

Configurational Analysis

From our analysis, we describe three configurations with the highest scores in the robustness test within the established parameters of consistency and coverage. Thus, we discuss three possible configurations of factors that are at the root of the causes of the company's business success. Table 4 show the configurational analysis result.

Table 4 - Configurational analysis result

Configuration	Consistency	Coverage	Raw score
1. AI <-> AJ	0.75	0.78	599
2. AK*PA <->AJ	0.73	0.76	213
3. T*AK <-> AJ	0.72	0.76	102

In the first possible configuration (AI <-> AJ), in 78% of the cases where companies achieved good business performance (AJ), they achieved investment (AI). We identified that in 76% of cases with AJ = 1 (174 cases), this configuration was present (174 * 0.76 = 133 cases). Of the 174 cases with AJ =1, 137 had AI = 1. In the second configuration (AK*PA <- >AJ), we also identified that the good performance of the business occurred when the company achieved a good performance in technology development (AK) and had the support to build internal competencies, in this case through Pipe (PA).

The third configuration (T*AK <-> AJ) suggests that when the company had an alliance in R&D (T) and good technology development also occurred (AK), the company was successful in the business. In two of the three configurations, there is the presence of AK (success in technology), a factor that alone is insufficient. Also noteworthy is the factor related to obtaining investment (in addition to the Pipe resource) as a sufficiency condition for success (configuration 1).

Discussion

Success in technology development is a key factor for business success, but it alone is not enough. The analysis of coincidences indicates that success in technology development, associated with the development of internal competencies such as those promoted by Pipe or the alliance for R&D, are platforms for business development. Access to investment appears in one of the configurations as a minimally sufficient condition for a technology-based company supported by FAPESP to succeed in business.

Get Investment (AI<-> AJ)

The results of previous studies showed that a higher level of financial resources is related to better performance of the new company (Song et al., 2008). However, this variable is difficult to control, given the variety of companies and their stages of development, especially technology-based companies with different degrees of uncertainty and maturity. Thus, we do not measure the level of resources, but whether the company has achieved the investments is expected to continue the development of the business. And we showed, through the configurational analysis, that getting investment was the most relevant cause for achieving success in the business.

This finding differs from studies that show that obtaining resources alone is not an important determinant of venture success, but if the right entrepreneur, strategy, and right product are chosen, and the capability is developed, the return will follow (Kakati, 2003). Getting investment for the business means that the challenges of the valley of death can be overcome with the correct use of this resource. Obtaining resources is the platform for this to happen. Accessing external financing for a new technology-based firm is difficult due to liabilities of newness that are increased by the innovativeness of the initial business idea, and financing has been seen as the resource important for all the other aspects of innovation and of newly started firms (Clarysse et al., 2007; Wright et al., 2006). And in a way, considering that the database studied is composed of TBS financed by PIPE, it is clear that the investment made allowed the entrepreneurs to achieve their business objectives.

Apart from providing important financial resources, getting investment from a government agency provides a signaling effect to other stakeholders. If the government agency and the subsidy are legitimate and prestigious, the receipt of such a subsidy can signal the quality of the new venture (Kleer, 2010). It also impacts potential contacts with key customers, additional investors, and generally higher credibility and legitimacy for the newly started firm (Markman et al., 2001).

Technology development associated with internal skills (AK*PA <->AJ)

As mentioned, in a TBS development context, being successful in technology is a necessary but insufficient factor to succeed in the business. So, the second most relevant causal configuration for business success is achieving success in technology development associated with building internal competencies.

Here, internal competencies are a construct formed by developing skills related to management, such as through entrepreneurial training of scientists, professionalization of management, formation of a qualified team, and construction of the necessary infrastructure for the development of the project. This configuration also serves as a platform for business development. We can interpret this result as follows: associating technology development and the development of internal competencies for business and infrastructure for project development results in greater business success.

The explanation for this configuration concerns the fact that the development of a business goes beyond the development of technological research in a laboratory or research and development activities. It is necessary to associate other skills such as management, market, and entrepreneurial vision (Kakati, 2003). It is a challenge for especially academic founders with little prior market knowledge and no previous professional investment experience to select which business dimensions can support successful firm creation, development, and survival. The TBS need for experienced management increases when technology and environments change, and the intensity of competition exerts pressure on the firm (Löfsten, 2016).

In this sense, training actions offered by the investment agency and the use of "smart money" by investors are essential actions to complement competencies when there is a satisfactory development of technology. Also, considering the impact of being supported by a program like PIPE helps to overcome the "liabilities of newness." Taken together, new ventures that receive prestigious and competitive government subsidies should be able to attract a larger number of more qualified job candidates due to increased awareness and certification signals (Söderblom et al., 2015).

R&D alliances associated with technology development (T*AK <-> AJ)

The R&D alliance is another success factor identified in previous studies (Song et al., 2008) that presented heterogeneous results regarding the impact on the performance of small technology-based startups. In the present study, we identified that when the company is successful in technology development and has an alliance in R&D, it has good business performance. Here, there may be mutual influence between the conditions; that is, being successful in technology development favors an alliance, and having an alliance favors the success of the technology, and the two, when associated, are platforms for good business performance.

By making alliances, companies gain greater integration with other players in the ecosystem, favoring access to diverse knowledge and being able to gain access to customers. These sources can give the venture access to a large pool of technological capabilities necessary to develop new products, offset weaknesses in the venture's R&D, expedite product development, and offer opportunities for learning (Shaker A. Zahra & Bogner, 2000). By establishing partnerships with universities and research institutes, companies have access to knowledge and state-of-the-art infrastructure for research, which favors the development of technology. In the studied sample, 74% of the companies reported having a partnership with a university and/or research institute, and 67% had a partnership with other companies.

When considering the credibility problem of TBS, R&D partnerships increase the legitimacy of the new venture by signaling to others that it is worthy of resource exchange, thus facilitating the acquisition of important additional resources from other stakeholders. In other words, the relationships with important organizations certify new ventures' legitimacy (Söderblom et al., 2015).

Conclusions

The main objective of this article was to analyze the success factors of technology based startups. Although the list of factors in the literature helps to highlight essential points in the management of TBS, it does not inform how these factors combine. In this sense, the novelty of the present study is to verify possible combinations of these factors, to achieve a certain measure of performance. Understanding these combinations can help entrepreneurs and development support institutions reduce the mortality rate of TBS.

Coincidence analysis indicates that success in technology development, associated with the development of internal competencies or the alliance for R&D, are platforms for business success. In addition, it is evident that success in technology development is a central factor for business success, but it alone is not enough. We have identified that access to investment and success in technology development are highly influential conditions for business success. However, to be successful in the business, the development of technology is a condition that needs to be associated with other conditions, of which the following stand out the formation of alliances in R&D and the development of internal competencies, such as entrepreneurial training, qualified work, and equipment infrastructure.

Financial support helps build the infrastructure and qualified staff that are fundamental for developing technology, which, together with the development of internal skills, support the path to business success. This study also helps to highlight the broad impact of a government agency investment on the development of beneficiary companies overcoming the liabilities of newness. The careful selection of projects to be beneficiaries strengthens the recognition of the quality and seriousness of the beneficiary companies before, favoring partnerships and alliances.

As main practical implications, there is the indication that the financing programs of the nature of the PIPE must be structured to offer, in addition to the financial resource, mechanisms that provide the training of entrepreneurs as well as the promotion of interaction with other agents of the ecosystem of innovation and entrepreneurship.

One of the limitations of this study is that the analyzed database contains only companies that benefited from the PIPE, which may imply restrictions on the generalization of results. Future research may analyze companies' sectoral and size impact on success factors. In addition, a comparative study with companies that were not benefited is a suggestion for future studies.

Acknowledgements

The authors acknowledge funding from the São Paulo Research Foundation—FAPESP (Grants #2021/15091-8, #2015/26662-5, São Paulo Research Foundation (FAPESP) and the funding by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – process 141181/2021-4.

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Living labs and the innovation learning process: A literature review using the template analysis

Abstract ID#291

Elaine Mosconi, Luis Antonio de Santa-Eulalia (Nacional Public Administration School, BR) Murilo Marques (Université de Sherbrooke, CA)

Purpose

In a world that is changing faster than the capacity of organizations to respond, living labs are spaces for multidisciplinary experimentation whose main ability is to create or improve products, services, and policies.

Literature Review

However, the aspects of learning in living lab methodology remain underdeveloped, which hinders the implementation of new initiatives. There are few studies on the integration of learning practices into innovation processes in the field of living lab innovation. This review explores the literature on living labs identifying a learning typology linked to their activities while considering the characteristics and problems of living labs.

Methodological Procedures

We draw on a literature review using the template analysis technique, including its exploratory, systematic, and analytical stages, with which we unpack the learning dynamics in collaborative innovation contexts.

Findings

Our finds comprise themes about the relationship between learning and the development methodology of living labs, namely the dynamics of innovation intermediaries' roles and the management of unexpected outcomes through the living lab learning experience.

Implications

We provide an agenda for further research as well as a discussion of practical implications in innovation management by including a learning process in living lab activities.

Predicting incremental technological change based the technological life cycle

Abstract ID#199

Juan Andrés Niño Peñalosa, Luciano Gallon, Jorge Manrique, Santiago Quintero Ramirez
(Pontifical Bolivarian University)

Purpose

Within Management of Technology continuous change is a permanent fact without which the management itself would lose meaning since it will maintain conditions in a stable or stagnant state. Technological change is an inherent factor to the development of society itself; these changes are rarely radical or disruptive, most of the changes are incremental, being related to their own technological trajectory and the surrounding factors that make them possible. The determination of the future of a technology is a complex area, as it integrates several factors of affectation, so a question arises: what is the structure of variables and the methodology that allows predicting the incremental technological change of a technology based on the sociotechnical system surrounding it and its life cycle? To solve the question, three objectives are determined: Identify the position of a technology within its own life cycle as a determinant of its possible future behavior; Characterize and select the variables of the surrounding sociotechnical system that have the greatest impact on the speed and type of changes generated; Build a prediction model using recurrent neural network machine learning tools that can predict technological changes on a multivariate data structure.

Literature Review

The theory of technological change proposed by Schumpeter (Schumpeter, 1935) is the basis on which the theory of evolutionary technological change is built, which manifests itself in four stages for both products and technologies: introduction, growth, maturity, and decline, as proposed by Theodore Levitt (Levitt, 1965). The diagramming of the evolutionary change of technology is achieved during the 1960s and 1970s, and was Frank Bass and Everett Rogers (Bass, 1969; Rogers, 1976) who present this evolution as a sigmoidal curve, or also called an S curve. Professor Giovanni Dosi (Dosi, 1982) provides from evolutionary economics the relationship between innovation and entrepreneurs, with the dynamics of the market and the signals that it provides for the definition of the path of technological change. His documents are approached by authors such as Keith Pavitt (Pavitt, 1984) as a source of support for his ideas on evolution and technological change. After the 1990s, research in technological evolution have decreased and there is a gap between theory and practice for the detection of the position of a technology in its life cycle and its management.

Methodological Procedures

To address technological change, the World Intellectual Property Organization - WIPO patents are selected in subclass A01B, these data are treated by frequency accumulation, obtaining a sigmoidal curve, which is segmented according to its inflection point and the critical points that divide the stages of introduction, growth, maturity, and decline, obtaining the position of the technology within its own life cycle. Using open databases, world historical data series of 274 variables are obtained, of which the patents at the subclass level are taken as the prediction destination. Then data is prepared and cleaned obtaining 62,554,642 registers, eliminating 151 variables in the process due to lack of complete data regarding the forecast time horizon or data coverage. The remaining variables are ordered according to the structure of the developed sociotechnical system and with them different configurations of variables are evaluated to determine their contribution capacity in the prediction of technological change, using recurrent neural networks, and a multivariate LSTM model.

Findings

After applying the evaluation processes of the configurations of the sociotechnical system that allow a greater precision in the prediction of technological change, it is found that the greater the variety of sources and types of data, the greater the precision is obtained. The prediction horizon is based on 50 years from 1970 to 2019 and is limited to 5 years later with acceptable levels of precision, after which the error increases and therefore the reliability decreases, making it necessary to update the model every year to adjust the predictions. The prediction includes a level of error and uncertainty, for which it is necessary to take the data obtained with the necessary precaution to interpret them according to the trajectory of the technology itself, its substitutes, and complementary ones.

Implications

The identification of promising technologies according to their position in the life cycle and their prediction of change makes it possible to focus efforts and results with the greatest impact, optimizing resources and time to obtain positive changes. The patents data has a longer period than the variables that support the prediction, so there is a gap between the data that prevents a study with a longer time horizon. The code developed can be reformed so that it acts with different observation windows, which would allow changes in precision and early detection of triggers of technological change. The model can be scaled to the level of geographical identification of the emergence of technological changes, identifying heat maps of the change and the conditions that make it possible. On the other hand, the model can also be replicated in different technologies by including specific variables of the sector involved.

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SUSTAINABLE DEVELOPMENT I

May 1st: 3h10 pm – 5h pm

Chair

Marly Carvalho (University of São Paulo, Brazil)

Papers

Agripreneurship value creation in the context of the circular economy

Nonceba Ntonayanto-Tyatyantsi, Anthea Patricia Amadi-Echendu

Brazilian B corps: An analysis looking for ESG, circular economy and stakeholders

Maiara Lais Marcon, Taís Provensi, Simone Sehnem, Lucila Maria de Souza Campos, Adriane Queiroz

Implementation of sustainability and circular economy aiming performance in the context of industry 4.0

Cleber Gaspar Correa Duarte, Cleber Grafietti, Juliano Sampaio Conegundes de Souza, Mauro Luiz Martens, Mauro Vivaldini

The circular lifecycle perspective around the healthcare business ecosystem

Aline Sacchi Homrich, Ana Lucia Figueiredo Facin, Marly Monteiro de Carvalho

Agripreneurship value creation in the context of the circular economy

Abstract ID#210

Nonceba Ntoyanto-Tyatyantsi, Anthea Patricia Amadi-Echendu (University of South Africa)

Purpose

The United Sustainable Development Goal (SDG) No 8 promotes sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, while SDG No 9 is focused on building inclusive and sustainable industrialization through innovation. Agri-preneurs cannot compete with larger farmers in the market and also do not possess sufficient resources to achieve economies of scale. Value creation has over time evolved to incorporate economic benefits and profitability throughout all stages of the process, job creation and competitive advantages through the coordinated exchange of commodities across interdependent horizontal and vertical linkages to optimise forward and reverse processes.

Literature Review

The lack of access to the markets and rising food standards has stifled the incorporation of small scale farmers into mainstream value chains (Swinnen, Colen and Maertens, 2013:294-296). Rigorous public requirements concerning marketing, labelling, contamination, hygiene and traceability (Sibomana, Workneh & Audain, 2016:398) become barriers for small-scale agri-preneurs who lack the necessary resources. In Kenya for example, local potato farmers could not supply KFC as they did not meet global quality and safety specifications which led to a shortage of potatoes for KFC (Otieno, 2022:1).

In addition, access to credit is problematic often as a result of the lack of sufficient collateral, and affordability curb the growth of farming operations. Poor infrastructure affects logistics, security and operations resulting in increased cost, low profit margins and lower productivity.

Food processing and agro-processing have the capability to improve economic activity. The competitive advantage is possible through collaborative activities that connect players such as farmers, processors, marketers, food service businesses, retailers, and supporting teams such as research teams, transporters, credit organisations, policymakers and suppliers (Olomu, Ekperiware & Akinlo, 2020:527).

Unlocking socio-technical and institutional barriers can remove limits through the creation of new agricultural value chains in which small agri-preneurs are integrated. Cooperative efforts among agri-preneurs will promote interaction, learning and capacity building, cost reductions, the mitigation of risks and increased opportunities (Bitzer & Bijman, 2015). Coordination will also facilitate contractual arrangements to build long-term relations among agri-preneurs and other players in the value chain.

Methodological Procedures

A desktop literature review will be used to explore strategies of value creation that have been introduced in various parts of the world. A review of environmental imperatives together with the use of the NRBV will provide a lens with which to adapt existing practices for sustainable agricultural and value-adding activities to deploy.

Findings

The paper provides insights into value creation strategies that can be employed by small scale agri-preneurs to achieve economies of scale and build competitive advantages through building value chains in local communities. The inclusion of circular economy precepts can lead to the adoption of environmentally-friendly technologies and processes

Implications

The paper argues that a multi stakeholder approach may lead to better organisation through collective activities to build resilient value chains. By combining efforts and resources, small scale agri-preneurs can secure market opportunities that can lead to innovative strategies to build sustainable jobs, while optimising resource efficiencies through circular economy precepts. The advancement of local products and cultures can promote economic development through inclusive industrialisation. Enhanced profitability through the value chains can enable opportunities for small scale agri-preneurs to gain access to credit that could lead to the inclusion into bigger value chains and markets.

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Brazilian B Corps: an analysis looking for ESG, circular economy and stakeholders

Abstract ID#329

Maiara Lais Marcon, Taís Provensi (University of the West of Santa Catarina), Simone Sehnem (University of the West of Santa Catarina and University of the South of Santa Catarina), Lucila Maria de Souza Campos (Federal University of Santa Catarina), Adriane Queiroz (Federel University of Mato Grosso do Sul)

Abstract: This article aims to analyze how the circular economy (EC) and ESG guidelines are being internalized in Brazilian B Corps from the perspective of the Stakeholder Theory. A case study with multiple units of analysis was carried out, in which 12 B Companies participated in a semi-structured interview and 76 responded to questionnaires. The results suggest that: (i) circular economy actions through the ReSOLVE framework are partially implemented by B Corps; (ii) circular economy practices require engagement with stakeholders, especially for the share and cycle actions of the ReSOLVE framework that mainly involve customers and the community; (iii) government and consumers were identified as key stakeholders for accelerating the circular economy. The contributions of this article are: (i) presentation of a typology that brings together exploratory theoretical propositions about strategic stakeholders, circular economy assumptions and business models of B Corps; (ii) correlation between the ReSOLVE framework, Impact Assessment B and the Stakeholder Theory; (iii) validation of the exploratory theoretical propositions with the 84 different participating B companies; (iv) identification of key stakeholders for accelerating the transition to the circular economy.
Keywords: B Corps; Stakeholders Theory; Circular economy; ESG.

Introduction

Organizations exist to meet human needs and influence various actors around them such as customers, employees, shareholders, suppliers, community and government. Currently, companies are closely monitored by these various stakeholders (Global Compact, 2022). The return expected by stakeholders is guiding business decisions, via growing concern about not only economic aspects of organizations, but also environmental, social and governance - ESG (Irigaray, Reis & Stocker, 2022). The term ESG has gained notoriety as it is on the financial market agenda on sustainability, putting strong pressure on the business sector (Global Pact & Stilingue, 2021). Organizations are increasingly recognizing the need to go beyond profits and serve a greater purpose (Freeman, Phillips & Sisodia, 2020). However, purpose and profit are inseparable (Global Pact & Stilingue, 2021). Achieving profit and at the same time sustainable goals is a challenge and B Corps appear as a solution to face it, as this certification allows them to inform their stakeholders about their social responsibility and achieve greater financial results (Ferioli, Gazzola, Grechi & Vătămănescu, 2022).

To become a B Corp, organizations undergo a B Impact Assessment (BIA), in which it analyzes how it interacts with different stakeholders, including governance structures, customer and supplier relationships, employee satisfaction and measurement of impacts caused by the company on the community and the environment (Sistema B Brasil, 2022). The objective is that the decisions of these companies are taken not only for the benefit of shareholders, but also for their stakeholders, making them better for the world (Paizinho, 2015). System B's vision is “An economy where success is measured by the well-being of people, societies and nature - redefining the meaning of success in the economy” (System B, 2022, p.1). Among the reasons for a company to seek to become a B Corp is joining the “movement to create a new economy with a new set of rules” (Kim, Karlesky, Myers & Schifeling, 2016, p. 4).

Corroborating the concept of a new economy, the circular economy comes into play. Various stakeholders such as government, community and consumers are increasing pressure for companies to adopt circular economy practices (Jabbour, Seuring, de Sousa Jabbour, Jugend, Fiorini, Latan & Izeppi, 2020). Certification B is a bottom-up approach to the circular economy (Poponi, Colantoni, Cividino & Mosconi, 2019). The circular economy emerges to change the mentality of "take it, make it, consume it and discard it", aiming at consumers and organizations to rethink about the end of the life cycle of products (Circular Economy Club, 2020). For the Circular Economy Club (2020), it is possible to have economic growth while taking care of the planet, moving from a linear model (obtaining resources, production and waste) to a circular model (seeking the end of an era of waste). The adoption of circular economy principles makes it possible to achieve sustainable organizational performance, which means improving economic, environmental and social efficiency (Jabbour et al., 2020), so the circular economy is part of the ESG concept.

Although there is a growing interest in the circular economy on the part of politicians, academics, practitioners and in the area of strategic management, there is still a lack of contributions to explain how companies adapt their business models and adopt this new paradigm (Urbinati, Chiaroni & Chiesa, 2017). Sehnem (2018) corroborates this argument by stating that, despite the increase in publications about the circular economy, one of the biggest challenges for academia is to find organizations that have characteristics in line with its premises. Considering the above, this article seeks to analyze how the circular economy and ESG guidelines are being internalized in Brazilian B Corps and the role of stakeholders in this process. In addition to this section, section 2 presents the theoretical foundation alluding to ESG, circular economy and Stakeholder Theory, resulting in the theoretical framework and exploratory theoretical propositions. Section 3 covers the methodological procedures performed, while section 4 presents the data collected. The results, lessons learned and managerial implications are contained in section 5. Finally, section 6 brings the final considerations, with the contributions and limitations of the study.

Theoretical Background

From the theoretical review, 3 exploratory theoretical propositions were identified that were used for data analysis:

P1: Taking on the commitments of Company B positively influences the engagement of stakeholders towards the internalization of the circular economy.

The proposition is based on Rodrigues (2016, p. 197), when he states that: "The B Corp certification represents a method of measuring socio-environmental practices and management by stakeholders" (Rodrigues, 2016, p. 197). B Corps aim to balance economic and non economic efforts, so they undergo a third-party social and environmental audit (Moroz & Gambleb, 2020). In this process, they look for articulations capable of creating this link between profit and socio-environmental purpose, belonging to a community with shared values and potential for networking and partnerships (Rodrigues & Comini, 2019). Upon being certified, they need to insert specific clauses that include the interests of stakeholders in their legal documents (Rodrigues, 2016).

The measurement of socio-environmental performance aims to ensure that sustainability is part of the business model of B Corps, and that this impact generates benefits for stakeholders (Rodrigues, 2016). As a critical factor for the transition to the circular economy, the social aspect of B Corps drives the activation of a network of stakeholders in achieving the objectives of certification and the principles of the circular economy (Poponi et al, 2019). In their relationships with stakeholders, B Corps seek their engagement, awareness and education (Wecker & Froehlich, 2022). This allows B Corps to have a higher level of sustainability than traditional companies (Ferioli et al., 2022).

P2: The adoption of the ReSOLVE framework positively influences the internalization of B Corp commitments.

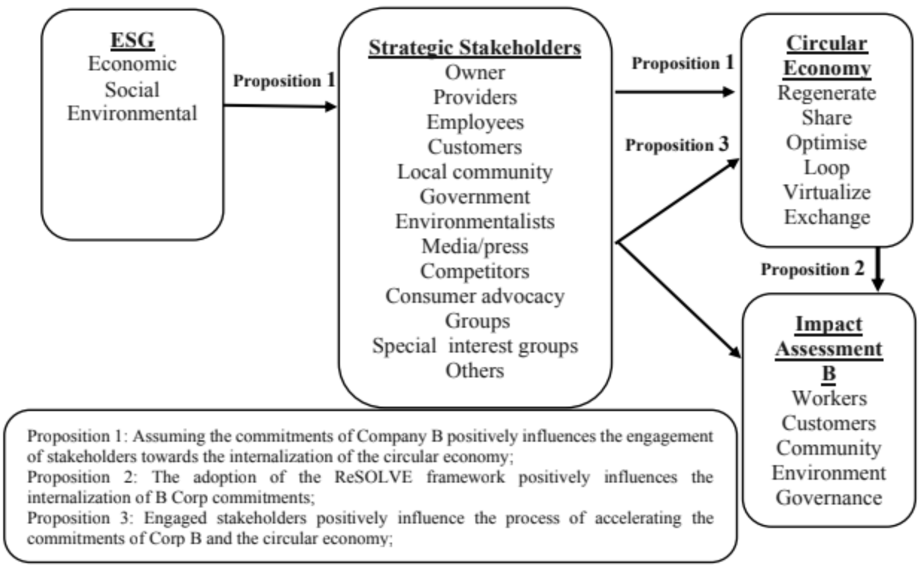
Movement B is driven by the trend of more expressive incorporation of socio environmental value at the center of organizations' strategy and performance (Rodrigues, 2016). Impact Assessment B, in the environment category, will assess ecological products and services, use of renewable energy, recycling, as well as practices that negatively affect the environment – such as emissions, transport, water use (Cao, Gehman & Grimes, 2017). However, although there are several circular business models, the "ReSOLVE" framework reflects most of them (Lewandowiski, 2016), proposing six transition actions to the circular economy (Ellen MacArthur Foundation, 2022b). The ReSOLVE framework was created by the Ellen MacArthur Foundation, which is a reference institution in circular economy, which can positively influence the circular practices of B Corps.

P3: Engaged stakeholders positively influence the process of accelerating the commitments of Corp B and the circular economy.

The transition to the circular economy requires the involvement of stakeholders at all levels of society (Marjamaa et al., 2021). Effective collaboration between sectors and value chains is imperative for the establishment of CE (Ellen MacArthur Foundation, 2022b), and different actors can activate CE paths through B certification (Poponi et al, 2019). Pressure from stakeholders such as government (Cainelli et al., 2020; Govidan and Hasanagic, 2018; Ellen MacArthur Foundation, 2014) and owners and shareholders (Jabbour et al. 2020), are able to reduce barriers and promote the adoption of the principles of circular economy. Thus, B companies must adopt a multi-stakeholder approach to incorporate their socio-environmental role into their business strategy (Rodrigues, 2016).

Supported by the Theory of Stakeholders, ESG, circular economy and B companies, the theoretical framework proposed for this study emerges, as shown in Figure 1. To implement ESG and the circular economy, the management of strategic stakeholders is essential.

Figure 1 - Theoretical framework of the study



Methodological Procedures

The research carried out aimed to analyze how the circular economy and ESG guidelines are being internalized in Brazilian B Corps from the perspective of the Stakeholder Theory. To make it feasible, a survey was carried out on the websites of B Lab (https://www.bcorporation.net/en-us/) and Sistema B Brasil (https://www.sistemabbrasil.org/) to identify the B Companies Brazilians. The number of Brazilian B Corps is inaccurate because it is constantly expanding and there are differences between the B Lab and Sistema B sites. The latest version of this information was collected from the respective sites on August 24, 2022. In order to contact as many companies as possible, a comparative table of these two sites was made, summarizing the companies mentioned and their websites and social network were researched - resulting in 264 companies, which define the participants of this multiple case study. The companies received encryptions so that it was possible to maintain their anonymity. Those on the Sistema B Brasil website were classified from S1 to S200; those from B Lab were classified from B1 to B218; and those that were in both were classified from A1 to A154.

All companies were contacted through at least three different ways (website, email, instagram or linkedIn) to answer the questionnaire (which was divided into two parts due to its size). The target audience was managers, preferably at a strategic level, since it was identified in the literature that the adoption of circular business models is a strategic decision. As a result, 76 respondents were obtained (39 for the questionnaire - part 1 and 37 for the questionnaire - part 2).

In addition, through this initial contact, 12 B Companies were randomly invited and/or volunteered to participate in a semi-structured interview. Questionnaires were collected via an online form (Google form) and interviews were conducted with company managers via Zoom. The interview data took about 7 hours and 15 minutes of recording and 115 pages of transcription. Data collection took place from June 25, 2022 to September 5, 2022.

Along with the quantitative data from the questionnaires and secondary data, a qualitative analysis was performed. The categorization of the analysis of this study is carried out using the subcategories of the ReSOLVE framework (Ellen MacArthur Foundation, 2022b), the Impact Assessment B (B Impact Assessment, 2022) and strategic stakeholders (Freeman, 1984). The results were summarized in tables, and circular economy actions were classified into:

0 – Non-existent (red color) – 0%

1 – Some evidence (orange color) – between 0.1 and 33.33% of implantation

2 - Partially implanted (light orange color) - between 33.34% and 66.66% of implantation

3 – Implemented at an advanced stage (yellow color) – between 66.67% and 99.99%

4 - Fully implanted (green color) - 100%

This study is characterized as qualitative, using the case study strategy, with multiple units of analysis and cross-comparison, and the units of analysis were the B Corps. The companies certified as B Corps are leaders in a global movement that aims to a more inclusive, just and regenerative economy (B Corporation, 2022). These are companies with corporate social responsibility strategies that meet concepts such as conscious capitalism, sustainability and business with a purpose and are more humanized (Rocha, 2020). Being identified as a B Corp is a way of publicly showing an unconventional identity: an organization that seeks not only the success of its shareholders, but also of all stakeholders (Kim et al., 2016). The propositions were validated from empirical evidence. Data triangulation was also used, due to different sources of collection: questionnaires, content of the interviews, and collection of secondary data from the companies' websites and social networks.

The originality of this article lies in integrating the Stakeholder Theory with the premises and assumptions of circular economy and B Corps. - The search for articles associated with the subject at hand in this research reveals that there are few studies that have a similar scope, namely: “The stakeholders' perspective within the B corp certification for a circular approach” (Poponi et al., 2019), “Sustainable behavior of B corps fashion companies during covid-19: A quantitative economic analysis” (Ferioli et al., 2022) , “A sustainable circular economy: Exploring stakeholder interests in finland” (Marjmaa et al., 2021), “Stakeholders, innovative business models for the circular economy and sustainable performance of firms in an emerging economy facing institutional voids” (Jabbour et al. , 2020) and “Circular business model evolution: Stakeholder matters for a self-sufficient ecosystem” (Moggi & Dameri, 2021).

Presentation of Data Analysis

B Corp and Circular Economy Interfaces

The commitments of being a B Corp involve generating a positive impact, be it social and/or environmental. This positive impact is measured and managed through the Impact Assessment B (BIA), which is one of the prerequisites for being a certified company (Sistema B Brasil (2022). In version 5.0 of the impact assessment, organizations are assessed in the following sustainability dimensions: environment, workers, customers, community and governance (Cao et al., 2017) Table 2 presents the outstanding impact model identified in the B Corps interviewed.

Table 2 - Impact business model according to interviews and BIA

	Workers	Customer	Community	Environemnt	Governance	Circular Economy
A18				X		X
A20				X		X
A24		X	X			
A28				X		X
A31	X (BIA)			X (enterview)		X
A41			X			
A58		X				
A121				X		
A126			X (BIA)	X (enterview)		X
B211		X				
S190				X		X
S192				X (enterview)		

It was identified in the interviews that the emphasis of the topics covered coincided with the dimension in which companies had the highest score in Impact Assessment B (except for interviewees A31 and A126). It is noted that eight of the twelve interviewees have the environment as the most prominent dimension.

Of the companies that stood out in the customer and community dimension, companies A24, A41 and B211 also develop positive environmental impact initiatives, however, as they are service companies, their impact is indirect, mainly reflected in actions with customers and support for the community. Only one company (A58) among the twelve interviewed does not have the environment and/or circular economy in its main scope.

Regarding the business model, despite most of the interviewees developing significant environmental actions, companies A18, A20, A28, A126 and S190 mentioned being adopters or contributors to the circular economy, according to excerpts extracted from the interviews presented in table 3.

Table 3 - Evidence of the Adoption of the Circular Economy

	Excerpts from the Adoption of the Circular Economy
A18	"We take the circular economy to our client".
A20	"I started hearing about the circular economy. And then I started to study a lot, because I said: "people this is what we do". (...) Three pillars, right? Circular design, redesign and innovation. Always circulating, always thinking that it all has to come back".
A28	"We are experts in the circular economy. We generate new business models through solutions for waste, mainly complex waste. (...) The strategy is to insert companies in the circular economy through the transformation of waste into raw material and the development of products with circular design".
A121	"And I think that the great secret of the [brand], of the circularity and quality of everything, comes from there, right? Because retail was never a problem for her, it was always a solution".
S190	"We realized that there was a new opportunity beyond the circular economy, to start positioning itself more as an ESG company, right? (...) And then today we work, actually for some time now, with some industries that have some circular economy initiatives. (...) We led this process of how we implement the guidelines of a circular economy within its industrial production, right? We created indicators, and created a plan, together with them, to make a more integrated management looking at the circular economy. How we reduce, how we reuse, how we make it possible for our waste to become an input for our chain or another chain in another industry".
A31	The company did not use the term circular economy, but cited sustainable management: "And from then until today, we have an internal process of building sustainable management".

The companies participating in the questionnaire, in turn, were asked a question about the adoption of common values between B Corps and the assumptions of the circular economy, identified in the literature review. Table 4 summarizes the results.

Table 4 - Interfaces between System B and circular economy

Analyzed Aspects	Questionnaire 1	Questionnaire 2	Total	%
A fairer, inclusive and regenerative economy	31	27	58	76,32%
Redefining success in the economy	20	20	40	52,63%
Sustainability	36	30	66	86,84%
Ethical, environmental and social objectives	38	35	73	96,05%
Reduction of environmental impact	33	31	64	84,21%
Promoting changes in society	32	31	63	82,89%
Conscious capitalism	27	20	47	61,84%
Concern for all stakeholders	28	29	57	75,00%
B Corp certification and/or circular economy or sustainability practices as a competitive strategy	36	30	66	86,84%
Innovative sustainability/circular economy strategies for products and services	24	20	44	57,89%

Most respondents stated that their value is sustainability; ethical, environmental and social objectives; reducing environmental impact and creating innovative sustainability and circular economy strategies for its products and services. Likewise, 75% of them highlighted that among their values is concern for all stakeholders.

Regarding engagement with stakeholders, the companies interviewed highlighted that among the advantages of having the B seal is the network, knowing that they are not alone and that more companies think in a similar way. Some companies reported that they often felt they were going in the opposite direction of the market logic and the fact of being part of the B community minimizes the feeling. The fact that it is a B seal also offers greater credibility and visibility to stakeholders.

In addition, strengthening the importance of B Corporations having impact business models, Sistema B encourages the dissemination of good practices, such as the annual delivery of the "Best for the World" award. According to Sistema B (2022), this award is a recognition granted by B Lab to certified companies that have BIA scores which are among the top 5% of all B Companies in their group and corresponding size.

Company A18 received the "Best for the World" award in the environment category in 2019, 2021 and 2022. Company A28 was also featured in the environment category in 2018, 2019, 2021 and 2022. Interviewee B211, in turn, was awarded in 2022 in the customers category. The S190 received the award in several categories (general category, governance, workers and community) in several editions. In the environment category, the S190 was featured in 2016, 2019, 2021 and 2022. (B Corporation, 2022).

Discussion of Results

In this section, the three research propositions presented above are discussed together with the relevant results found. The three propositions were validated through evidence from this research.

a) Proposition 1 (Assuming the commitments of Company B positively influences the engagement of stakeholders towards the internalization of the circular economy) proved to be valid. Assuming the commitments of Company B submits these organizations to be evaluated from the perspective of impact relationships with different stakeholders (within the 5 dimensions of Impact Assessment B). In addition, the relationship with stakeholders is strengthened due to the network, credibility and visibility, which were mentioned by the companies interviewed as advantages of B certification. towards the circular economy (such as sustainability, ethical, social and environmental objectives, reduction of environmental impact, creation of innovative sustainability and circular economy strategies for its products and services and concern for all stakeholders).

Regarding the engagement towards the internalization of the circular economy, it is noted that, when evaluated in the environmental dimension by BIA, many B Corps already adopt good practices. In particular, eight of the twelve B Corps interviewed in this research stood out in the impact business model focused on the environment, and many of them even mentioned a relationship with the circular economy. In addition, the fact that they work in a network facilitates the dissemination of the theme and good practices (like the Best for World award).

b) Regarding proposition 2 (The adoption of the ReSOLVE framework positively influences the internalization of the commitments of Companies B) it was found that the circular economy actions are, above all, in a partially implemented stage (between 33.34% and 66, 66% of implementation) in the organizations surveyed. This corroborates with Rebelatto & Sehnem (2018) who claim that circular economy practices are being gradually incorporated in companies – many of them are still in embryonic stages or in consolidation.

It was found that the adoption of the ReSOLVE framework has a close connection with the 5 dimensions of Impact Assessment B. The environment dimension (BIA) can be subdivided into the six actions of the ReSOLVE structure. The share action (ReSOLVE) can be grouped with aspects of the community and customers (BIA) dimension.

The cyclic action (ReSOLVE) is also dependent on partnerships, especially with customers and the community (BIA), especially the collectors' cooperatives. This finding is in line with Jabbour, Luiz, Luiz, Jabbour, Ndubisi, Oliveira and Hourneaux (2019) when stating that to cycle organizations must develop stakeholder engagement with recycling cooperatives and customers, to improve the rate of post-recycling products. consumption.

Therefore, proposition 2 is validated through impact actions, mainly environmental, but also collaborating with social impacts (community) and in the customer dimension (indirect impact) - which are already being partially implemented by Companies B.

c) In addition to having verified that circular economy practices, especially the share and cycle actions of the ReSOLVE framework, require interaction with stakeholders (especially customers and the community), the companies interviewed highlighted strategic agents for accelerating the adoption of practices circular. Different key stakeholders were identified and different actions were proposed for the transition to circularity, however, the importance of the government in this process, consumers and external pressure (ESG) stands out. In this way, proposition 3 (Engaged stakeholders positively influence the process of accelerating the commitments of Company B and the circular economy) also proved to be valid. This result is in line with the Ellen MacArthur Foundation (2014) which summarizes that government regulations that encourage and reward the adoption of circular practices are one of the motivators for the circular economy. It also corroborates with Cainelli et al. (2020) which states that circular economy initiatives depend on government policies. Govidan and Hasanagic (2018) had highlighted that the government is the stakeholder with the greatest impact for the implementation of the circular economy, depending on laws, policies and incentives. However, Jabbour et al. (2020) highlight that emerging countries suffer from weak and absent laws and institutions, and in Brazil the government has not yet developed legal frameworks requiring organizations to implement measures for the adoption of the circular economy. In this case, in addition to government pressure, other actors such as owners and shareholders may be more relevant in pushing for the adoption of the circular economy (Jabbour et al., 2020).

Above all, the findings of this research demonstrate that, although in the phase of partially implemented actions, engagement with stakeholders helps in the internalization of the circular economy and ESG guidelines by B Corps.

Final Remarks

This study sought to analyze how the circular economy and ESG guidelines are being internalized in Brazilian B Corps from the perspective of the Stakeholder Theory. B Corps are inserted in the context of ESG and the circular economy, and the B Impact assessment drives the adoption of good practices and that B Corps engagement with their stakeholders was identified as relevant. The fact that B Companies seek to be better for the world, generating a positive impact and being evaluated, among other aspects, in the environmental dimension, means that they already contribute in some way to circular economy actions. It was found that the actions investigated in this research are in the stage of partially implemented. And that the assumptions, principles and assumptions of circular economy business models are translated into values by most B Corps.

Studying the business models of B Corps and their alignment with the assumptions of the circular economy and knowing the actions that are being developed can generate a competitive advantage for the System as a whole. The study provides relevant information for Sistema B to disseminate good practices that are being developed by companies B both to other organizations of the movement (internally) and externally. However, it became evident that there is still a need for greater consumer and society awareness of the importance of circularity, so that companies can break the paradigm of sustainability as a cost and for EC actions to gain scalability. The ESG theme is gaining prominence, which can further boost System B and circularity – since CE can be encompassed through ESG and the financial system is putting pressure on organizations for social, environmental impacts of governance. However, it is expected that top executives are aware of the importance of impact management and CE actions, not needing to wait for external pressure or the financial market, nor seeking certifications such as the B seal only as a competitive advantage, marketing or fad.

The practical contribution of this research, in addition to the managerial implications already mentioned, is the validation of the three propositions in the context of B Corps. The identification of key stakeholders and actions to accelerate the transition to the circular economy is also a relevant contribution. The emphasis given to the ReSOLVE framework can also help organizations implement the circular economy. However, the need for the theme to be more present on the agenda of public policies is evident. To accelerate the transition to circularity, it is important for the government to propose an agenda of actions in favor of sustainability, with actions aimed at studying the possibility of adopting a legal structure for benefit corporations, reducing taxes, granting tax incentives to organizations that develop actions environmental issues, implement selective collection and establish criteria to prioritize environmentally correct suppliers. Therefore, accelerating circular economy practices requires the involvement not only of companies, but also of government, suppliers, non-governmental organizations, universities and civil society movements.

As for the theoretical contribution, the study is unique, with the connection between these three constructs (circular economy, ESG and B Corps) and an already consolidated theory (Stakeholder Theory). As a limitation of the research, it is identified that many of the participating companies were of services, and their impacts occur with the final result of their services and not internally or in the day to day of operations. It is up to a future study to better investigate the reason why some actions suggested in the questionnaire were marked as not applicable and the fact that some companies refused to answer the questionnaire justifying that they are service companies. For future studies, it is suggested to create a specific guide on how small and service companies can adopt the circular economy, both to raise awareness of the subject and since many of them mark “not applicable” for many items. proposed in this research. In addition, the study focused on organizations with high scores in Impact Assessment B in the environmental dimension could be deepened; with a high percentage of adoption of ReSOLVE structure actions in this study (table 4) or with those that won the “Best from the world” award – environment category, to identify other successful initiatives, motivations and challenges for the adoption of the circular economy. Correlating the BIA score with the percentages obtained in table 4 would also be a proposal for future studies (verifying whether a higher score in the BIA's environmental dimension also means greater adoption of circular economy practices).

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Implementation of sustainability and circular economy aiming performance in the context of industry 4.0

Abstract ID#296

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Purpose

This research aims to provide a current overview of scientific knowledge produced through publications that associate Sustainability, Circular Economy and Performance in the context of industry 4.0 (I4.0). Dealing with these increasingly emerging themes throughout society, the following research question was formulated: What is the current panorama of publications that associate Circular Economy, Sustainability, Industry 4.0 and Performance?

Literature Review

Sustainable development is defined by World Comission on Environment and Development - SD (WCED, 1987) as a development that must preserve resources from present needs for the use and needs of future generations. The pursuit of SD in the industry must align with innovations, enabling the transformation of materials and reducing environmental impacts. And complementing this understanding of the importance of the environment there were advances in waste management, with the use of blockchain (Khan et al., 2021), one of the enabling technologies of Industry 4.0.

Organizations are increasingly adopting the concepts of Industry 4.0, sustainability and Circular Economy (CE) in their business practices (Luthra and Mangla, 2018). And this has been expanding and encouraging industries to improve their understanding of environmental impacts, cleaner production strategies and product reuse through the adoption of digital technologies (Mwangi et al., 2021).

Also motivated by interest in updating the business environment, where industry managers are integrating innovative concepts and technologies from I4.0, such as the Internet of Things (IoT) and CE (Frank et al., 2019). Given that the inclusion of I4.0 and CE practices has become essential for manufacturing organizations that want to compete globally (Okorie et al., 2018).

I4.0 deals with innovative digital technologies as the main driver of improving the competitiveness of companies. The aim of the CE concept is to achieve waste reduction through reprocessing products instead of disposal, removing harmful chemicals, improving material and product design, etc. (Okorie et al., 2018). The term CE emerged in 1970 suggesting an efficient approach to increase resource efficiency and provide stability between society and the environment (Dwivedi et al., 2020).

The concepts of I4.0 and CE help companies to reduce pressure on natural ecosystems and achieve sustainability, environmental safety, cleaner production, automation of manufacturing systems and flexible processes in their supply chains and improve their performance (Garetti and Taisch, 2012). Rosa et al. (2020) and Rajput & Singh (2019) declared industry 4.0 and CE as emerging technological and organizational trends that improve the company's sustainable production, and therefore, contributing to the improvement of project and organizational performance, making them more competitive in your region and around the world.

Methodological Procedures

The research approach has a qualitative character, as it aims to deepen knowledge about the implementation of sustainability and CE in the context of I4.0 and its influence on the performance of organizations. To this end, a systematic and bibliometric review was carried out by searching for articles published in the Scopus database, given between 2013 and September 2022. Inclusion and exclusion criteria were defined, which resulted in 31 articles. For cluster analysis, the VOSviewer software (Van & Waltman, 2010) will be used, through the analysis of author networks and keywords, and finally, content analysis techniques will help the textual understanding.

Findings

The results demonstrate that studies on this topic have focused on some areas, mainly in Environmental Science, Business, Management and Accounting and Engineering, in addition to showing that the topic is recent. It is noticed that the literature on the subject has evolved significantly in recent years. Studies that apply the concepts studied are still incipient, being still in the context of models, framework and exploratory analyzes and I4.0 technologies are still very focused on IoT and Blockchain.

Implications

This study intends to serve as a basis for researchers in this field looking for references, concepts, gaps and research trends on the topic, as well as for those who apply or implement the concepts of sustainability and circular economy seeking better performance through Industry 4.0 projects.

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The circular lifecycle perspective around the Health Business Ecosystem – a multi stakeholder mapping perspective

Abstract ID#305

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Purpose

The lenses of the business ecosystem may help to face the significant barriers regarding circular business development in the sense of circumventing the challenges of one of the most complex and regulated systems in the world, the Healthcare Business Ecosystem. In this sense, this paper intends to deepen the understanding of the stakeholders' relationships involved in an example of a Brazilian Health Care business ecosystem developed around some Product-Service System (PSS) offers of complex medical equipment. Adding to this perspective, we explored how the PSSs business model archetype were being developed under the circular business umbrella lenses, taking into consideration the perceptions of the multiple stakeholders involved.

Literature Review

The multiple sectors that affect health, frequently driven by various stakeholder and interest groups, have different cultures, values, and vocabularies and usually lack experience working together, which can also likely hinder partnership and collaboration (DELOITTE, 2019). A systemic perspective towards exploring the stakeholder networking and innovation capacities across ecosystems layers is needed (Pombo-Juarez et al., 2017) to understand the health sector better. The synergies among health care ecosystem actors influence the value co-creation factors and outcomes at the different levels, integrating "different actor roles, technology, and information while facilitating ecosystem coordination and co-evolution" (BEIRÃO; PATRÍCIO; FISK, 2017, p. 227).

In this context, considering the latent potential of Product-Service Systems (PSS), it is mandatory to understand how the Business Ecosystem (BE) configuration can interlock the stakeholders to "boost their solutions to a more sustainable level" (GUZZO et al., 2019, p. 2). According to Amor et al. (2018), such multi-actor perspective, different from the usual one sided PSS evaluation (customer point of view or provider perspective), is needed to manage the economic, organisational and new social infrastructure transitions to support the desired environmentally benign performance. The PSS network value must be intensified by all stakeholders (especially by policymakers); in this sense, it is crucial to add them all to this multi-actor perspective (MONT, 2002) to reach the expected performance.

Efforts have been made to understand the multi-layered perspective of Health Systems, leading to a systemic understanding of the challenges from international, national, regional and local innovation ecosystems (POMBO-JUÁREZ et al., 2017). The application of a more sustainable PSS in developing countries is still an underexplored area since they have to face the challenge of balancing economic growth with social and environmental considerations (NNOROM; OSIBANJO, 2008). According to Shokohyar et al. (2014), many developing countries are consumers of imported products from other countries, especially high tech embedded products/equipment. Such a situation has as a consequence that only the consumption and the end of life (EOL) phases occur in these countries. Therefore, theoretically, manufacturers and their representations tend to introduce more sustainable PSS schemes to manage usage and EOL phases. Such as the case of medical equipment in Brazil. The healthcare business ecosystem has undergone profound changes, and new business paradigms make the Brazilian healthcare market “promising and attractive” compared to the rest of the world (Vargas et al., 2016; PwC Brasil, 2013, p. 3).

Nevertheless, companies in the medical diagnostics sector face significant challenges due to increasing exam capacity and market share. Large competing conglomerates tend to predominate in the health sector. The bargaining power is held basically by health insurance companies (Prieto and Carvalho, 2011), transforming the price per exam, metaphorically, into commodities. That is why the business ecosystem concept comes into the scene. According to Williamson and De Meyer (2012, p.26), ecosystem strategies allow organisations to coordinate "difficult-to-manage relationships with many different types of parties as well as “the exchange of knowledge between many, mutually dependent partners (p.30)", which fits the challenges of improving healthcare PSS.

Methodological Procedures

The set of cases was chosen regarding product and service compositions ranging from MRI to complex sets of blood sample analysis machines provided to clinics and largely known hospitals in Brazil. Semi-structured interviews within 20 interdependent companies were performed, and the relationships between health providers, manufacturing/service companies, regulatory agencies, government, digitalisation companies, and hospitals/clinics were mapped and in-depth explored.

Findings

Among the findings, this paper presents the healthcare business ecosystem configuration with its main roles through the lenses of PSS life cycle stages. The main aspects of each stage are discussed within each PSS business modality: product-oriented, result oriented and use-oriented, emphasising circular economy aspects in emergent business opportunities influenced by the Business Ecosystem. Finally, a framework shows the integration of the main stakeholders’ groups of the chosen business ecosystem, hindering and fostering aspects of a more circular perspective of the business configuration.

Implications

This research contributes to broadening the understanding of the challenges regarding PSS implementation towards circular economy and the healthcare business ecosystem influence, suggesting future possible approaches to overcome them.

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PARALLEL SESSIONS

Day 2 – May 2nd

10h30h am – 12h30 am

- Digital Innovation II
- Innovation Capabilities II
- Innovation Evaluation and Impact II
- Sectoral Innovation II
- Internal and External Collaboration I

3h10 pm – 5h pm

- Special Topics on MOT II
- Innovation Ecosystems II
- Innovation Capabilities III
- Service Innovation I
- Sustainable Development II
- Strategy and Innovation I

DIGITAL INNOVATION II

May 2nd: 10h30 am – 12h30 pm

Chair

Leonardo Gomes (University of São Paulo, Brazil)

Papers

Relationships between dynamic capabilities and digital transformation: A systematic literature review

Clarissa Rocha, Rafaela Plantes Pavloski, Fernando Deschamps

Identification of characteristics and challenges for the digital transformation for SMEs

Tami Marieli de Andrade Bischoff, Luís Maurício Resende, Rui Tadashi Yoshino

Support model for the design of distance learning higher education programs for engineering

Valeria Constanza Hernández Jorquera, Rodrigo Alexis Contreras Núñez, Daniel Gálvez

Digital transformation: Proposed framework for analyzing the microfoundations of dynamic capabilities

Mauro Kowalski, Roberto Bernardes, Felipe Borini, Leonardo Gomes

Relationships between dynamic capabilities and digital transformation: A systematic literature review

Abstract ID#298

Clarissa Rocha; Rafaela Plantes Pavloski, Fernando Deschamps (Pontifical Catholic University of Paraná)

Context and Purpose

Digitalization is changing and disrupting companies' operating models, and digital technologies can potentially enable businesses to gain or increase their competitive advantage (Rocha et al., 2021). These solutions include IoT, digital twins, Augmented and virtual Realities, Additive Manufacturing, drones, Collaborative Robots, Artificial Intelligence, and Big Data Analytics. Dynamic Capabilities (DC) can be a suitable theoretical foundation to understand those mechanisms that enable companies to pursue the Digital Transformation (DT) journey. This Systematic Literature Review (SLR) analyzes this journey and its relationship with the construction of DC, exploring the fit between DC as a conceptual foundation and DT as a phenomenon of interest. Therefore, this SLR explores whether DT research could benefit from further engaging with the DC perspective.

Literature Review

DT is the creation, and subsequent change, of product offerings, services, processes, or business models that result from the adoption of digital technologies. More companies are leveraging these technologies to work smarter, reduce costs, accelerate innovation, and be more competitive. The DT management refers to the practices, processes and organizational principles that underpin the effective orchestration of digital innovation. The literature still lacks a detailed understanding of the social, strategic and managerial aspects of DT.

The DC approach (Teece et al., 1997) identifies the capabilities that help companies succeed in applying their resource base in various situations. Through DC, companies generate economic income, because they are more effective than their rivals in reconfiguring resources. DC enable firms to innovate and adapt to changes in their environment through three main mechanisms (Teece et al., 1997): sensing, seizing, and transforming.

Digital solutions need to be developed and established to allow companies to expand and renew their resource bases. Hylving (2015) explored how DC occur in companies as they try to meet the growing demands for digital innovation. Teece (2018) focuses on ecosystems based on digital platforms at the forefront of the digital revolution. Helfat and Raubitschek (2018) provide a theoretical analysis explaining how DC sustain value creation and capture by leading digital platform companies.

DT acknowledges the need for firms to engage with other parties to generate digital innovation. The literature on DT highlights changes to an organization's leadership structure as a key enabler of new business models. Little is known regarding digital structure and leadership as drivers for DT. There is a need to better understand how communication and coordination take place in the context of digital platforms and ecosystems.

Methodological Procedures

SLR was carried out following a three-phase approach: Phase I – Planning the Review Process – Research objective definition, relevance presentation and the necessity of an SLR in this theme. Phase II – Identifying, selecting, evaluating and synthesizing the pertinent research studies. Phase III – Reporting and Dissemination of the main research findings – Descriptive reporting of results and thematic reporting of acceptable articles through result tables. Therefore, keywords were combined into two search groups: DC and DT. The search was conducted at the databases Scopus and Web of Science (WoS), from 2010 to 2020, being Business Management and Accounting and its correlated areas as subject areas. Documents were also filtered as articles published in highly relevant journals only. With these restrictions applied, 113 studies at Scopus and 139 at WoS were identified. To further verify these studies, they were extracted in the bibliometric format (.bib) files and had the duplicated entries removed. Bibliometrix, which is a package for bibliometric analysis compiled under the language R was used to have duplicates removed, resulting in 233 studies. After their reading, 50 were considered fully valid, obeying the focus of this research. These studies were cross-checked by the researchers to make sure that all articles, in fact, should be accepted. After this process, 12 were rejected, totaling 38 articles that constitute the corpus of this SLR, and that were analyzed in depth.

Findings

An in-depth evaluation of the 38 papers contributions was carried out to extract similarities. By doing this, clusters were identified, characterized, and schematized, representing thematic research axes. For most papers, DCs are evaluated as preparatory factors for DT. Only 4 articles start from the opposite premise: the DT context stimulates the need for firms to renew their resource base.

DT is about developing a strategy, leadership, skills, culture, and organizational structure that promotes the relevance of using digital technologies for business competitiveness. It is also about building new capabilities for professionals to obtain digital skills. Based on DC, the DT process can be formulated as sensing the digital opportunities and threats, seizing the sensed digital opportunities, and digitally reconfiguring the existing resources for building digital organizational capabilities. This paper contributes to: (1) developing knowledge and improving literature on DC in information systems (IS) research; (2) discovering the main topics of interest for IS researchers to deploy the DCs perspective in their studies.

Contributions and Future Work

This SLR shows how and which DCs can contribute to organizations' digital journey and the implications of DCs on digital practices are also discussed. More detailed findings and contributions to practitioners and literature are provided in the full article. Regarding suggestions for new research avenues, this study extracted clusters from each of the 38 articles, that were presented and deeply characterized, assisting the academic community in exploring research topics.

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Identification of characteristics and challenges for the digital transformation for SMEs

Abstract ID#279

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Purpose

Digital transformation is a consequence of the development of new technologies in Industry 4.0 (I4.0) and this transformation offers benefits for organizations and many challenges, especially for Small and Medium Enterprises (SMEs). These challenges originate from some characteristics that these companies present. The objective of this research was to identify the characteristics that SMEs have that influence the process of digital transformation and what challenges these companies face.

Literature Review

Many large companies have already started the transformation to the Fourth Industrial Revolution, however SMEs have had difficulties with the initial steps or are not aware of the need to make this digital transformation (MITTAL et al., 2018; SOMMER, 2015). For Moeuf et al. (2018) there are many challenges for SMEs towards the Fourth Industrial Revolution or the deployment of I4.0 initiatives and these challenges need more research. For Brozzi et al. (2020) SMEs face more challenges for digital transformation compared to large enterprises. SMEs have more challenges because of some characteristics them present (MITTAL et al., 2018). According to the affirmation of the authors addressed so far it is possible to state that there is a need to identify which characteristics these companies possess that can influence the digital transformation process and which challenges these companies may encounter on the transformation route.

Methodological Procedures

A systematized literature review was conducted to achieve the proposed objective. The research followed the phases of the Methodi Ordinatio methodology of Pagani, Kovaleski and Resende (2015), with the systematic selection of the most relevant literature on the investigation of the question research. The search for articles was conducted in the Web of Science and Scopus databases and a portfolio of 41 articles was examined.

Findings

In the quest to discover the characteristics that SMEs possess that influence the digital transformation process and the challenges that these companies may face in this process, a catalog was composed with 18 specific characteristics that SMEs may possess that influence digital transformation and 26 challenges that these companies may face in the digital transformation process.

Implications

This paper presents a literature review of existing research covering an important issue of Industry 4.0 in relation to SMEs, analyzing the relevant and current literature portfolio. This shows that it is a new and important subject for researchers. Some aspects limited this research, the main ones are highlighted below. First, the research considered only articles in English, which excludes possibilities of identifying research by authors who publish in other languages. Since the study used only the literature to build a panorama of the characteristics and challenges that SMEs, research based on interviews with managers of these companies may add information to this research regarding the particularities that these companies may present in certain segments or certain geographic locations.

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Support model for the design of distance learning higher education programs for engineering

Abstract ID#267

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Purpose

To present a support model for the design of a distance learning program in higher education in the area of engineering, considering the key factors in the implementation of distance learning for different purposes, contexts, and types of students, promoting the establishment of virtual laboratories to improve interaction among those involved. This research seeks to answer the question: What should be the factors to be considered for the implementation of distance education in high quality higher education?

Literature Review

Teaching-learning schemes have changed significantly over the years, currently there is a wide variety and combinations of methods supported by innovative technologies; the modalities correspond to face-to-face, distance or hybrid, allowing access to quality education when and where a person wants. Face-to-face corresponds to traditional education where both the student and the teacher participate in the educational process, meeting in the same place and at the same time (Vassallo & Chiyong, 2020). There have been a number of efforts to delineate the types of distance learning. For Xu, D. & Xu, Y. (2019) this learning refers to education delivered to students in remote locations with online courses via the Internet. In 2020, the pandemic pushed millions of college students into non-face-to-face programs which became a necessity for all universities. This rapid digitization of education forced institutions to adapt the traditional mode to a non-face-to-face environment. This learning is called emergency remote learning and is defined as the adaptation that education underwent in the period of the pandemic and differs from distance learning in that the latter has an extensive and anticipated planning, with long-term investment strategies, on the contrary, remote learning does not have all the characteristics mentioned above, being an alternative in circumstances of crisis (Hodges et al., 2020).

In addition, the literature review shows that the distance learning modality provides a series of benefits to those involved, among the most outstanding are the flexibility in time and space acquired by students and teachers, as well as cost reduction, among others. In contrast, difficulties such as the shortage of qualified teachers, technological problems, high sense of absence on the part of students and teachers, etc. are highlighted (Bailey et al., 2018). Several studies conclude that there is a great lack of methodologically rigorous empirical research to compare both types of learning (Xu, D. & Xu, Y., 2015; Bailey et al., 2018) for this reason educators and institutions need summaries of research evidence to draw reasonable conclusions and make decisions. The implementation of distance learning requires human resources (teachers, computer engineers, etc.), administrative and material resources (equipment, trainings, etc.), pedagogical resources (learning management platforms, etc.), infrastructure (offices, virtual libraries, etc.), among others. In addition, it is necessary to define the profiles, functions, competencies, roles, etc. of each of those involved in order to finally recommend a basis for the establishment of this type of learning, designing courses around the diversity of students, consolidating synergic institutional networks and collaborative work between universities, among others.

Methodological Procedures

To conduct this study, the research is divided into four stages. In the first stage, a systematic review of the literature is accomplished with the objective of providing a general description of the methods, benefits, barriers, comparisons of the types of learning, identifying the components and participants. In the second stage, a validation of the crucial factors for the model is performed with the collaboration of various experts. The third stage presents the construction of the model. Finally, in the fourth stage, a meticulous validation of the model is carried out again with the relevant stakeholders.

Findings

This research article provides an integral vision and solution to counteract the difficulties and challenges when applying distance programs in an effective way, such as training, virtual laboratories, etc., instituting solid bases, based on the self construction of new virtual techno-pedagogical knowledge to improve learning teaching and diminish the reputational stigma that exists around distance education.

Implications

The main limitation is that the article focuses on higher education programs in Engineering, so the factors considered are tailored to the context in this area. In addition, there is still a lack of previous studies on the subject that indicate requirements needed to implement quality distance education.

The implication is that it offers a support tool for the design, administration, and management of a distance engineering higher education program, capable of being developed or implemented, allowing the standardization of processes so as not to depend on the experience and knowledge of the professional in charge of the program.

The future challenge is to adapt the base model presented in this document over time, considering the evolution of new emerging technologies and improving the weak points and main gaps in order to achieve quality distance education. In addition, it seeks to inspire further research to better exploit the potential and significantly increase learning outcomes.

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Digital transformation: proposed framework for analyzing the microfoundations of dynamic capabilities

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Abstract: The objective of this research is to propose a framework so that companies can design a strategy for the development of dynamic capabilities to induce digital maturity. This proposal is built on the basis of a review of the literature on dynamic capabilities and digital transformation. The research was consolidated with the application of case studies in companies with ongoing and advanced processes of digital transformation. Academic contributions: a) mapping of dynamic capabilities, their theoretical foundation and their inclusion in the dimensions of a framework to measure their strength in inducing digital maturity; (b) through analyzes and comparative case studies, we consolidated the micro-foundations "Analytical intelligence for the customer experience journey" and "Digital analytical innovation management"; the internal barriers "Leadership without digital skills" and "Lack of strategic human resources management for DT"; and the internal enablers "Defined strategy for DT" and "Data-driven culture" that may be relevant to digital maturity not mapped in previous studies. Contribution to management practice: through the application of the proposed framework, it is possible for companies to design a roadmap for digital transformation in accordance with their strategy.
Keywords: Dynamic capabilities, Digital Transformation, Microfoundations

Introduction

Digital transformation and innovation create new challenges for companies' competitive strategies and architectures, opening windows of opportunity or pitfalls for new business models (PORTER; HEPPELMANN, 2014; STURGEON, 2019; SUBRAMANIAM; IYER; VENKATRAMAN, 2019). The environmental scenarios of competition that project horizons of prosperity are based on the cooperation and incorporation of productive experiences between manufacturers, suppliers, complementors and customers with the digitalized integration of their value chains and the orchestration of innovation ecosystems (BJÖRKDAHL, 2020; XU et al., 2018).

Companies are faced with uncertainty about which critical capabilities to manage. Maturity models for digital transformation (DT) place special emphasis on enabling technological and operational capabilities, giving little value to exploring capabilities that allow the company to initiate initiatives to reconfigure its business in new markets (KAGERMANN; WAHLSTER; HELBIG, 2013; SCHUH et al., 2017). Competition in the digital economy requires companies to develop dynamic capabilities to gain competitive advantages (WARNER; WÄGER, 2019). For Warner and Wäger (2019), the innovative nature of digital transformation depends on dynamic capabilities. Karimi and Walter (2015) sought to understand which dynamic capabilities should be created, focusing on the microfoundations of digital sensing, digital seizing and digital reconfiguration capabilities.

The purpose of creating dynamic capabilities is to adapt to new or ever-changing scenarios, rapidly renewing your digital business models (WARNER; WÄGER, 2019). One of the sensitive dilemmas for companies would be how to map and manage the dynamic capabilities for the innovative DT journey.

With this, the theoretical gap that underlies the question of this research would be: What are the dynamic capabilities and their micro-foundations that drive the DT journey, allowing companies to adapt and explore the new institutional environment of digital competition?

This research aims to propose a framework for companies to identify which are these dynamic capabilities and their micro-foundations to design a capability management strategy for DT.

This proposal is built based on a literature review of dynamic capabilities, DT and the application of case studies companies impacted by DT. In strategic management, dynamic capabilities refer to a company's abilities to integrate, develop, and reconfigure internal and external competencies in order to cope with an ever-changing environment (TEECE; PISANO; SHUEN, 1997). Dynamic capabilities are strategic routines by which companies reach new configurations of resources as markets emerge and evolve (HELFAT; PETERAF, 2009). Although Teece (2007) has proposed dynamic capabilities for sensing, seizing and reconfiguration organizations to create or sustain competitive advantage, little attention has been paid to this topic with the advent of DT (WARNER; WÄGER, 2019).

The main proposed academic contributions are: a) mapping of dynamic capabilities, their theoretical foundation, inclusion of dimensions in the proposed framework to measure their strength in inducing the maturity of the DT journey; b) Through analyzes and comparative case studies, we consolidated the micro-foundations “Analytical intelligence for the customer experience journey” and “Management of digital analytical innovation”; the internal barriers “Leadership without digital skills” and “Lack of strategic human resources management for DT”; and the internal enablers “Defined strategy for DT” and “Data-driven culture” that may be relevant for maturing the maturity of the DT journey not mapped in previous studies (KARIMI; WALTER, 2015; SOUSA-ZOMER; NEELY; MARTINEZ, 2020; WARNER; WÄGER, 2019).

The contributions to the managerial and applied practice is the application in companies of the proposed framework, based on the scientific literature, which enables companies to develop a roadmap for the digital transition oriented towards their business and management strategy based on indicators for measuring capabilities dynamics and its microfoundations for DT.

Literature Review

This section, literature review, aims to present the main theories related to dynamic capabilities and DT.

Dynamic capabilities for DT

In strategic management, dynamic capability (DC) is defined by Teece; Pisano and Shuen (1997, p. 515) as “[...] the ability of a company to integrate, build and reconfigure internal and external competencies to deal with a rapidly changing environment”, while Helfat et al. (2007, p. 1) defines it as “the capacity of an organization to purposely create, extend or modify its resource base”, and Eisenhardt and Martin (2000, p. 1107) define it as “organizational and strategic routines through which companies reach new configurations of resources as markets emerge, collide, split, evolve and die”. According to Pavlou and El Sawy (2011), DC serve as support to expand, change and reconfigure the resources and capabilities of the company for the business to face frequent changes in the market.

There is a consensus that capabilities are, most of the time, specific to organizations and refer to how the company distributes its resources by combining explicit and tacit elements that are in its internal processes, which have been developed throughout its history (WANG; AHMED, 2007; WINTER, 2003; ZAHRA; SAPIENZA; DAVIDSSON, 2002).

The theory of DC had its beginnings in the seminal article by (TEECE; PISANO; SHUEN, 1997), in which an extension of the RBV was proposed, due to the fact that the RBV is unable to explain how companies obtain competitive advantage in constantly changing environments. change, since it is considered static (BARNEY, 1991).

The foundation of DC improved and expanded the RBV, bringing environmental changes as a focus for the evolution and transformation of resources and critical capabilities that are specific to the company (WANG; AHMED, 2007; ZOLLO; WINTER, 2002).

Teece (2007) proposed that three classes of analysis for DC should be considered, namely: sensing (detecting opportunities and threats), seizing (developing and seizing opportunities) and reconfiguration (transforming and renewing competencies and businesses) according to the dynamism of the environment and, thus, propose new models and strategies for the organization to create or sustain competitive advantage. In the digital economy, it is no different, however, little attention has been given to this topic (VIAL, 2019; WARNER; WÄGER, 2019).

According to Warner and Wäger (2019), the generativity provided by the digital economy, in which changes occur at a greater speed, generating more volatility and uncertainty, it becomes imperative to develop DC to respond quickly to the market (TORTORA et al., 2021).

The microfoundations of DC, according to Teece (2007, p. 1319), are "[...] the skills, processes, procedures, organizational structures, decision rules and distinct disciplines that support the capabilities of sensing, seizing and reconfiguration in the enterprise level that are difficult to develop and deploy".

One of the reasons for breaking down DC into microfoundations is to facilitate the understanding: (a) of the relationships between the constructs; (b) what drives such behavior; (c) the cause of differences in company performance (FELIN et al., 2012).

The dynamic capability "sensing" and its microfoundations for DT (Figure 7) is intended to understand the external environment and discover opportunities and threats, technology trends, detect customer-centric trends, through formal or non-formal means, formulate digital strategies, understand the direction of market, analyze competitors, create a digital mindset and strategically position the company in the dynamism of the digital economy (VIAL, 2019; WARNER; WÄGER, 2019). Sensing capabilities help to make strategic choices and invest in tangible and intangible assets to deliver value, shape markets (HELFAT; PETERAF, 2009) and maintain sustainable competitiveness (TEECE, 2007).

The dynamic capacity "seizing" and its microfoundations for DT (Figure 8) are related to experimentation and enable the design of business models, revenue sources and their due exploration based on detected opportunities (TEECE, 2007). Rapid prototyping, strategic agility and innovation in creating digital businesses are examples of microfoundations (WARNER; WÄGER, 2019).

The dynamic capability "reconfiguring" and its microfoundations for DT (Figure 9) allow companies to remain competitive by modifying their resource base with what was observed and projected and, definitively, transforming business models and executing their strategies for DT journey. Entrepreneurial culture, redesign of internal structures, dedicated resources, digital maturity and orchestration of open innovation ecosystems are examples of microfoundations for this dynamic capability (KARIMI; WALTER, 2015; SOUSA-ZOMER; NEELY; MARTINEZ, 2020; WARNER; WÄGER, 2019).

Digital Transformation

The DT has already impacted society and a wide range of business sectors for some time. (VERHOEF et al., 2019). All businesses, regardless of sector, will be impacted by DT in the creation of products, processes, strategies, which may cause profound reformulations in companies or the completion of businesses and sectors (HESS et al., 2016).

Leaders responsible for business strategies act on the DT journey with the aim of creating competitive advantage, innovating, and improving their customers' experience (FERREIRA, J.; FERNANDES; FERREIRA, F. 2019; HESS et al., 2016).

Companies are engaged in the creation and use of new digital technologies, and they need to create capabilities to deal with the technologies to compete in the digital world (VIAL, 2019).

Although it is a priority, the understanding of what DT is still not clear to everyone (YOO; HENFRIDSSON; LYYTINEN, 2010) and, according to Warner and Wäger (2019), the term DT is used inappropriately by many leaders, generating misalignment strategic, planning errors to achieve the DT.

According to Verhoef et al. (2019), three phases are identified for DT: digitization, digitalization and DT. Digitization involves internal processes and does not create value; digitization refers to the automation of internal and external processes with value creation; while DT involves new business models, new ways of creating and capturing value, new organizational structures and new business strategies.

Digitalization and DT do not have the same meaning: digitalization is related to the automation of internal company processes through the use of digital technologies (HANELT et al., 2020). DT refers to the change in the business model and in what the company delivers value to its customers (VERHOEF et al., 2019).

The DT can occur with the incorporation of digital resources (software and data) to objects that were previously considered only physical, or with the creation of digital-only objects (MARTIN, 2008; PORTER; HEPPELMANN, 2014; TEECE, 2018). Thus, new possibilities are opened for the dissemination of the use and the generalization of the application of products, opening doors for innovations and business. Many of the innovations made available by DT were not designed in the initial design, but created after its use (YOO et al., 2012).

The DT is facilitated by digital means such as information systems, data networks, IoT, cloud computing, smartphones, AI, blockchain, big data and robotics. Such means open up the possibility of interaction with all actors involved in the value chain (FERREIRA, J.; FERNANDES; FERREIRA, F., 2019), and bring consumers closer to manufacturers, bringing consumers to the center of product development, either because the products share information with the manufacturers, or because consumers shared comments on social networks about the products, or because consumers share reviews of their experiences; that provides businesses with an opportunity to develop better solutions (PORTER; HEPPELMANN, 2014).

The authors Matt, Hess and Benlian (2015) argue that companies should make explicit in their strategy for DT how to use digital technology to change the way of creating and capturing value, how to structure themselves organizationally for the use of such technologies and where the financial investments for DT will be applied to improve the company.

The DT must be treated in a multidisciplinary way and integrated into the company's value chain (MATT; HESS; BENLIAN, 2015; VERHOEF et al., 2019) and not as a project for the information technology area, since this area has skills for managing technology infrastructure and little impact on new business development (BJÖRKDAHL, 2020; HESS et al., 2016; MATT; HESS; BENLIAN, 2015).

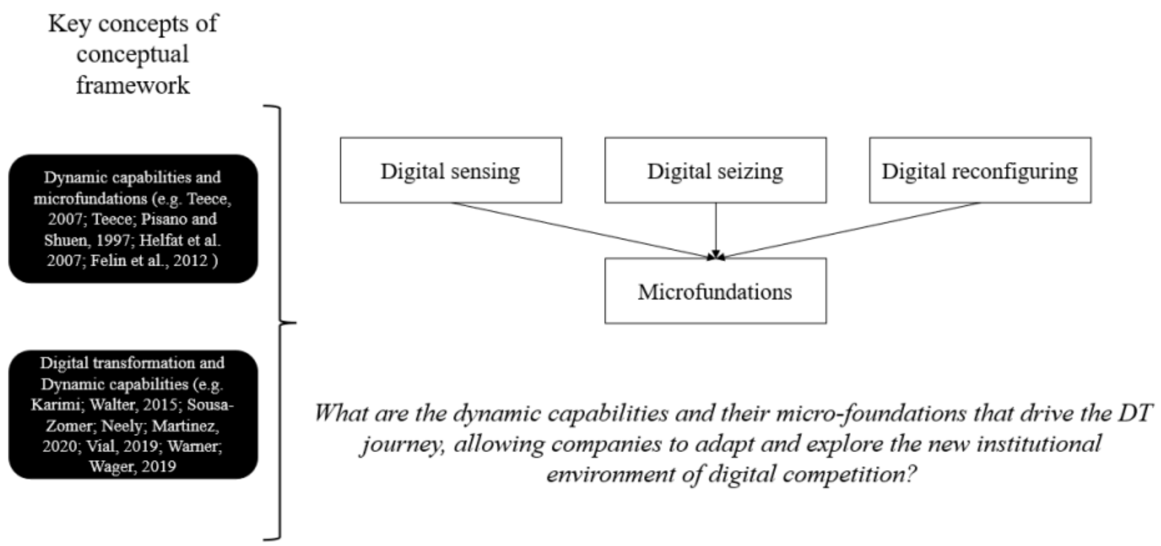
Companies generally choose one of two digital strategies: (a) the customer engagement strategy; (b) digitalized solutions strategy (SEBASTIAN et al., 2017). Regardless of the strategy selected, successful companies with DT act to improve their current business by better understanding customers and delivering advantage to them with additional services.

Organizational changes are expected to achieve DT. Adoption of separate digital units, agile organization, digital functional areas, low hierarchy (VERHOEF et al., 2019), culture of learning from mistakes, risk-taking, creativity, entrepreneurship, experimentation (KOPALLE; KUMAR; SUBRAMANIAM, 2020). Collective work, effective communication, flexible internal processes, recording experience in a knowledge base and exchanging experience among employees are among the factors that help achieve success with DT (BJÖRKDAHL, 2020).

Conceptual Framework

We developed a conceptual framework (according to Eisenhardt, 1989) that guided our empirical investigation (data collection and analysis). Our conceptual framework (Figure 1) merged 2 different research streams: dynamic capabilities and digital transformation. This indicates that the proposed framework will be able to diagnose and enable the planning of the development of dynamic capabilities and their microfoundations, in order to reach maturity in the DT journey.

Figure 1: Conceptual Framework



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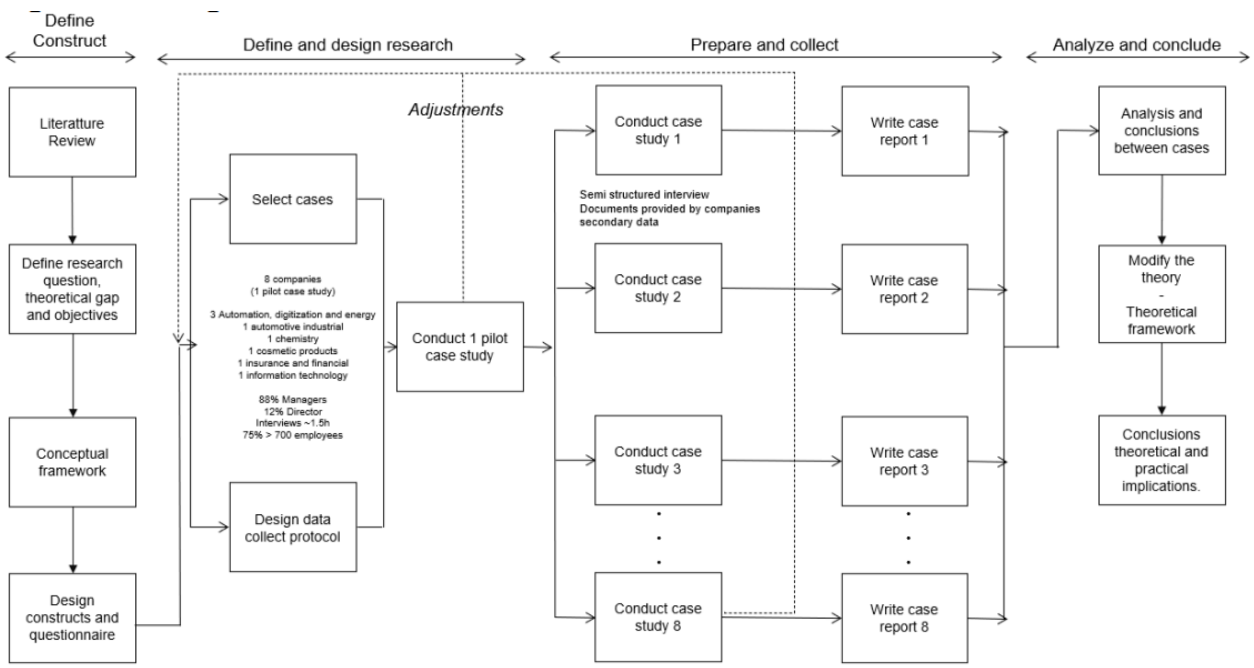
Methodological Procedures

An exploratory and descriptive qualitative empirical approach was used. The sample consisted of eight companies from the industry (automation, digitalization, energy, chemical, cosmetic and automotive), information and communication technology, insurance and financial services. The selected national and multinational companies are leaders in their segments in the DT process. Data were triangulated from three different sources: a) conducting 16 in-depth semi-structured interviews with the executives responsible for the DT process in their companies, informing the development of dynamic capabilities and micro-foundations for DT between 2016 and 2021; b) the interviews were complemented with additional documents and reports.

Figure 2 – Design research



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Due to the fact that there are few theories and evidence on how dynamic capabilities induce maturity in the DT journey (WARNER; WÄGER, 2019; VIAL, 2019), this research employed a qualitative empirical approach of an exploratory and descriptive nature (YIN, 2015).

Research using case studies has the ability to deal with a wide variety of evidence and is applied in studies of contemporary and complex real-life phenomena, which is the case of DT, we believe that this is the best method to undertake the present research (YIN, 2015). Furthermore, the application of case studies, in this research, also occurs to validate the applicability of the framework proposed in this study.

Case selection – Unit of analysis

In order to avoid sampling bias, the sample was composed of companies from the industrial (automation, digitization, energy and automotive), chemical, information technology, cosmetics, insurance and financial sectors from different countries located in Brazil. The selected national and multinational companies are leaders in their segments and have already started the DT process (See Figure 3).

In order to obtain more reliable information, the headquarters of the selected companies were organizationally affected by DT in their countries of origin, for example: (a) subsidiaries in Germany, the birthplace of Industry 4.0; (b) Japan, where the “Industrial Value Chain” initiative exists; (c) Brazilian companies, references in the use of technologies related to DT and Industry 4.0.

Companies in the automation, digitalization and energy sectors were selected because they are impacted by DT and Industry 4.0 technologies (LEE, I.; LEE, K., 2015; LIAO et al.,2017; FIRJAN; 2016). The automation, digitalization and energy sector is one of the most promising for the rapid adoption of DT enabling technologies (ANCARANI; DI MAURO; MASCALI, 2015; KIEL; ARNOLD; VOIGT, 2017), since, in Brazil, this sector is the most advanced to receive DT and Industry 4.0 technologies, since they provide solutions for this purpose (FIRJAN, 2016).

Figure 3 – Company and interviewees

#	Company	Market segment	Number of employees in Brazil	Interview time	Main area of activity of the interviewees
1	Alfa	Chemical	700~1000	152 min	#1- Engineering Manager – Responsible for managing the portfolio of technological projects. #2- Project Manager – Responsible by technological projects
2	Beta	Engineering and automation	100~150	203 min	#1- R&D Manager - Responsible for leading automotive R&D. #2- Technical Sales Manager
3	Gama	Insurance and finance	3500~4000	174 min	#1- Head of IT and Digital Transformation #2- Head of IT Innovation and Digital Strategy
4	Delta	Cosmetic products	6500~7500	102 min	#1- Senior Management - CoE Industrial Latam – Responsible for the Industry 4.0 program. #2- IT Project Manager – Responsible by DT projects
5	Épsilon	Technology, information and communication	300~500	139 min	#1- Director – Digital Solution Architecture. #2- Director – Head of Customer engagement
6	Zeta	Industrial and automotive	1200~1500	106 min	#1- Engineering and Manufacturing Quality Manager – Responsible for the master plan for implementing Industry 4.0 and Innovation for manufacturing. #2- Project coordinator – Responsible by DT projects in manufacturing.
7	Eta	Engineering, automation and digitalization	7500~8000	136 min	#1- Engineering coordinator for Industry 4.0 application. #2- Digital Business Director
8	Teta	Engineering, automation and digitalization	6000~6500	133 min	#1- Business Development Specialist (Global Meat Market) – Responsible for spreading the concept of Industry 4.0 in Brazil – Currently: Promoting the concept of Industry 4.0 in the Global Meat Market. #2- Project coordinator for IT

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Data collect

We triangulated data from three different sources (EISENHARDT, 1989) as follows: a) carrying out multiple in-depth semi-structured interviews with the executives responsible for the DT process in selected companies; b) the interviews were complemented with additional documents provided by the company, such as reports informing the development of dynamic capabilities and microfoundations for DT between 2016 and 2021, and the level of digital maturity of companies applying the IMPULS model (LICHTBLAU et al., 2015); c) secondary data sources, such as online material on official websites, publications in electronic newspapers and magazines, public reports and public presentations made by companies.

In order to obtain more precise and assertive answers, which can direct the study towards a clearer situational understanding, all executives from the selected companies who participated in the interviews were involved in projects related to DT and Industry 4.0.

The guiding questions, which guided the interviews, were developed based on the scientific literature that provided the conceptual framework. The interviews lasted around one to two hours and were digitally recorded.

Data analysis

Based on the content of the interview transcripts, documents provided by the companies and secondary data, categories were developed according to the existing literature, in order to allow concepts to emerge from this process. This codification allowed the contribution to the construction of the theory (EDMONDSON; MCMANUS, 2007) and this is part of the plan to compare each case and its data with the theory (EISENHARDT, 1989).

After this step, individual reports were built to report each case autonomously and with unique patterns and, later, reports between cases to seek generalization, comparing cases, counteracting trends and observing the data in several different ways. Based on the developed categories, similarities and differences within and between cases were sought.

Based on codification, reports and due analysis, propositions were tested, constructs, implications and contributions to the literature and business practice were defined. Figure 2 presents the multicase framework adopted for this research.

Results and Discussion

In the research, we found that companies with high digital maturity have more skills to analyze large volumes of data from customers, products and digital platforms, with the purpose of identifying trends and opportunities for new products and businesses, with the customer at the center of the creation of the value proposition (BREM; GIONE; WERLE, 2021; DUAN; CAO; EDWARDS, 2018; MARIANI; NAMBISAN, 2021; MARIANI, et al., 2022), which led us to propose the microfoundation "Analytical intelligence for journey of the customer experience" to the framework.

The second microfoundation proposed by this research is "Digital analytical innovation management", which is the ability to implement a strategy for managing resources and knowledge flows, with the objective of stimulating a culture in which digital analytical innovation occurs integrated with the company's innovation value chain, with the purpose of obtaining increasing profits with new products and digital businesses (BREM; GIONE; WERLE, 2021; FRANCO et al., 2021; NAMBISAN et al., 2017).

Our evidence points out that companies with high digital maturity have structured an area with dedicated human resources, which work systematically in management, innovation and R&D activities, with a focus on DT (FALLON-BYRNE; HARNEY, 2017; MARIANI, et al., 2022)

Regarding the two dimensions of internal barriers, it was observed in the research that leadership without digital skills to propose value to the business by combining SMACIT technologies - social, mobile, analytics, cloud and IOT - (DABROWSKA, et al., 2022; PORFÍRIO et al., 2021), and the lack of a strategic HR management plan aligned with the DT strategic plan (KOPALLE; KUMAR; SUBRAMANIAM, 2020; VERHOEF et al., 2019) prevent companies from developing advances on the journey to DT.

Our field research also showed that companies with high digital maturity have the ability to define and implement the strategy, indicators and long-term vision for DT, which led us to propose the internal enabler "Defined Strategy for DT". The internal enabler proposal is in line with authors (DABROWSKA, et al., 2022; HESS et al., 2016) who argue that DT journeys should be integrated into the strategies of new business models and organizational culture.

The internal enabler "Data driven culture", proposed by this research, is based on evidence of the dissemination of data-based culture observed in companies with high digital maturity, where there are organizational and behavioral patterns with the aim of fostering production, accumulation, materialization, monetization and guaranteeing the right audience the data for learning, dissemination of knowledge and improvement of products, processes and business (DABROWSKA, et al., 2022; GUPTA; GEORGE, 2016).

Based on the result of the analysis of comparative cases, in which we conducted in depth interviews, we applied the framework proposed in this project and applied the IMPULS digital maturity model (LICHTBLAU et al., 2015). It was also possible to collect evidence that DC induce digital maturity, since the more developed the DC, the greater the company's digital maturity, as shown in Figure 4 and Figure 5. These results confirm the literature (KARIMI; WALTER, 2015; SOUSA-ZOMER; NEELY; MARTINEZ, 2020; VIAL, 2019; WARNER; WÄGER, 2019), which proposes that the development of DC for DT is imperative for companies to quickly create, implement and transform their businesses in order to remain relevant in rapidly changing scenarios in the digital economy.

The results indicate that companies with low digital maturity are also developing the “Sensing” DC, which shows that DT is already part of the companies' business strategy. On the other hand, it is clear that few companies are developing the “Reconfiguring” DC and its microfoundations. We interpret that companies are still focusing on the development of the "sensing" and "seizing" DC, to then develop the "reconfiguring" DC. The research shows that the microfoundation “Create the digital mindset”, consisting of establishing a vision for long-term DT, enabling the digital entrepreneurial mindset in the organization and enabling a horizontal and flexible organization with a collaborative environment focused on DT (DABROWSKA, et al., 2022; WARNER; WÄGER, 2019), leads to DT and is a trait of companies researched with high digital maturity.

Figure 4 – Companies, dynamic capabilities, microfoundations and digital maturity

Dynamic Capabilities / Microfoundation		Company							
		Alfa	Beta	Gama	Delta	Epsilon	Zeta	Eta	Teta
Sensing	Digital analytical scouting								
	Digital scenario planning								
	Create digital mindset								
Seizing	Rapid prototyping								
	Balancing digital portfolios								
	Digital strategic agility								
Reconfiguring	Improving digital maturity								
	Dedicated human and finance resources								
	Innovation ecosystems orchestration								
	Redesign internal structures								
	Digital entrepreneurial culture								
Frequency: Microfoundation developed		**1**	**2**	**1**	**3**	**1**	**7**	**8**	**8**
Innovation management structured for DT									
Classification – Dynamic Capabilities for DT		**Low**	**Moderate**	**Low**	**Moderate**	**Moderate**	**High**	**High**	**High**
Digital Maturity IMPULS (classification)		**2,5 Learner**	**3,0 Learner**	**3,27 Learner**	**3,35 Learner**	**4,29 Intermediary**	**4,78 Experient**	**4,88 Experient**	**6,23 Specialist**

Font: Authors. Label: Black: developed; Gray: in development; White: absent.

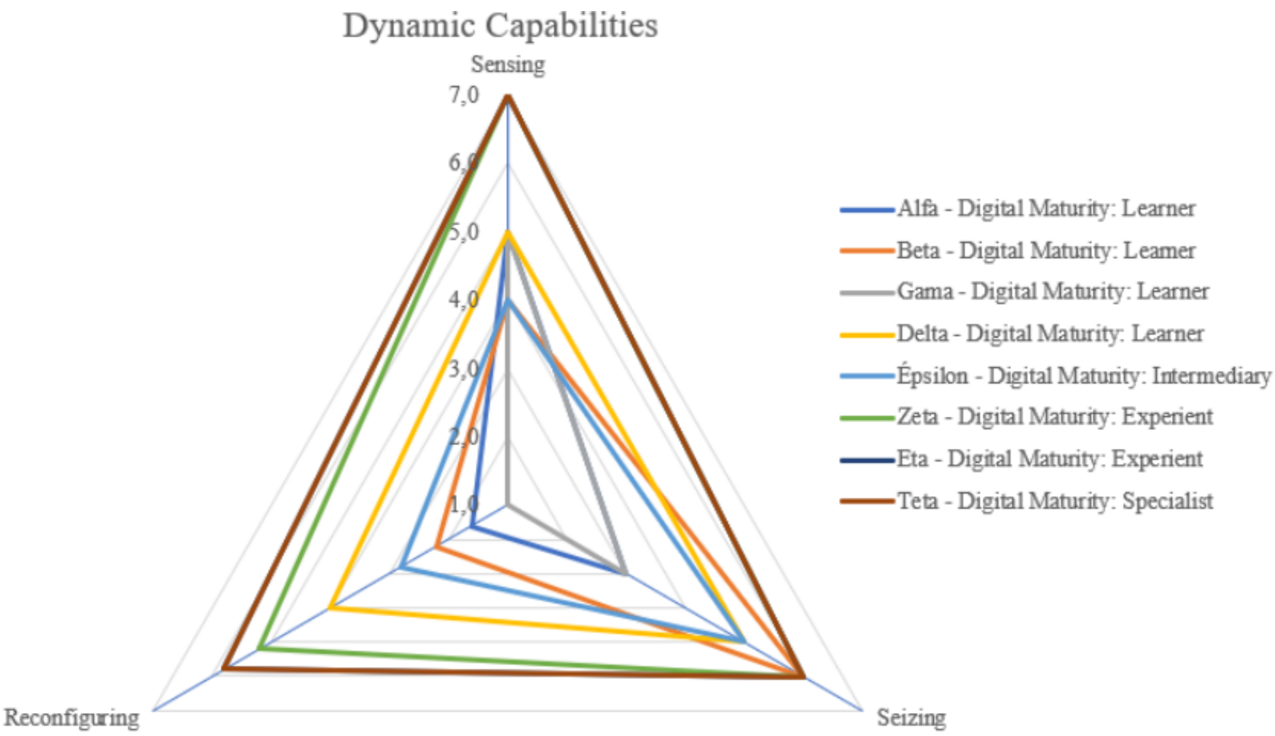
In the research, it was clear that the more dedicated human and financial resources companies have for DT, the better their maturity, confirming the literature (KARIMI; WALTER, 2015). We observed that companies with low maturity present opportunities to be explored in this sense.

Corroborating the internal barriers proposed by this research, the qualitative data also presented opportunities to be explored by all companies in the development of the microfoundation “Improving digital maturity” (SINGH; HESS, 2017; VERHOEF et al., 2019).

The use of technologies, such as big data analytics and artificial intelligence, to identify trends and opportunities for innovation (BREM; GIONE; WERLE, 2021; KAKATKAR; BILGRAM, 2020) is still under development in the companies studied. Even in companies with high digital maturity and technological infrastructure for this purpose, there are opportunities to be explored.

As for being digital in relation to the customer interface (DABROWSKA, et al., 2022 WARNER; WÄGER, 2019), all companies can to improve this microfoundation and the evidence shows that this is a challenge on this journey. The process to go digital at the customer interface is underway and is most visible in companies with high digital maturity, but with many opportunities in less mature companies.

Figure 5 – Dynamic capabilities of the studied companies and their digital maturity



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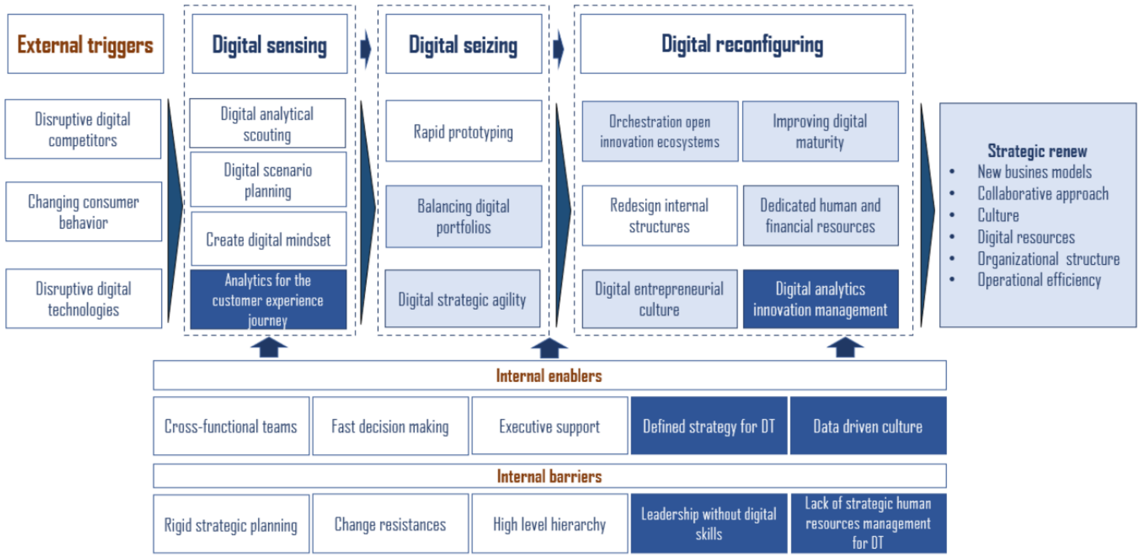
To complement the analysis, based on empirical research, we interpret that the microfoundation “Digital entrepreneurial culture” (WARNER; WÄGER, 2019) is a trait of companies with high digital maturity and induces DT.

Figure 6 presents the complete structure with the mapping of dynamic capabilities and their microfoundations for DT based on empirical results. Items in dark blue are the findings of this research. In turn, Figure 7, Figure 8, Figure 9 and Figure 10 present the summary with construct, domain and authors related to the new microfoundations, internal barriers and enablers added in the framework proposed in this research.

Figure 6 - Theoretical framework - Dynamic capabilities and their Microfoundations for DT



Font: Authors. Note: Elaborated based on the conceptual framework and empirical results

Figure 7 – Dynamic capability constructs: Sensing (digital opportunities and threats)

Dynamic capability: Sensing (digital opportunities and threats)		
Construct	**Domain**	**Authors**
Digital analytical observation	• Identify new digital technology trends. • Identify digital competitors. • Identify trends and opportunities for new products, processes and digital businesses based on "customer centric".	(VERHOEF *et al.*, 2019; VIAL, 2019; WARNER; WÄGER, 2019)
Plan the digital scenario	• Create digital strategies based on digital analytical observation. • Interpret future digital business scenarios based on Digital Analytics Observation.	(SOUSA-ZOMER; NEELY; MARTINEZ, 2020; WARNER; WÄGER, 2019)
Create the digital mindset	• Establish a long-term vision for DT. • Enable digital entrepreneurial mindset in the organization. • Enable a horizontal and flexible organization with a collaborative environment, with a focus on DT.	(KARIMI; WALTER, 2015; SOUSA-ZOMER; NEELY; MARTINEZ, 2020; WARNER; WÄGER, 2019)
New proposed microfoundation		
Analytics for the Customer Experience Journey	• Analyze large volumes of data from customers, products and digital platforms in order to create or change processes, products and businesses that transform the customer experience journey. • Analytical ability to identify trends and opportunities for new products and deals with the customer at the heart of value proposition creation.	(BREM; GIONE; WERLE, 2021; DUAN; CAO; EDWARDS, 2018; GUPTA; GEORGE, 2016; KAKATKAR; BILGRAM, 2020; MARIANI, et al., 2022; VERHOEF et al., 2019; VIAL, 2019)

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Figure 8 – Dynamic capability constructs: Seizing (digital opportunities)

Dynamic capability: Seizing (digital opportunities)		
Construct	**Domain**	**Authors**
Rapid prototyping	• Application of agile techniques for project development. • Creation of MVP (minimum viable product). • Use lean start-up methodology. • Create a digital innovation laboratory.	(KOPALLE; KUMAR; SUBRAMANIAM, 2020; WARNER; WÄGER, 2019)
Strategic agility	• Quickly reallocate resources. • Adaptability to accept changes. • Provide quick strategic responses. • Risk and uncertainty management.	(KOPALLE; KUMAR; SUBRAMANIAM, 2020; SOUSA-ZOMER; NEELY; MARTINEZ, 2020; VERHOEF *et al.*, 2019; VIAL, 2019; WARNER; WÄGER, 2019)
Balance with digital portfolios	• Build a balanced portfolio with internal and external options. • Generativity. • Scale new innovative business models.	(BJÖRKDAHL, 2020; KARIMI; WALTER, 2015; SEBASTIAN *et al.*, 2017; SOUSA-ZOMER; NEELY; MARTINEZ, 2020; WARNER; WÄGER, 2019; YOO *et al.*, 2012)

Font: Authors.

Figure 9 - Dynamic capability constructs: Reconfiguration

Dynamic capability: Reconfiguration (organization and business model)		
Construct	**Domain**	**Authors**
Improve digital maturity	• Knowing the digital maturity of the company's human resources. • Hire "digital natives". • Training, attraction and retention of human resources with digital skills.	(KARIMI; WALTER, 2015; SOUSA-ZOMER; NEELY; MARTINEZ, 2020; VERHOEF *et al.*, 2019; VIAL, 2019; WARNER; WÄGER, 2019)
Orchestrating open innovation ecosystems	• Ability to explore the potential of the digital ecosystem. • Hiring external R&D. • Interaction and cooperation with multiple external partners and institutions. • New ventures. • Development of co-creative skills to create value with users and suppliers.	(DABROWSKA, et al., 2022; SOUSA-ZOMER; NEELY; MARTINEZ, 2020; TEECE; LINDEN, 2017; WARNER; WÄGER, 2019)
Redesign internal structures	• Digitize the business model. • Dissemination of data-oriented culture in the organization. • Design an organizational structure based on squads, with ideals aimed at DT.	(SOUSA-ZOMER; NEELY; MARTINEZ, 2020; WARNER; WÄGER, 2019)
Dedicated resources	• Human resources allocated full time to activities related to DT. • Financial resources directed to DT.	(KARIMI; WALTER, 2015; SOUSA-ZOMER; NEELY; MARTINEZ, 2020)
Digital entrepreneurial culture	• Strategy for dissemination in the organization of a digital entrepreneurial culture. • Encouragement to deal with uncertainty and risk-taking. • Encouraging initiatives for experimentation and learning from mistakes. • Incentives to creative and innovative initiatives. • Stimulation of digital entrepreneurship.	(KARIMI; WALTER, 2015; KOPALLE; KUMAR; SUBRAMANIAM, 2020; SOUSA-ZOMER; NEELY; MARTINEZ, 2020; VERHOEF *et al.*, 2019; VIAL, 2019; WARNER; WÄGER, 2019)
New proposed microfoundation		
Digital analytics innovation management	• Formation of an area with human resources systematically dedicated to the company's innovation and R&D activities. • Definition of a strategy for managing resources and knowledge flows with the purpose of stimulating a culture in which digital analytical innovation occurs integrated into the company's innovation value chain. • Interpret, assimilate and integrate digital technologies and large volumes of data in order to create innovative digital products and businesses. • Obtain increasing profits with new products and digital businesses (innovative performance). • Formalization of a corporate governance strategy for digital innovation.	(BREM; GIONE; WERLE, 2021; DUAN; CAO; EDWARDS, 2018; FALLON-BYRNE; FRANCO et al., 2021; GUPTA; GEORGE, 2016; KAKATKAR; BILGRAM; FULLER, 2017; MARIANI, et al., 2022; NAMBISAN et al., 2017; YOO; HENFRIDSSON; LYYTINEN, 2010)

Font: Authors

Figure 10 - Contextual factors

Contextual factors		
Construct	**Domain**	**Authors**
External triggers	• Disruptive external competitors. • Change in consumer behavior. • Disruptive digital technologies.	(KOPALLE; KUMAR; SUBRAMANIAM, 2020; VIAL, 2019; WARNER; WÄGER, 2019)
Internal enablers	• Cross-functional teams. • Fast data-driven decision making. • C-level support. • Defined strategy for TD • Data-driven culture	(KOPALLE; KUMAR; SUBRAMANIAM, 2020; VERHOEF *et al.*, 2019; WARNER; WÄGER, 2019)
Internal enablers (New proposed)		
Construct	**Domain**	**Authors**
Defined strategy for DT	• Ability to define and implement the strategy for digital transformation. • Ability to define and implement indicators to measure the digital transformation. • Ability to define and implement the long-term vision for digital transformation.	(BJÖRKDAHL, 2020; VERHOEF *et al.*, 2019; VIAL, 2019)
Data-driven culture	• Ability to transform data into strategic assets for business success and competitive advantage. • Ability to make strategic decisions based on data. • Ability to train human resources with analytical skills. • Ethics, respect and transparency for privacy institutionalized in the organization as pillars in the use of data. • Ability to encourage the use of data to generate innovative ideas and opportunities for new products, processes and businesses.	(BREM; GIONE; WERLE, 2021; DUAN; CAO; EDWARDS, 2018; GUPTA; GEORGE, 2016; KOPALLE; KUMAR; SUBRAMANIAM, 2020; VERHOEF *et al.*, 2019; VIAL, 2019)
Internal barriers (New proposed)		
Construct	**Domain**	**Authors**
Lack of strategic human resources management for DT	• Lack of a strategic HR management plan aligned with the DT strategic plan. • Lack of a favorable environment for hiring digital natives. • Lack of policy for training, attracting and retaining digital talent. • Lack of training for digital work.	(KOPALLE; KUMAR; SUBRAMANIAM, 2020; VERHOEF *et al.*, 2019; VIAL, 2019)
Leadership without digital skills	• Superior cognitive skills to provide value to the business, combining SMACIT technologies (social, mobile, analytics, cloud and IoT). • Socio-emotional skills (leadership, negotiation, management, business strategy, learning and entrepreneurship) aimed at DT.	(PORFÍRIO *et al.*, 2021; SEBASTIAN *et al.*, 2017)

Font: Authors.

Conclusion

Answering this project's research question – What are the dynamic capabilities and micro-foundations that drive the DT journey? –, we start from the model proposed by Warner and Wäger (2019) and expand it with the addition of contributions from other authors: Karimi; Walter (2015); Sousa-Zomer; Neely; Martinez (2020).

In this way, we map and present the conceptual foundation of strategic and organizational dynamic capabilities, and their microfoundations for the new digital economy, thus proposing the application of a framework to assess, in organizations, strategic and organizational vectors related to dynamic capabilities to the DT (Figure 6).

With the application of the proposed framework, we identified two new microfoundations, two dimensions of internal barriers and two dimensions of internal enablers, which may be relevant for deepening the maturity of DT, not mapped in previous studies (SOUSA- ZOMER; NEELY; MARTINEZ, 2020; WARNER; WÄGER, 2019)

Implications for theory, and practice

The main academic contributions elaborated from the gaps found in Karimi's studies; Walter (2015; Sousa-Zomer; Neely; Martinez, (2020); Warner; Wäger, (2019) are:

a) mapping of dynamic capabilities, their theoretical foundation, inclusion of new dimensions in the framework:

b) validation of the **Sensing dynamic capability dimension** and its microfoundations for DT the new constructs of *"**Analytics for the customer experience journey**",* in the **Digital reconfiguring dimension**, the constructs of ***"Digital analytics innovation management" and "Innovation ecosystem orchestration***"; ***the internal barriers "Leadership without digital skills" and "Lack of strategic human resources management for DT***"; the ***internal enablers "Defined strategy for DT" and "Data-driven culture***" not mapped in previous studies.

Contributions to managerial practice enable companies to develop a roadmap for the digital transition, oriented towards their business and management strategy, based on indicators to measure dynamic capabilities and their microfoundations for DT.

Limitations

As this research has an exploratory and qualitative nature, the presented results have limitations, among them: (a) possible biases, for which we describe, in the methodology, precautions to avoid or minimize their effects; (b) the generalization of the findings is limited due to the size of the sample, the origin of the companies and the representativeness of sectors, even having a recommendation, in the sample, of eight cases (EISENHARDT, 1989).

Future research

The development of this qualitative research followed consolidated quality criteria with the purpose of presenting validity in the results and serving as a basis for future quantitative research to test its findings. Therefore, validating whether our findings are valid in a large-scale survey with companies from different sectors, sizes, headquarters, subsidiaries and countries, taking into account national, cultural and organizational differences, would be useful to reflect different judgments related to dynamic capabilities for DT.

As dynamic capabilities offer the possibility of designing longitudinal research, a project with this perspective could evaluate the development of such capabilities with the aim of obtaining competitive advantage and strategic renewal over time.

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INNOVATION CAPABILITIES II

May 2nd: 10h30 am – 12h30 pm

Chair

Ricardo Léo (Federal University of Rio Grande do Sul, Brazil)

Papers

Exploring innovation capabilities (RE) combinations over time: A configurational approach on panel data

Estêvão Passuello Ruffoni, Fernanda Maciel Reichert, Ana Mônica Fitz-Oliveira

The relationship between innovation capability and non-financial performance

Cleber Webber, Janaina Ruffoni, Marte Solheim

Measurin ecosystems' innovation capabilities with the innovation potential of individuals: A systematic review of multidimensional construct

Annie Passalacqua, Catherine Beaudry

Smart innovation capabilities: New business models and innovation

Paulo Antônio Zawislak, Carlai Netto

How the adoption of artificial intelligence technologies affects the innovation capabilities of firms

Rafael Toassi Crispim, Eduardo Vasconcellos

Exploring the evolution and recombination of innovation capabilities in the rise of industry 4.0: evidences from agricultural machinery manufacturers

Abstract ID#165| Full Paper ID#481

Estêvão Passuello Ruffoni, Fernanda Maciel Reichert, Ana Mônica Fitz-Oliveira (Federal University of Rio Grande do Sul)

Abstract: Innovation is the mean by which firms adapt to market changes, being the result of the firm's capabilities. Studies generally explore only how firms combine their capabilities to innovate in a given moment, little addressing how firms evolve their capabilities and recombine them to innovate overtime. The current fourth industrial revolution (a.k.a. Industry 4.0) involves many simultaneous, radical, and accelerated market changes, to the point of being considered a paradigm change. This scenario makes even more relevant a deep understanding of how firm's capabilities evolve and are recombined. In this regard, the present study examines four innovation capabilities (development, operations, transactions, and management) of agricultural machinery manufacturers transiting to Industry 4.0. Using panel data from two periods (2014 and 2018), the Wilcoxon test was applied to examine how firms evolved their capabilities overtime, and the fsQCA technique to address how firms recombined their capabilities to innovate overtime. The results indicate that agricultural machinery manufacturers strongly evolved their four capabilities, as well as recombined them to innovate between these periods – from a combination driven towards technological innovations to a combination driven towards business innovations.
Keywords: Innovation Capabilities, Capability Evolution, Industry 4.0, Agriculture 4.0, fsQCA, Panel Data

Introduction

Market changes, such as the advent of new technologies or of new business opportunities, are frequently occurring (Dosi, 1982). Firms adapt to market changes through innovation, which is the result of their capabilities – sets of routines, skills and knowledges accumulated overtime (Dopfer and Nelson, 2018; Francis and Bessant, 2005; Teece, 2007). The literature states that firms have different types of innovation capabilities, exploring mainly how firms combine them to innovate in a given moment of time (e.g., Guan and Ma, 2003; Reichert, et al., 2016; Wang et al., 2008).

Some studies observed that, overtime, firms evolve their innovation capabilities (Fan, 2006; Figueiredo et al., 2020) as well as recombine them to keep innovating (Collinson and Wang, 2012). Although market changes are the rule, these two topics: the evolution and recombination of innovation capabilities overtime, are very little explored in the research field, even more jointly.

The current fourth industrial revolution (a.k.a. Industry 4.0) highlights the importance to better explore these two issues. The fourth industrial revolution encompasses many simultaneous, radical and accelerated market changes, such as the emergence of disruptive new digital technologies and the demand for more customized products (Culot et al., 2020). In this regard, the present article aims to answer two pressing questions: How do firms adapting to Industry 4.0 evolve and recombine their innovation capabilities overtime?

To answer these questions, the theoretical framework of innovation capabilities proposed by Zawislak et al. (2012) was adopted. The framework embraces previous perspectives on the firm's innovation capabilities, enabling a comprehensive approach to the phenomenon through four capabilities: Development, Operations, Transactions, and Management. While development and operations capabilities are driven towards technological innovation (new products and new manufacturing processes), transactions and management capabilities are driven toward business innovation (new strategies and new managerial processes). Furthermore, development and transactions capabilities are change driven, respectively pushing the firm's technological and business change, while operations and management capabilities are stability-driven, focusing on obtaining efficiency from the given technology and business strategy (Pufal and Zawislak, 2021).

To observe the phenomenon, a sample of 29 Brazilian agricultural machinery manufacturers was utilized, with panel data related to two periods (2014 and 2018), which correspond to the rise of Industry 4.0 (Kagermann et al., 2013; Xu et al., 2018). Firms in this sector were chosen because of their considerable efforts to transition to Industry 4.0 (Mantovanni et al., 2018; Smania et al., 2022), being selected for the present study only companies that invest in this regard. The Wilcoxon test was applied to measure the evolution of each individual innovation capability, while the fuzzy-set Qualitative Comparative Analysis (fsQCA) technique was used to identify how firms have recombined their innovation capabilities.

Results show that firms consistently evolved and recombined their four innovation capabilities in their adaption to Industry 4.0. In 2014 firms innovated by combining development, operations, and management capabilities (DC*OC*MC), focusing on technological innovations, while in 2018 firms innovated by combining transactions, operations and management capabilities (TC*OC*MC), focusing on business innovations. It is argued that this recombination of capabilities occurred probably due to firms' difficulties in seizing new business opportunities. The results obtained reinforce perceptions of previous studies that firms' adaptation to Industry 4.0 involves a balance between technological and business changes, and that innovation needs some sort of organization to occur, since operations and management capabilities were present in both combinations.

Theoretical Background

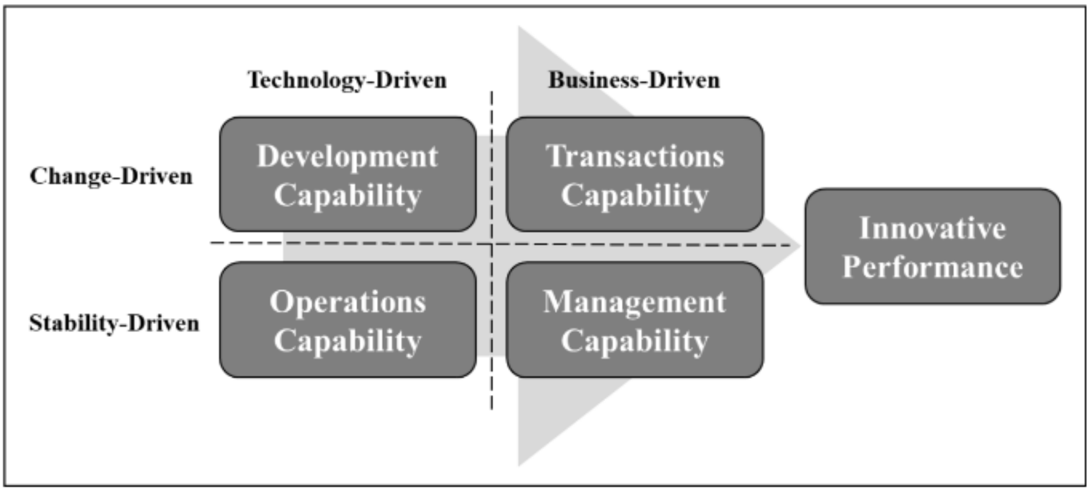
The Firm Innovation Capabilities

Firm innovation capabilities consist of sets of knowledges, skills, and routines through which firms adapt to market changes and innovate (Dosi et al., 2000; Helfat, 2018). Studies about this subject can be divided in two different approaches: a dimensional approach and a processual approach. The dimensional approach considers that firms can have different types of capabilities, each one being responsible for generating one type of innovation: new products, new manufacturing processes (Lall, 1992), new strategies, and new managerial processes (Francis and Bessant, 2005; Guan and Ma, 2003).

The processual approach, in turn, considers that firms have three types of dynamic capabilities, each one being responsible for one stage of the innovation process: sensing technological and business changes, seizing the opportunities arising from such changes, and reconfiguring firm routines to adapt to these changes (Teece, 2007). The processual approach also considers that firms have ordinary capabilities, which are not involved in the innovation process but are responsible for maintaining the firm efficiency. Although only dynamic capabilities can sustain competitive advantages in the long term, ordinary capabilities are also necessary for the firm to achieve high performance (Achenthagen et al., 2013; Teece, 2007; Warner and Wager, 2018).

The theoretical framework of innovation capabilities put forward by Zawislak et al. (2012) was adopted, due to its efforts to build a bridge between the dimensional and processual approaches, enabling a broad perspective on the phenomenon. For Zawislak et al. (2012), every firm has four innovation capabilities: Development, Operations, Transactions, and Management. Development and operations capabilities are technology-driven, resulting in innovations in products and in manufacturing processes, while transactions and management capabilities are business-driven, achieving innovations in strategies and in managerial processes (Zawislak et al., 2012). Moreover, development and transactions capabilities are change-driven, resembling dynamic capabilities, while operations and management capabilities are stability-driven, similarly to ordinary capabilities (Pufal and Zawislak, 2021). Figure 1 illustrates the theoretical framework.

Figure 1 – Firm Innovation Capabilities Framework



Source: Pufal and Zawislak (2021)

The development capability is responsible for pushing the firm to a technological change (Pufal and Zawislak, 2021) by sensing, seizing, and converting new technologies into new products or new manufacturing processes (Lall, 1992). The development capability reconfigures firm's routines in order to make them able to conceptualize, design, and develop products and manufacturing processes that fit a new technological paradigm (Figueiredo et al., 2020; Peeraly et al., 2022).

However, technological change only consolidates when the firm became able to operate new technologies efficiently, which occurs through the operations capability (Zawislak et al., 2012). The operations capability seeks for the most efficient way to use the given technological resources (Peng et al., 2008), organizing firms' routines to enhance the tangible quality of products, as well as the efficiency and flexibility of manufacturing processes, reducing costs and lead times (Moldner et al., 2020; Wang et al., 2008).

On the other hand, the transactions capability is responsible for pushing the firm to a business change (Pufal and Zawislak, 2021) by sensing, seizing, and converting new business opportunities into new strategies (Francis and Bessant, 2005). The transactions capability reconfigures firm's routines to make them able to create new marketing and distribution strategies (Merilles et al., 2011), as well as supply chain strategies (Aslam et al., 2021), that fit a new business paradigm (Warner and Wäner, 2018).

Like technological change, business change only consolidates when the firm is manageable in a new business environment, which occurs through the management capability (Pufal and Zawislak, 2021). The management capability seeks for the most efficient way to formalize and spread the given strategies to different areas of the firm (Guan and Ma, 2003), organizing firm's routines to improve business models, managerial processes and organizational culture, resulting in a better allocation of resources (Anzola-Román et al., 2018; Leonard-Barton, 1992).

The literature generally explores how firms combine their capabilities to innovate in a given moment of time (Guan and Ma, 2003; Reichert et al., 2016; Ruffoni et al., 2018; Yam et al., 2004). However, since innovation is a dynamic process (Teece, 2007), it is expected that, overtime, firms evolve (Fan, 2006; Figueiredo et al.; 2020) and modify their combinations of innovation capabilities

(Collinson and Wang, 2012). Even more, when adapting to Industry 4.0, given the intensive changes involved.

The Fourth Industrial Revolution

Firms adapt to market changes, such as the rise of new technologies or new business opportunities, by creating innovations based on a given paradigm (Nelson, 1991). A paradigm consists in a delimitation to the innovations that a firm can perform (Dosi, 1982), and may change when market changes are too intensive (Freeman and Perez, 1988).

The previous three industrial revolutions delimited innovations to a paradigm in which products must be standardized, developed through a linear approach (from the firm to the market), and manufactured in mass production systems (Liao et al., 2017; Xu et al., 2018). However, the beginning of the fourth industrial revolution (a.k.a. Industry 4.0) in the last decade (2010) stablished a new innovation paradigm, in which products must be customized, developed through a co-creation approach (between the firm, its customers, and its suppliers), and manufactured in highly flexible production systems (Culot et al., 2020; Sjödin et al., 2018).

According to Frank et al. (2019), the fourth industrial revolution results in the offering of smart products and in the building of smart processes. Smart products consist in products with digital technologies embedded to collect and convert data related to their own performance into knowledge to improve their development process and adequacy to consumers' needs. Smart processes consist in manufacturing, logistics, and management processes automated and optimized through digital technologies to considerably reduce costs and provide never seen levels of productivity (Meindl et al., 2020).

The literature highlights that both technological and business changes are necessary for firms to succeed in their adaptation to Industry 4.0. In this context, the firm's technological change encompasses the selection and absorption of a plethora of emerging new digital technologies, such as the Internet of Things, Cloud Computing, Big Data Analytics, Artificial Intelligence, Advanced Robotics, and Additive Manufacturing, to only cite the main ones (Zhong et al., 2020). Although an appropriate technological change enables the firm to master the knowledge to implement and use these digital technologies (Horváth and Szabó, 2019; Tamvada et al., 2022), it cannot ensure a successful transition toward Industry 4.0.

To do so, firms also need to conduct business changes to create and implement strategies that meet the emerging new business opportunities, such as the offering of customizable products, of products with low environmental impact, or of products complemented by digital services (Rachinger et al., 2018). An adequate business change is necessary for firms to find the best ways to obtain profits from investments in digital technologies (Raj et al., 2019; Saihi et al., 2022). Many firms struggle to adapt to Industry 4.0 because they do not conduct a proper business change (Vial, 2019).

Considering agricultural machinery manufacturers – the object of this article – many studies are observing consistent efforts of these companies to adapt to the fourth industrial revolution (e.g., Mahda et al., 2022; Wolfert et al., 2017; Zambon et al., 2019). This is not different in Brazil, where this transition can be considered even more evident, as agribusiness plays a key role in the country (Bolfe et al., 2020; Mantovanni et al., 2018; Smania et al., 2022), which is one of the main producers of food and agricultural commodities in the world (Ruffoni and Reichert, 2022; Vieira and Fishlow, 2017). Therefore, Brazilian agricultural machinery manufacturers consist in an adequate sample to observe how firms evolve and recombine their innovation capabilities when adapting to Industry 4.0.

Method

Sample

To answer how firms adapting to Industry 4.0 evolve and recombine their innovation capabilities overtime, a database of the same companies, collected with the same research instrument but in different time periods (panel data), was utilized. The database used is the result of a research about innovation capabilities in Brazilian manufacturing firms, collected through a survey instrument with questions based on the firm's innovation capabilities framework proposed by Zawislak et al. (2012). The database was built through two data collections: in 2014 and 2018, and included firms from different manufacturing industries.

Although the fourth industrial revolution started in developed economies at the beginning of the 2010 decade (Kagermann et al., 2013; Liao et al., 2017; Xu et al., 2018), it should be taken into account that Brazil is an emerging economy, which are known to suffer from technological delays (Dutrénit et al., 2019; Wong and Goh, 2014). In this regard, the time interval between 2014 and 2018 is appropriate to understand how Brazilian manufacturers evolve and recombined their innovation capabilities to adapt to Industry 4.0.

Departing from this database, were selected only manufacturers of agricultural machinery, such as tractors, planters, harvesters, sprayers, grain dryers, silos, and so on. Then, based on magazines about digitalization in agribusiness, sectoral reports, news, companies' websites and products catalogs, were selected only firms in which there is evidence of a conversion to Industry 4.0. Therefore, were considered only firms offering smart products (e.g., apps to monitor the product performance, to support the customer process, or to simulate farming conditions), or conducting initiatives to digitalize their processes (e.g., implementation of cloud computing platforms, acquisition of robots, and of additive manufacturing equipment). The selection resulted in 29 manufacturers of agricultural machinery.

Data Analysis

To analyze the firm's innovation capabilities and innovative performance, the same questions adopted by Reichert et al. (2016) were considered, all of which with answers on five point scales (ranging from total disagreement to total agreement). Operations and management capabilities, respectively, include 6 and 7 items. Development capability include 6 items (also adopted by Alves et al., 2017; Oliveira et al., 2019; Pufal and Zawislak, 2021; Ruffoni et al., 2018), transactions capability includes 5 items (also adopted by Oliveira et al., 2019), and innovative performance includes 3 items (also adopted by all these studies). All studies cited here identified a Cronbach Alpha greater than 0.7 for each construct, indicating satisfactory reliability (Hair, 2014). The items are detailed in Table 1, in the Results section.

The Wilcoxon signed rank test was applied with SPSS software to compare the means of each item and of each construct, identifying how firms evolved their innovation capabilities between the periods considered (2014 and 2018). Then, the fuzzy-set Qualitative Comparative Analysis (fsQCA) technique was applied with the fsQCA 2.0 software, identifying how firms recombined their innovation capabilities between these periods. Both the Wilcoxon test (Amado et al., 2017; Poba-Nzaou et al., 2016) and the fsQCA technique (Berger and Kuckertz, 2016; Boratynska and Grzegorzewska, 2018; Núñes-Pomar et al., 2016) are adequate to examine small samples.

According to Ragin et al. (2017), fsQCA identifies combinations of conditions for a given outcome based on a set membership approach, in which the researcher must define the variables that are sets of conditions, and those that are sets of effects. Following Reichert et al. (2016), each firm's capability was taken as a condition set and the firm's innovative performance as an outcome set (Ruffoni and Reichert, 2022).

After this, data must be calibrated in fuzzy scales by stablishing thresholds, which represents degrees of set memberships (Ragin et al., 2017). Regarding five-point scales, authors use different approaches: direct correspondence (5 for full-membership, 3 for partial membership, and 1 for non-membership) (Leischng and Kasper-Brauer, 2015); percentiles (Sjödin et al., 2016); relationship between the mean and standard deviation (dispersion) (Da Silva et al., 2019); and so on. In each period, the data were calibrated with the same approach in order to maintain the same criteria of analyzes. Considering that the 2014 values are considerably lower than the 2018 values, thresholds that represent a middle ground between periods were adopted: 5, 3.5, and 2 (Pappas and Woodside, 2021).

With variables calibrated, the fsQCA generates a truth table, listing all possible combinations of conditions for the desired effect, which indicates the number of observations in each combination, and the degree of observations' membership to each combination (raw consistency). Following Ragin et al. (2017), the truth table was reduced by excluding combinations without cases and with a raw consistency below 0.80. Then, the fsQCA generates three types of solution: complex, parsimonious, and intermediate, of which the intermediate solution was considered for being the most interpretable (Ragin et al., 2017). The following section presents the results obtained.

Results

The results of the Wilcoxon test (Table 1) indicate that agricultural machinery manufacturers strongly evolved their four innovation capabilities from 2014 to 2018, and also presented a more consistent innovative performance. The evolution of business-driven capabilities (transactions and management) was significant at 1%, being more representative than the evolution of technological-driven capabilities, which were significant only at 10% (development) and 5% (operations).

Table 1 – Wilcoxon Test

Item – Does your firm:	Mean 2014	Mean 2018	Z	Asymp (2 tailed)
Designs its own products	3.59	4.17	-1.900	0.057 *
Monitors the latest tendencies in technology in the industry	3.69	4.34	-2.583	0.010 ***
Use formal project management methods (e.g., Stage Gate, PMBOX, Innovation Funnel)	3.31	4.07	-2.616	0.009 ***
Adapt the technology in use for its own needs	3.61	3.93	-1.732	0.083 *
Prototypes its own products	3.69	4.38	-2.329	0.020 **
Launch its own products	4.07	4.17	-0.365	0.715
Development Capability [DC]	**3.66**	**4.18**	**-1.731**	**0.083** *
Keep statistical control of the process	3.59	4.14	-2.334	0.020 **
Using leading edge technology within the sector	3.59	4.10	-2.482	0.013 **
Maintain adequate stock levels of materials for the process	3.93	4.24	-1.469	0.142
Carry out the productive process as scheduled	3.90	4.10	-1.177	0.239
Establish a productive routine that does not generate rework	3.93	4.31	-2.057	0.040 **
Manage to expand the installed capacity whenever necessary	3.59	4.28	-2.707	0.007 ***
Operations Capability [OC]	**3.75**	**4.20**	**-2.296**	**0.022** **
Conduct formal research to monitor the market	3.24	4.10	-2.487	0.013 **
Impose its prices on the market	3.38	3.86	-1.807	0.071 *
Impose its negotiating terms on its customers	3.31	4.62	-4.081	0.000 ***
Conduct research to measure its customers satisfaction	3.24	4.69	-3.897	0.000 ***
Use formal criteria to select suppliers	3.52	4.28	-2.758	0.006 ***
Transactions Capability [TC]	**3.34**	**4.31**	**3.367**	**0.001** ***
Formalize production planning and control procedures	3.17	4.31	-3.569	0.000 ***
Formally define its strategic aims annually	3.59	4.34	-3.150	0.002 ***
Use information technology to integrate all of its areas	3.34	4.38	-3.596	0.000 ***
Standardize and document the work procedures	3.59	4.24	-3.189	0.001 ***
Update its management tools and techniques	3.57	4.45	-3.338	0.001 ***
Maintain adequately trained personnel for company function (training)	3.90	4.59	-3.320	0.001 ***
Use modern financial management practices	3.57	4.28	-3.061	0.002 ***
Management Capability [MC]	**3.54**	**4.37**	**-3.841**	**0.000** ***
Had growth in net profits over the last three years	3.48	4.21	-2.623	0.009 ***
Had growth in market share over the last three years	3.79	4.31	-2.304	0.021 **
Had growth in revenue over the last three years	3.57	4.10	-1.939	0.052 *
Innovative Performance	**3.61**	**4.21**	**-2.639**	**0.009** ***

*** Significant at 1%; ** Significant at 5%; * Significant at 10%

After this, the fsQCA technique was applied to identify how firms modified their combinations of innovation capabilities between 2014 and 2018. First, the necessity analysis was conducted (Table 2) to measure the consistency of each individual condition (innovation capabilities) in relation to the outcome (high innovative performance). The consistency represents the interdependence between a condition and an outcome, similarly to the statistical correlation (Hsiao et al., 2015). A condition is considered as “necessary” or “almost always necessary” when its consistency is respectively greater than 0.900 or 0.800 (Ragin, 2000; Santos and Gonçalves, 2019). Thus, Table 2 demonstrates that development and operations can be considered as almost always necessary capabilities for high innovative performance in both periods, while transactions and management capabilities can be considered necessary capabilities, but only in 2018.

Table 2 – Analysis of Necessary Conditions

Period:	2014		2018	
Outcome:	High Innovative Performance		High Innovative Performance	
Condition	Consistency	Coverage	Consistency	Coverage
Development Capability [DC]	0.82 *	0.79	0.86 *	0.83
~Development Capability [~DC]	0.50	0.66	0.31	0.97
Operations Capability [OC]	0.84 *	0.79	0.89 *	0.85
~Operations Capability [~OC]	0.52	0.70	0.30	0.95
Transactions Capability [TC]	0.66	0.80	0.92 **	0.85
~Transactions Capability [~TC]	0.66	0.68	0.24	0.90
Management Capability [MC]	0.78	0.84	0.92 **	0.83
~Management Capability [~MC]	0.61	0.71	0.23	0.98

** Necessary condition (>= 0.90); * Almost always necessary condition (>= 0.80)

After this step, the sufficiency analysis (Table 3) was performed to identify whether conditions can result alone in the outcome or if they must be combined with each other to do so. The results demonstrate that none of the conditions is sufficient to provide the outcome alone. In 2014, agricultural machinery manufacturers achieved high innovative performance by combining development, operations, and management capabilities (DC*OC*MC), while in 2018, this performance was obtained by combining transactions, operations, and management capabilities (TC*OC*MC). Besides being evaluated through their consistency, combinations of conditions (solutions) are also evaluated by their coverage, which measures their explanatory power, resembling the R^2 (Hsiao et al., 2015). To consider a solution valid, its consistency and coverage must be, respectively, above 0.750 and 0.250 (Woodside, 2013). Table 3 shows that both cutoffs were met.

Table 3 – Analysis of Sufficient Conditions

Period:	2014	2018
Outcome:	High Innovative Performance	High Innovative Performance
Condition	Solution	Solution
Development Capability [DC]	●	
Operations Capability [OC]	●	●
Transactions Capability [TC]		●
Management Capability [MC]	●	●
Solution Consistency	0.88	0.87
Solution Coverage	0.70	0.81

● = Causal condition must be present for the outcome to occur.

The next section further discusses the implications of the results obtained.

Discussions

First, the strong evolution observed in the four innovation capabilities (Table 1) can be taken as an evidence of firms transition to the fourth industrial revolution. Firms would have strengthened their innovation capabilities to adapt to the constant emergence of new digital technologies and business opportunities. In this regard, results converged in indicating that firms were focused on technological innovations in 2014, and became focused on business innovations in 2018. Besides business-driven capabilities (transactions and management) presented a more significant evolution (Table 1), they also alternated from non-necessary to necessary capabilities for high innovative performance, while technological-driven capabilities (development and operations) remained as almost necessary capabilities (Table 2). Furthermore, firms also recombined their innovation capabilities from a combination with two technological-driven capabilities in 2014 (DC*OC*MC), to a combination with two business driven capabilities in 2018 (TC*OC*MC) (Table 3).

These results reinforce previous studies demonstrating that innovation requires some sort organization to occur, once in both periods firms innovated by combining two stability driven capabilities (operations and management) with one change-driven capability (either development or transactions). A highly developed management capability facilitates investments in innovations through a better plan and control of resources (Anzola-Román et al., 2018), while a consolidated operations capability allows the development of new products and the address of new markets through efficient and flexible manufacturing processes (Moldner et al., 2020). Therefore, the role of stability-driven capabilities is to configure all pieces for the change-driven capabilities to conduct technological and business changes (Pufal and Zawislak, 2021).

In this regard, the DC*OC*MC combination, given the presence of the development capability, represents the technological changes carried out by agricultural machinery manufacturers in 2014. Firms were focused on sensing, seizing, and converting new technologies into new products and manufacturing processes. As 27 firms alleged that the development of processes and the acquisition of production equipment were their main innovation activities in 2014, it can be said that the DC*OC*MC combination was oriented, above all, to improve manufacturing processes. In this scenario, the operations capability seeks for the most efficient way to operate the new manufacturing processes, while the management capability applies the new technologies acquired to optimize business processes. Considering the context of transition to Industry 4.0, firms were absorbing new emerging digital technologies (Peeraly et al., 2022) to transform manufacturing, logistics, and management processes into smart processes (Meindl et al., 2020).

On the other hand, the TC*OC*MC combination, due the presence of transactions capability, demonstrates the business changes performed by agricultural machinery manufacturers in 2018. Firms became focused on sensing, seizing, and converting new business opportunities into new strategies. As 22 firms stated that the launch of new products was their main innovation activity in 2018, the TC*OC*MC combination can be taken as orientated to find new markets for products already developed, given the absence of the development capability in the combination. In this context, to meet the new marketing, distribution, and supply chain strategies, the management capability establishes new business processes, while the operations capability reorganizes the production. Taking into account the context of adaptation to Industry 4.0, firms were creating strategies to offer customizable products, products with low environmental impact, and products complemented by digital services (Rachinger et al., 2018; Sjödin et al., 2018).

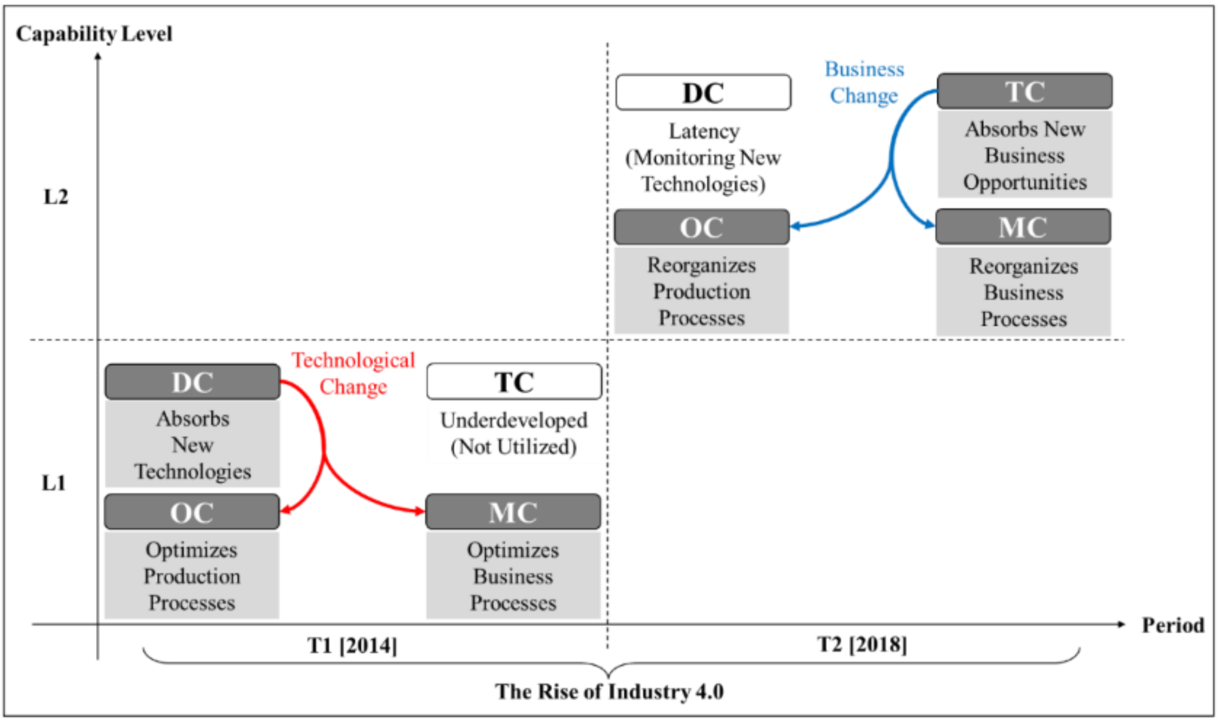
A question that arises is why agricultural machinery manufacturers changed from the DC*OC*MC combination to the TC*OC*MC combination. This is partially answered by the fact that firms' adaption to industry 4.0 requires a balance between technological and business changes to be well succeed, as identified by previous studies. The simple absorption of emerging new digital technologies does not guarantee that firms will be able to create value propositions (Vial, 2019). Business changes are necessary to develop new strategies and new business models that exploit the full potential to aggregate value of these new technologies (Rachinger et al., 2018; Raj et al., 2018; Vial, 2019).

Firms probably started with technological changes in 2014 because they are machinery manufacturers, which are traditionally orientated to technological development, investing considerable amounts in research and development activities (OECD, 2016). The focus of the DC*OC*MC combination in incorporating new digital technologies to reduce production costs can be related to the fact that machinery manufacturers, in emerging economies, are more focused in mass replicate products developed by their headquarters in central countries, rather than in developing new products (Ruffoni and Reichert, 2022).

This focus on technological change led to a very weak transactions capability, being the less developed capability in 2014, with the lowest mean (Table 1). As a consequence, firms faced challenges to seize new business opportunities in this period, staying limited in improving manufacturing processes. Therefore, to create new strategies and business models that exploit the full potential of the new digital technologies absorbed, firms evolved their transactions capability and recombined it with the others in the TC*OC*MC combination (Warner and Wäner, 2018).

Unlike transactions capability in 2014, the development capability was not underdeveloped in 2018. In this regard, the absence of development capability in the TC*OC*MC combination does not mean that firms no longer use it. The development capability has also evolved from 2014 to 2018, and remained as an almost necessary capability (Table 2). Since the monitoring of the latest trends in technology was among the elements of this capability that presented the most representative evolution (significant at 1% – Table 1), it can be assumed that firms put the development capability in a latent stage, to keep monitoring the emergence of new digital technologies. Figure 2 illustrates the main results.

Figure 2 – The evolution and recombination of innovation capabilities of agricultural machinery manufacturers in the rise of Industry 4.0



In sum, the results show that, to convert to Industry 4.0, firms first focused on their technological change through the DC*OC*MC combination. After facing challenges to find new business opportunities, firms evolved their four innovation capabilities and recombined them into the TC*OC*MC combination to focus on business changes. In parallel, firms let the development capability in a latency stage to keep monitoring the advent of new digital technologies.

Conclusions

The study achieved its objective of identifying how firms adapting to Industry 4.0 evolve and recombine their innovation capabilities overtime. Departing from a four innovation capabilities framework, it was identified that agricultural machinery manufacturers strongly evolved their four innovation capabilities between 2014 and 2018, and also recombined them.

Results reinforced evidences from previous studies that innovation requires organization to occur, and that firms' conversion to Industry 4.0 depends on a balance between technological and business changes to be well succeed.

This research offers academic and practical contributions. In terms of academic contributions, besides addressing two topics that are little explored in the literature – how firms evolve and recombine their innovation capabilities overtime – the article also contributed by examining how firms' capabilities behave in a context of paradigm change, in the case, the fourth industrial revolution.

Regarding practical contributions, the study demonstrates that all capabilities are necessary for innovation to occur, even if, at a given moment, one or more of them are relegated to a secondary role. Therefore, managers need to work not only to evolve the capabilities of their companies, but also to maintain them developed and ready to be recombined whenever necessary. Moreover, a transition path for firms aiming to convert to Industry 4.0 was indicated: from technological changes to business changes.

A limitation of this study lies in the generalization of results, since the sample utilized was small, and includes companies from only one country. This can be overcome by future studies, using larger samples, approaching other industries, and addressing companies from different countries. Future studies can also go deeper into case knowledge to enrich with more details how firms evolve and recombine their innovation capabilities overtime.

An important topic that requires further examination is the relationship between the firm's digitalization and the evolution of its capabilities. Considering that firms innovated through the DC*OC*MC combination in 2014, which is associated with the incorporation of digital technologies, the strong evolution observed in their capabilities between 2014 and 2018 could be a consequence of the absorption of these technologies. Once digital technologies collect and convert data into knowledge, one of the building blocks of firms' capabilities, future studies could explore if and how firms' digitalization accelerate the evolution of their capabilities.

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The relationship between innovation capability and non financial performance

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Abstract: Innovation capability is considered a strategic differentiation factor and competitive advantage source to organizations, leading firms to improve their performance. However, there is a lack of studies that demonstrate the effect of the dimensions of innovation capabilities on various aspects of performance. In this context, this paper aims to demonstrate the relationship between innovation capability and non-financial firm performance. This study is a theoretical paper, and the results are supported by an extensive bibliographical review. Findings reveal that the developed model contributes to a better understanding of the relationship between innovation capabilities and firm performance. In addition, it demonstrates in a more specific and direct way how each innovation capability leads to superior firm performance. This provides a strategic view of innovation capabilities. Another important contribution is the proposition that Management innovation capability moderates the relationship between innovation capabilities and different types of non-financial firm performance. This premise brings a new dynamic to the construct of innovation capabilities proposed by Zawislak et al. (2012). The framework can be used to help managers of organizations that seek to develop innovation capabilities and obtain better organizational performance.
Keywords: innovation, innovation capability, non-financial performance, firm performance, balanced scorecard

Introduction

Innovation capability is considered a strategic differentiation factor and source of competitive advantage to several kinds of organizations, turning knowledge and ideas into new products, processes and systems, meeting market gaps (Prahalad & Hamel, 1990; Dosi, Nelson & Winter, 2000). In this context, the ability to innovate is a resource that provides a competitive advantage. Consequently, it also contributes to abetter performance, making companies innovative and able to overcome periods of crisis and uncertainty, or start new ventures (Saunila & Ukko, 2012).

In this context, innovation capability can be determined by a series of key indicators of input, process and output of innovation (Carayannis & Provance, 2008). Several authors have tested the effect of innovation capability construct on firm performance, as in the research by Lawson and Samson (2001), Saunila and Ukko (2012), Kafetzopoulos and Psomas (2015), Alves et al. (2017), Oliveira et al. (2019). However, none of these studies establish a clear relationship between the different innovation capabilities and the non-financial performance of the firm. This leads us to the following research question: what are the relationships established between the different dimensions of innovation capabilities and different dimensions of firm performance?

In recent research, Mendoza-Silva (2020) presents some of the research gaps. It is highlighted the lack of studies on the effect of dimensions of innovation capabilities on various aspects of business performance. In addition, it also expressesthe need to examine alternative measures of business performance, with multidimensional constructs that include productive, financial, market and innovation performance (Gunday et al., 2011). Based on this research gap, this paper aims to demonstrate the relationship between innovation capability and non financial firm performance.

To better understand the innovation capability of the firm, Zawislak et al. (2012) developed an innovation capability model that is divided into two major dimensions: the technological and the business. In this model, the innovation capability of firms is formed by four resources: technological development, operation, management and transaction. The first two are considered technological capabilities and the others are business capabilities. This model proves to be the most suitable for this research because it uses the four dimensions of innovation capability that are most used by different authors in the most diverse constructs to measure innovation capability.

Based on the model by Zawislak et al. (2012), Alves et al. (2017) suggest that operational capabilities do not influence performance. However, performance in this study was measured through the variables increase in profits, sales and market share, which are related to financial and marketing performance. No operational or internal process performance variables were used.

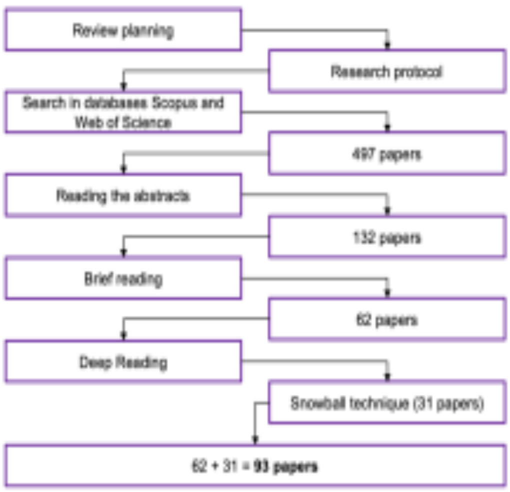
Most performance measures used as dependent variables about innovation capabilities emphasize the financial measures (Sher & Yang, 2005; Huang et al., 2009; Haryani & Gupta, 2017; Santos, Basso & Kumura, 2018). They are related to profitability, sales volume, and return on investment, among other measures that express monetary results. Non-financial measures are those that are not directly related to monetary values, such as market share, customer satisfaction, and productivity, among other indicators that are important performance measures.

To demonstrate non-financial firm performance, the Balanced Scorecard model, developed by Kaplan and Norton (1992) was used. This model presents four perspectives: financial, customers, internal processes and learning and growth. The choice of the Balanced Scorecard is justified because it is the management tool most used to measure non-financial organizational performance and the sixth most used management tool by companies in the world, according to research carried out by Rigby and Bilodeau (2011), which carried out a survey with more than 13,000 companies from 70 countries, in North America, Europe, Asia, Africa, the Middle East and Latin America.

Methodological Procedures

To find the state of the art on the theme "innovation capability and firm performance", a systematic literature review was carried out. The review was based on the procedures suggested by Tranfield, Denyer and Smart (2003), starting with the review planning, in which was identified the need for a review, prepared the proposal and developed a review protocol. The next step was the selection of studies, study quality assessment, data extraction and data synthesis. Finally, it was possible to proceed with a report, highlighting evidence of the selected papers. Figure demonstrates the steps of the literature review.

Figure 1 - Systematic literature review



Source: Developed by the authors (2022)

A search was performed in Web of Science and Scopus databases, using the terms “innovat* capabilit*” OR “innovat* capacit*” AND "firm performance" OR "business performance" OR "organization* performance", including title, abstract and author keywords of business, management and accounting fields, considering only “article” and “review”, until September 2022. As a result, 497 articles were found. At this stage, all abstracts were read and articles that did not deal with the relationship between innovation capabilities and performance were excluded. The exclusion criterion was the articles in which innovation capability was considered a dependent variable, that is, they sought to present influences of other factors in the ability to innovate. One hundred and thirty-two (132) articles were selected for a full reading.

At this stage, a brief reading was carried out, including the introduction, results and conclusion of the 105 articles, having excluded those that were not related to innovation capabilities and those that presented innovation performance measures (innovation as a dependent variable) and not of organizational performance, in addition to articles related to other areas of knowledge, such as engineering, technology, environment, among others. After this step, 62 articles were selected to be read in depth. In addition to the selected articles, 31 articles considered important for the theories studied were also used, many resulting from the snowball technique, which consists of reading articles based on authors cited in the articles selected in the literature review.

Theoretical Background

Innovation capability

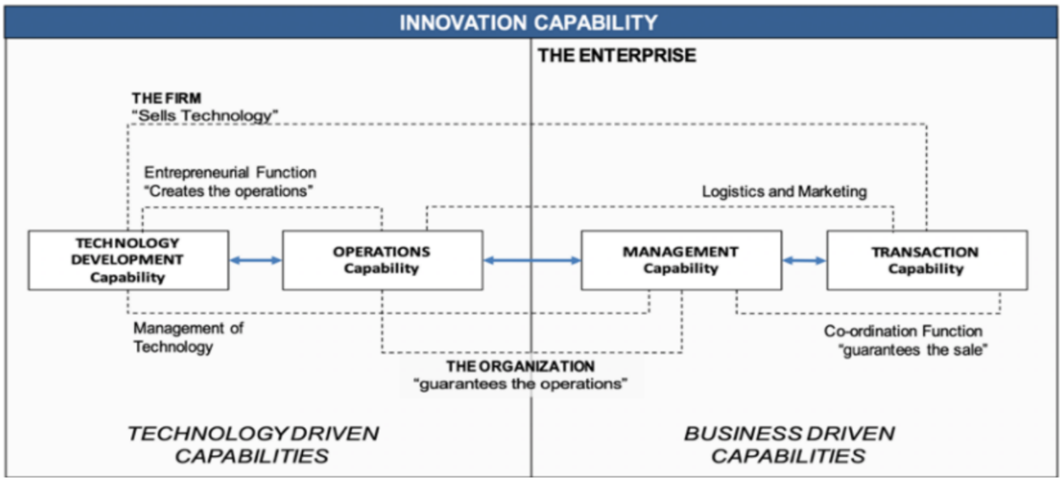
Considered a distinct field in studies on innovation, innovation capability has been gaining importance in studies that seek to measure the level of innovation of an organization. For Lawson and Samson (2001), the ability to innovate creates the potential for behaviors in all areas of the company, leading to systematic innovation activities within the company. Neely et al. (2001) defined ‘innovation capability’ as the potential of an organization to generate innovations with the implementation of all possible facilities available within the organization. Lall (1992), Bell and Pavitt (1995) and Helfat (1997), presented innovation capability based on technological resources, such as production resources and R&D activities. Despite the technological aspect being of great importance for innovation, these studies are limited to a broader understanding of innovation capabilities. Authors such as Figueiredo (2001), Bell and Figueiredo (2012) and Figueiredo (2014) have discussed innovative accumulation capabilities in latecomer firms. These studies shown the technological catch-up as an outcome of innovative accumulation capabilities in emerging countries context and also contribute to understand the firms’ innovation. However, the main focus is related to technological capability.

Lee et al. (2001) were concerned with the issue of financial resources, Guan and Ma (2003) sought to expand the understanding of innovation capability, proposing a model that includes learning, research and development, manufacturing, marketing, organization, resources and strategy. Yliherva (2004) demonstrated the importance of the ability to explore intangibles in such a way that it helps in the production of innovations. Lin (2007) added aspects such as creativity, risk, and agility to explain the ability of companies to innovate

Innovation capability is also shown through constructs with several variables by other authors such as Yang, Marlow and Lu (2009), Den Hertog et al. (2010), Hogan et al. (2011), Saunila and Ukko (2012), Rajapathirana and Hui (2018), Raghuvanshi, Ghosh and Agrawal (2019). All these constructs contribute in some way to classifying and measuring innovation capability. However, the greater the number of dimensions, the more specific the research becomes, being more difficult to apply in a greater number of companies. Thus, the four dimensional construct presented by Zawislak et al. (2012) represents the most balanced, as it considers the technological, operational, transactional and management capabilities. The model presented by Zawislak et al. (2012) was developed to be applied in industries, having been validated in several studies in this segment (Reichert et al., 2016; Alves et al., 2017; Ruffoni et al., 2018; Oliveira et al., 2019). This model is based on the dynamic capabilities (Teece, Pisano & Shuen, 1997) and presents a balance between the entrepreneurship of the evolutionary line of the theory of the firm and the coordination of the organization, aligned with the concepts of the theory of transaction costs (Coase, 1937; Schumpeter, 1942; Zawislak et al., 2012).

The innovation capability model proposed by Zawislak et al. (2012), which is shown in Figure 2, is divided into two major dimensions: the technological dimension, which is related to the vision of innovation, as a result of technological and operational development (Schumpeter, 1942); and the business dimension, which is related to innovation as a result of technological and operational development (Schumpeter, 1942) to the theory of transaction costs (Coase, 1937). This approach demonstrates that the combination of the views of Coase and Schumpeter helps to describe the nature of the company as an economic agent that promotes technological change and innovation. This happens in order not only to reduce costs but also to increase revenues by making it more efficient than the market (Zawislak et al., 2012).

Figure 2 - Innovation capability model



Source: Zawislak et al. (2012)

In this model, the technological dimension is composed of the technology development capability and the operational capability. Technological development capability is related to the ability that any company has, to interpret the current state of the art, absorb it and eventually transform a given technology to create or change its operating capability and any other capability to reach higher levels of technical-economic efficiency. (Zawislak et al. 2012).The technological development capability is the result of the learning process through which companies internalize new knowledge to produce technological changes and consequently, new processes and products (Zawislak et al. 2012), which must be translated into a specific operational capacity with processes and routines (Winter & Nelson,1982). Technological operation capability refers to the ability to perform a given productive capacity through the collection of daily routines that are embedded in knowledge, skills and technical systems at a given time (Zawislak et al. 2012). The objective is to make the products or services developed reach the market with quality and competitive prices (Alves et al., 2017). As an operation, the use of technology, quality control, maintenance, workflows, and inventories, among others can be considered (Zawislak et al. 2012).

Secondly, Management capability is part of the managerial capabilities group and can be described as the ability to transform the outcome of technology development into coherent operations and transaction agreements, coordinating assets and activities so that things get done right. (Alves et al., 2017; Zawislak et al. 2012). It must be flexible in terms of solving problem solving and require different skills (Langlois, 2003).

Lastly, Transaction capability is focused on commercial aspects and consists of the ability to reduce your marketing, outsourcing, negotiation, logistics and delivery costs and other factors related to transaction costs (Zawislak et al. 2012). This means finding the sources of assets and complementary channels needed to bring technological development to the market (Teece, 1986), using market information and looking for ways to reduce transaction costs (Coase, 1937; Williamson, 1979).

Firm performance

Organizational performance measures are used to monitor the vital signs of companies, providing information that can be used in different ways, such as determining the current situation of a company or controlling the expected results of previously defined actions (Hronec, 1994; Atkinson et al., 2015). Many theories that explain the development of the firm and those that refer to organizational strategy are related to the theory of organizational performance. Thus, some organizational theories considered classic provide reasons to measure performance, such as the agency theory (Jensen & Meckling, 1976), the stakeholder theory (Freeman, 1984) and the resource-based view (Wernerfelt, 1984).

The theories presented about organizational performance have different characteristics, but they can be considered complementary. Agency theory with a greater approach related to financial performance; stakeholder theory is more concerned with the performance from the point of view of shareholders, customers, and employees, among others; and the resource-based view, which places greater emphasis on measuring the performance of the company's internal resources.

The financial indicators, defined by Bomfim, Teixeira and Callado (2013) are fundamental for managers because with them it is possible to measure the company's processes, services and products, following the result of decisions made by the organization. Financial performance measures reflect the results of transactions that have already taken place, because of several other factors, but for the creation of future values, the company must be able to exploit intangible assets (Kaplan & Norton, 1997). To link intangible assets to tangible resources, intangible results must be linked to tangible results, being necessary the development of new metrics for the management of intangible assets to obtain tangible results through performance indicators (Carayannis, 2004).

Among the tools used to measure organizational performance, the Balanced Scorecard (BSC) stands out. BSC is a tool that seeks to translate the company's strategy into a coherent set of performance measures. This happens through financial measures of past performance with the vectors that drive future performance through non-financial means (Kaplan & Norton, 1992), being widely used by organizations.

Kaplan (2009) points out that the BSC can provide a performance measurement system that includes the emphasis on the financial performance of the agency theory, the concern with stakeholders presented in the stakeholder theory and the organization's internal resources, from the RBV. The key point is the creation of a more robust measurement and management system that includes operational metrics as leading indicators and financial metrics as lagging results, along with several other metrics to measure a company's progress in driving future performance (Kaplan, 2009).

In addition, the advantage of the BSC is that the transition from the strategic level to the process level, achieved through the process perspective, is very straightforward. Another positive aspect of this value chain is that the innovation process is at its beginning and includes the investigation of current and future customer needs, as well as the investigation and development of new ways to satisfy these needs (Zizlavsky, 2014). Kaplan and Norton (1992) state that business strategy can be translated into objectives and measures, organized into four perspectives that represent the organizational pillars (Figure 03): financial, customer, internal processes and learning and growth perspectives.

Figure 3 - The Balanced Scorecard

Source: Kaplan & Norton (1997)

From the financial perspective, performance measures indicate whether a company's strategy, implementation and execution are contributing to the improvement of financial results. Financial objectives are typically related to profitability and measured, for example, by operating income, return on capital employed, or economic value added (Kaplan & Norton, 1997; t et al., 2015).

The customer perspective typically includes several basic or generic measures of the success of a well-formulated and well-implemented strategy. Key outcome measures include customer satisfaction, customer retention, and account (customer) shares in the target segments. The vectors of essential results for customers are the critical factors for customers to change or remain loyal to their suppliers (Kaplan & Norton, 1997; Atkinson et al., 2015).

At last, from the perspective of internal processes, the critical internal processes in which the company must achieve excellence are identified. This allows the business unit to offer value propositions capable of attracting and retaining customers in target marketsegments and satisfying the expectations that the shareholders have excellent financial returns (Kaplan & Norton, 1997; Atkinson et al., 2015).

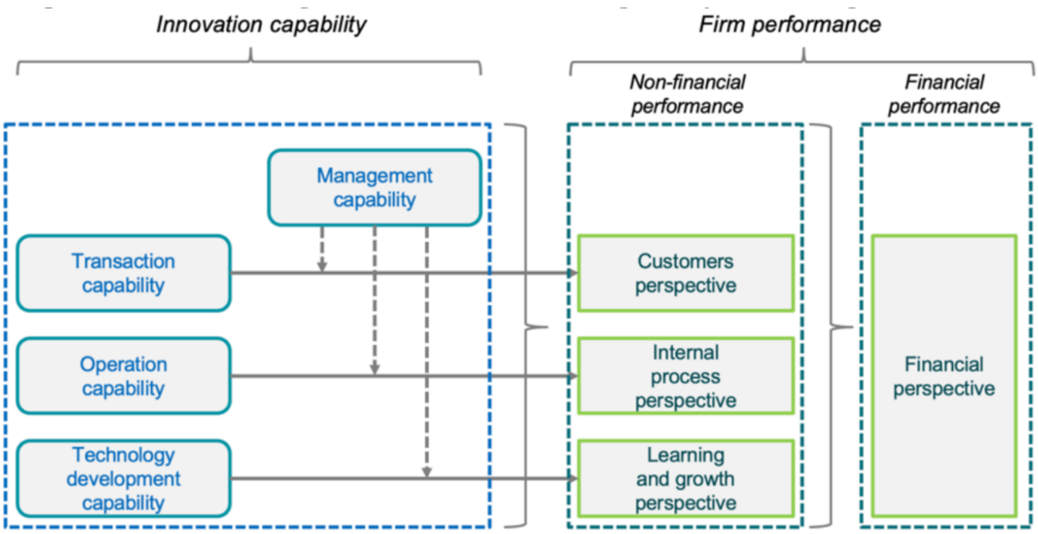
The learning and growth perspective identifies the infrastructure that the company must build to generate long-term growth and improvement. According to Atkinson et al. (2015), in this view, intangible assets such as human resources, information technology and organizational alignment are considered (Kaplan & Norton, 1997; Atkinson et al., 2015).

Results

The interest in measuring the organizational performance obtained by innovation capabilities has been growing every year, given the significant increase in the number of publications on this topic in recent times. Innovation capability is determined by a series of key indicators of input, process and output of innovation and should help to identify the triggers, drivers and obstacles of innovation and to manage innovation in companies (Carayannis & Provance, 2008).

In this sense, it is necessary to better understand the relationship between innovation capability and firm performance, considering the different dimensions of innovation capability and different dimensions of firm performance. Thus, in Figure 4, we presented a model based on Zawislak et al. (2012) discussion about innovation capability and firm performance, based on Balanced Scorecard (Kaplan & Norton, 1992).

Figure 4 - Relationship between innovation capability and firm performance.



Source: Developed by the authors (2022)

Based on the relationships demonstrated between innovation capabilities and non financial performance, where innovation capabilities present positive relationships in performance, it is possible to deduce that innovation capability, based on the model by Zawislak et. al (2012) leads to better non-financial performance. Thus, the following proposition is presented:

P1: The innovation capability has a positive impact on the non-financial firm's performance.

The use of balanced performance measures, considering financial, marketing, internal processes and learning and growth (innovation) indicators (Kaplan & Norton, 1992), makes it possible to accurately determine the impact of each type of innovation capability on the different organizational performance perspectives.

In studies on innovation, the capability for technological innovation is highlighted because it is related to technology, which is an area in which numerous innovations occur. Many studies have sought to relate technological development capability to performance, such as the work by Rhodes et al. (2008), Lopez-Cabrales, Pérez-Luño and Cabrera (2009), Fores and Camison (2011) and Hartono and Sheng (2016). Akroush and Awwad (2018) demonstrated that the improvement of new product development capabilities has a positive and significant effect on performance. Huang and Huang (2020) concluded that intellectual capital partially mediates the relationships between organizational capabilities and organizational performance. Through this model, this capability is measured by the ability to design their products, follow industry trends, use product management methods, technological adaptability, ability to prototype their products, and ability to launch their products.

Using the BSC perspectives (Kaplan & Norton, 1992) as a way of measuring performance, the learning and growth perspective identifies the infrastructure that the company must build to generate growth and improvement in the long term. According to Atkinson et al. (2015), in this point of view, intangible assets such as human resources, information technology and organizational alignment are considered. Some measures based on human resources include employee satisfaction, retention, training and skills. Other measures may be related to knowledge management and the improvement indices of critical, internal, or customer-oriented processes (Kaplan & Norton, 1997).

Research and development, as well as other technological development activities, are possible due to the company's intangible assets, such as knowledge, which can have their results measured by performance indicators that demonstrate the level of qualification of the team, and the number of patents, among others.

Considering the relationships demonstrated in previous studies involving technological development capabilities and performance related to human and innovation resources, there is a relation between technological innovation capability and performance indicators related to the learning perspective and growth. Considering that none of the previous studies demonstrated this idea using the innovation capabilities model by Zawislak et al. (2012), and the Balanced Scorecard as performance measures, the following proposition is presented:

P2: The technological development capability has a positive impact on the performance of the learning and growth perspective.

Technological operation capability refers to the ability to perform a given productive capacity through the collection of daily routines that are embedded in knowledge, skills and technical systems at a given time (Zawislak et al. 2012). The objective is to make the products or services developed reach the market with quality and competitive prices (Alves et al., 2017).

The measures commonly used for operation capabilities are related to the use of production planning and control procedures, statistical process controls, use of technology, quality control, maintenance, workflows, inventories, and deliveries of goods, among others (Zawislak et al. 2012; Alves et al., 2017). Operational processes have the function of guaranteeing the production and supply of products and services to customers.

In this sense, it is possible to relate operational capabilities with the perspective of internal processes, which uses measures related to the operation of each company and consequently the efficiency of these processes, such as the level of efficiency of production processes, quality indices, and punctuality in service, between others. Despite the various studies, previous research does not distinctly demonstrate that there is a cause-and-effect relationship between operational innovation capabilities, considering the model by Zawislak et al. (2012) and performance, based on the BSC's internal processes perspective. Given the importance of demonstrating the relationship between operating capability and the perspective of internal processes, the following proposition was developed:

P3: The operational capability has a positive impact on performance from the perspective of internal business processes.

Transactional capability is included in the dimension of business capabilities, which is based on the theory of transaction costs. Transaction costs are considered relevant factors for the competitive business environment, as it presents factors such as limited rationality, complexity, uncertainty, opportunism and asset specificity (Fiani, 2013).

Regarding performance in the customer perspective, is related to marketing aspects and typically includes several basic or generic measures of the success of a well-formulated and well-implemented strategy. Key outcome measures include customer satisfaction, customer retention, and account (customer) shares in the target segments. The vectors of essential results for customers are the critical factors for customers to change or remain loyal to their suppliers (Kaplan & Norton, 1997; Atkinson et al., 2015).

Customer-related aspects such as after-sales services can represent an advantage in business competition. The transactional capability for innovation, which is related to the market, can lead to better results in terms of performance related to this perspective. It is possible to notice that previous studies do not show a relationship between the transactional capability for innovation, based on the model by Zawislak et al. (2012) and performance based on the BSC customer perspective, which leads us to the following proposition:

P4: The transaction capability has a positive impact on performance from the perspective of customers.

Management capability is related to the implementation of new or improved management methods and practices in the organization of work and the internal and external relations of companies (OCDE, 2005).

Several studies demonstrate the moderating effect of the capacity for innovation, as in the research by Yang (2012), Henao-García and Montoya (2021), Zimmermann and Ferreira (2020) and Tuominen and Anttila (2006). In other studies, Camisón and Vilar-Lopes (2014) demonstrated that organizational innovation favors the development of technological innovation capabilities. In addition, it shows that both organizational innovation and the technological capabilities of products and processes can lead to superior company performance. Lawson and Samson (2001) emphasize that for innovation to occur effectively, there must be a link between the technology strategy and the business strategy, which is provided by management capability.

Zawislak et al. (2012) describe the capability for managerial innovation as the ability to transform the result of technology development into coherent operations and transaction agreements. That is, this capability aims to make the other capabilities present better results. In this sense, Barney and Clark (2007) present an adjustment in the theory of the resource-based view when considering the organization as a fundamental factor for a company to have a sustainable competitive advantage, considering that it is not enough to have valuable resources or capabilities, which are rare and costly to imitate. There must be efficient management, to obtain the maximum advantage with such resources and capabilities.

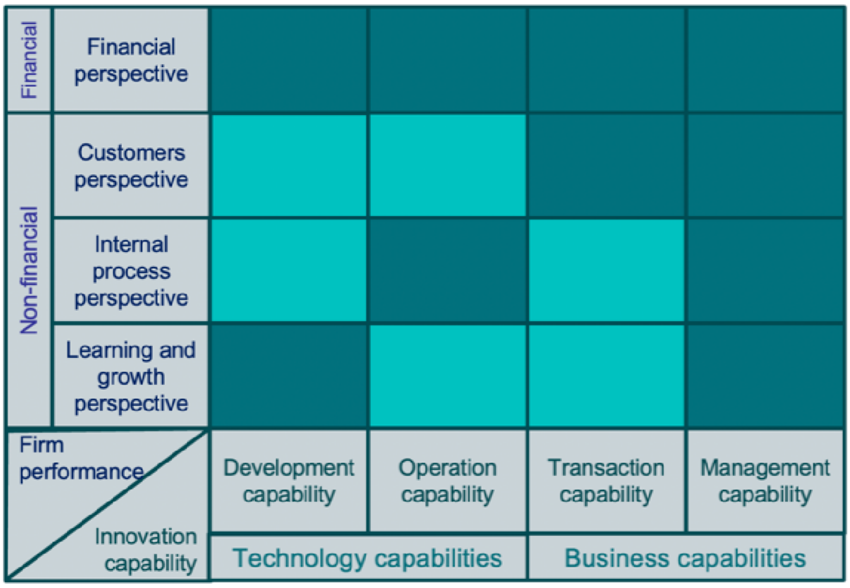
Management capability is, therefore, a determining factor to boost the business performance of other innovation capabilities (Technological, operational and transactional development). Thus, this capability can be understood as a moderating force, which will exert influence (positive or negative) on other variables (innovation capabilities). This means that a good level of management capability can improve levels of technological, operational and transactional development capabilities. Based on the above, the following proposition is presented:

P5: Management capability has a moderating effect on the relationship between innovation capabilities and different types of firm performance.

Relate each dimension of innovation capabilities, based on the model by Zawislak et al. (2012) with each of the performance perspectives, based on the BSC (Kaplan & Norton, 1992), contributes significantly to filling the gap in the theory of innovation capabilities, about the effect of different innovation capabilities on different dimensions of organizational performance, demonstrating that it is possible to improve organizational performance through actions to improve innovation capabilities.

Figure 5 demonstrates the relationship between innovation capabilities and performance perspectives. A relevant factor is that the different innovation capabilities can also influence the other performance perspectives. However, the greatest influence is related to a specific perspective, as it has similar characteristics. The darker boxes represent the relationships that present greater intensity.

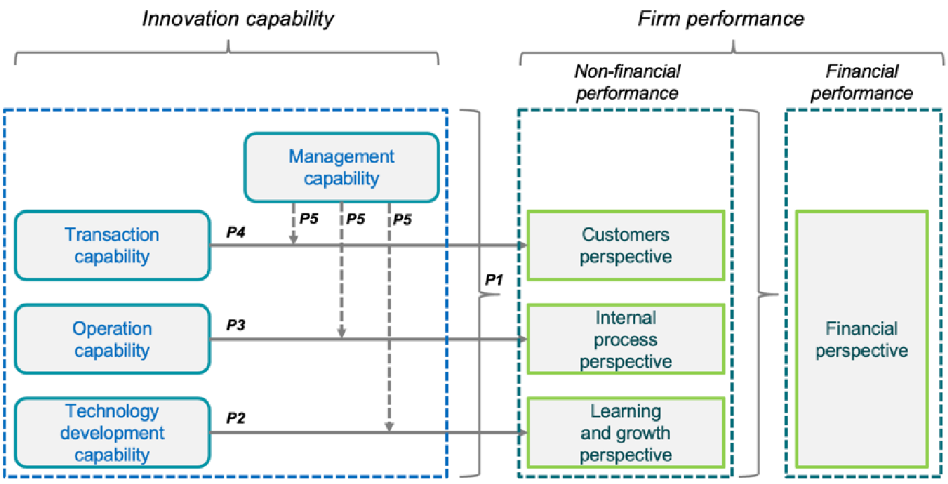
Figure 5 - Relationship between innovation capabilities and performance perspectives



Source: Developed by the authors (2022)

Figure 6 demonstrates the relationship proposed in this project between the dimensions of innovation capabilities and the dimensions of performance. The model was developed by Zawislak et al. (2012) to measure innovation capabilities. To measure organizational performance, the BSC perspectives were used, according to the model proposed by Kaplan and Norton (1992).

Figure 6 - Framework of the relationship between innovation capability and firm performance.



Source: Developed by the authors (2022)

Final remarks

This paper aimed to demonstrate the relationship between innovation capability and non-financial firm performance. To achieve this objective, we developed a model that combines innovation capability and firm performance, which is based on the model by Zawislak et al. (2012) on innovation capabilities and the perspectives of the BSC (Kaplan & Norton, 1992) to measure performance.

The developed model contributes to a better understanding of the relationship between innovation capability and firm performance, and demonstrates in a more specific and direct way, how each innovation capability leads to superior firm performance, providing a strategic view of innovation capability. This idea represents a breakthrough in innovation capability theory. Another important contribution is the use of management capability as a moderating variable between other innovation capabilities and non-financial firm performance perspectives, which brings a new dynamic to the construct of innovation capabilities proposed by Zawislak et al. (2012).

After the validation of the model, it is expected that it will be used to help managers of organizations that seek to develop innovation capabilities and obtain better organizational performance, as it will become an easy-to-implement performance measurement tool of great strategic importance to leverage the competitiveness and results of innovative companies. This is a theoretical paper, based on a literature review and the lack of empirical tests of the proposed model is a limitation of this study. For future studies, we suggest that the model can be used in quantitative researches.

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Measuring ecosystems' innovation capabilities with the innovation potential of individuals: A systematic review of multidimensional construct

Abstract ID#266

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Purpose

Innovations are intrinsically driven by individuals. Collective innovation between individuals across various teams, organizations and innovation ecosystems convey additional uncertainty and complexity to measure innovation capabilities. How measuring the innovation capabilities of ecosystems with the Innovation Potential of Individuals (IPI)? As innovation capabilities transform the innovation potential of upstream resources into the result of downstream innovation potential, understanding the IPI construct supports the creation of new indicators to better adapting to collective innovation approaches. This systematic review identifies IPI construct's multidimensions and presents a research agenda to measure ecosystems' innovation capabilities.

Literature Review

An innovation ecosystem is defined as a collaborative network between firms and individuals who share resources and interact to mobilize and converge the group's innovation capabilities. The complexity of measuring innovation capabilities value generation is related to structural, human, social, and relational attributes. As an ecosystem is a set of collaborating actors and represents natural interactions between actors of a system and its environment its composition and social structure influence intensity of collaboration, connectivity, co-evolution complementarity or interdependence between individuals. The innovative potential of individuals is a relatively emerging concept; it has been studied more thoroughly in very recent literature, but its origins date back to the 1960s from underlying concepts: human capital, innovation capabilities, and innovative human capital. IPI represents the level of readiness for carrying out efficient tasks to achieve the targeted innovation objectives. According to existing definitions, the IPI is a set of characteristics that align with a firm's innovation strategy, an opportunity, a skill, a systematic use of resources and a capacity. These studies assess the innovative potential rather at the organizational and systemic level. None of the studies analyzed is specifically related to the individual level. The dimensions identified are thus more economic and strategic. Notwithstanding these contributions, we lack comprehensive understanding of IPI.

Methodological Procedures

Based on an inductive approach using grounded theory technique and a systematic review of 353 academic articles from Proquest databases, this study presents the development of the IPI construct. The natural language processing technique is used to analyze the corpus content with morphosyntactic analyses, multivariate analysis/vectorization, term frequencies, concordances, co-occurrences, clustering, and specificities. Findings: An analysis of co-occurrences emphasizes the presence of combinations of terms: organization and change, market and study, relationship and supplier, technology, and research as well as development and activity. These term combinations seem less obvious in the corpus of 353 documents because the 13 terms with the most co-occurrences have equivalent relationships. Using information retrieval with a return to text and a Boolean matrix, we find that the term combinations are still present, except for relationship and supplier, which are both found in only 296 out of 353 documents.

When selecting a central terms – innovativeness and innovator – the co-occurrence network illustrates a strong relationship between 8 dimensions. The analysis indicates innovativeness as a central term but it rather indicates manager as a central term instead of innovator. The two networks demonstrate that team is the weakest dimension linked to the central term. Is the innovative potential therefore more linked to the individual, the organization and the ecosystem? The corpus has been segmented into 8 clusters which are segmented with a very unequal number of documents per cluster from 5 to 136. Cluster 4 attracts attention with 136 articles; the cloud of words most positively correlated to cluster 4 represents as example: network, ecosystem, team, and alliance. Additionally, as cluster 1 represents more meaning with the specificity of this cluster, we notice the most positively correlated terms to cluster 1: knowledge, capability, ambidexterity, absorptive, and dynamic. This reflects a strong link with the literature on dynamic capabilities and innovation ecosystems. These clusters demonstrate that the innovative potential at the individual level is weak in the literature. However, the articles in cluster 7 contain interesting keywords to understand the innovative potential specifically linked to human capital, such as skilled, workforce, human, and labor.

The innovative potential as a construct is diluted in different fields of literature, such as dynamic capacities, innovativeness, collective innovation and innovation ecosystems. Each computer-assisted text analysis method yielded a set of keywords and each keyword was categorized. This categorization presents a pattern of 6 dimensions: process, innovator, approach, results, resources, condition/context.

Implications

It is recognized that the human factor is under-represented in innovation measurement indicators. In practice, many challenges arise in managing and measuring individual, collective, organizational or ecosystem innovation capabilities. New approaches must be used to identify, capture, mobilize, and enhance innovation capabilities. Measuring and managing the value of innovative human capital, in other words the IPI, remains a challenge. Despite all the importance given to innovation capabilities, the IPI is little explored in the literature (Patterson & Zibarras, 2017), more particularly dimensions and factors that influence the potential as well as the indicators for measuring these determinants. It's considered that the determinants are not fully explored and there is no consensus on the determinants (Mendoza-Silva, 2020). It's recommended to advance research on measuring innovation capabilities on ecosystem level to close the existing gap. Further research is needed to advance on measuring innovation capabilities on ecosystem level. By discussing dimensions of the IPI construct, this paper proposes a research agenda on IPI as key measurement for ecosystem's innovation capabilities.

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Smart Innovation Capabilities: New business models and innovation
Abstract ID#104

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This paper aims to deepen the concept of smart innovation capabilities, by depicting the process of building the capabilities needed to establish itself in the new smart paradigm and thus make a company smarter.

We are experiencing a technology, socio-economic and behavioral revolution, motivated mainly by the digital transformation that has taken place in recent years. A series of smarter solutions ("smartization") started to be adopted, enabling efficiency gains and new ways of adding value. With this change, it can be said that the smart paradigm is established.

However, there is a gap in the literature when delving into the term "smart". One may can cite a more "technical" view, linked to technologies and devices, mainly related to the manufacturing industry; other, more "conjunctural" in nature, such as those available in reports carried out by global consultants; or even those that take ownership of the term as an adjective (e.g., smart cities, smart tourism). Few, however, define the concept of "smart" as to innovation capabilities.

Obviously, "smart" is linked to digital technology and, above all, to new functionalities, through their interconnection, synchronization and combined use of different technologies, previously "impossible" without the ability to process data and transformation into new actions (Hojer & Wangel, 2015). In this paper, by turn, we go beyond these definitions. It's not just an adjective in itself or about "digital" technological innovations. Smart will be considered a noun that concerns intensive and integrated use of knowledge for the ever more efficient use of resources in generating new products, processes or business models. In practice, what is targeted is the formation of these new business models – called "smart business" – that are leading to a convergence by breaking down the barriers between the different sectors of economic activities – industry, agribusiness and services. In the midst of this change, it is the innovative behavior of agents that changes profoundly.

By dealing with the digital revolution and new business models, this paper seeks alternatives for the process of building innovation capabilities towards the on-going technological and business revolution. In a simple view, innovation capabilities relate to the four dimensions of all companies: product (development capability and the respectively relationship with the innovation ecosystem), process (operations capability and the coordination of production), efficient coordination of resources (management capability and the building of a business model for better resource allocation) and coordination of commercial relations (transaction capability) (Zawislak et al., 2012).

This model advances in some ways. In addition to simplifying the firm's vision, adopting a Schumpeterian approach to innovation, allows one to have a relative look at the purely technological capabilities (product and process), as well as non-technological (business, organizational, relational — with knowledge system and market). With the validation (i.e., Alves et al., 2017) of Zawislak et al. (2012) innovation capabilities' model, a new spectrum of applications has become possible. From manufacturing to agribusiness until the service economy, its fitness seems to move on.

Now, the interconnection seems clear. The basic pillars of smartness – digital transformation; relational nature of economic activities; and the need for continuous development and innovation - serve as a starting point match. Knowledge and technologies whose application potential will be expanded by collaborative (internally and externally) physically and digitally to generate skills and routines that can have innovative performance in product development, operation of processes, management of business models and market transactions. At this point, the dynamic capabilities

(Teece, Pisano & Shuen, 1997) serve as support. The dynamic capabilities are underpinned by the skills needed to sense, seize and transform available resources – be they human, physical, informational or natural – in innovation. They are the ones that allow companies to adapt, reconvert and transform technologies into new businesses over time, dynamically.

The relational character of capabilities needs to be considered. The increase in the patterns of internal interaction (between capabilities) and external (with other ecosystem actors) can (mainly via digital capabilities) and should (for ensure the adaptation and learning process necessary to deal with a scenario increasing complexity) be considered.

The innovation capabilities - micro-foundations of innovation for companies -, have to be adapted in order to be more suited to the dynamics of change and business. In a smart context, it is possible to witness the emergence of innovation capabilities specifically related to this paradigm, what we will call smart innovation capabilities.

The smart Innovation capabilities are being understood as the set of dynamic innovation capabilities (knowledge, technology, resources, routines) of a firm that, integrated in a collaborative way (with each other and with other agents) and intelligently (through digitalization and relations), generate/work at higher standards of learning, creativity, rationality, efficiency, productivity, quality, agility, flexibility, diversity and, therefore, innovative and competitive.

Understanding this phenomenon is important in an emerging country such as Brazil. The digital revolution may open a window of opportunities for the country's competitive reconversion. Whether because of the revolution itself or because of the inherent need to remain competitive. Activities based on production chains, service systems, retail, logistics and ecosystems tend to be more affected yet. By dealing with the digital revolution, new business models, and smart innovation capabilities, this paper seeks alternatives for the process of building innovation capabilities, as well as for guidelines for policy making.

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How the adoption of artificial intelligence technologies affects the innovation capabilities of firms

Abstract ID#158

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Purpose

There is a clear interest of businesses worldwide to adopt artificial intelligence (AI) technologies aiming to achieve higher levels of productivity and to create novelty. However, effectively applying AI to develop new products, services or processes is particularly complex and involves new approaches to innovation. The firm's innovation capabilities, therefore, has to be adapted to adequately integrate AI. This way, departing from an evolutionary theory perspective, the objective of this study is to identify empirical evidence of how AI adoption affects the innovation capabilities of firms.

Literature Review

Despite the sector and the technology in question, the analysis of technical change is at heart of the Evolutionary Theory and expresses how a firm changes its production function (Nelson & Winter, 1982). As the literature identifies, in the tradition of evolutionary economics, much research has focused on how existing technological capabilities codified in the routines of a firm inhibits or enables its ability to adapt to environmental changes (Tripsas & Gavetti, 2000). Also, changes in technology often go hand in hand with the birth of or changes in organizational capabilities (Helfat, 2000). This process involves productivity gains through economies of scale and scope that in essence represent new products or markets, superior labor and capital productivity, or even cost advantages. In this sense, technological change support firms in their adaptations to new consumers demand, competition, institutional changes, and so on.

In addition, the development of new or improved products, services or organizational processes has been traditionally viewed as based on the application of human skills. However, the adoption of artificial intelligence technologies by companies has changed this scenario. That is why many researchers indicate that AI actually changes the way innovation management should be organized in companies (Cockburn, Henderson, & Stern, 2018; Hutchinson, 2020; Haefner et al., 2021), that is, the way AI technologies modify the innovation capabilities of these companies. Lou and Wu (2021), for example, indicate that AI resources should be managed and used in areas where tasks mostly depend on automated data processing and reasoning and that problem solving involves navigating a large space of search. In addition, other studies have shown that this type of technology is able to move from manufacturing automation to even influence the design of products and services (Verganti et al., 2020). In this sense, Mariani et al. (2022) indicate that the intersection field of study between AI applications and innovation research is still fragmented and mainly exploratory in nature, which confirms the necessity of a systematic evaluation of empirical research.

Methodological Procedures

The study will cover a systematic literature review whose investigation protocol will follow the guidance of Moher et al. (2015) (PRISMA), but also the methodology of Tranfield, Denyer and Smart (2003), which is especially dedicated to management studies. For this study, data will be retrieved from widely used academic databases (in particular Scopus and Web of Science), but also from databases specifically related to applied research and technological development, such as IEEE Xplore, ACM Digital Library and the AIS eLibrary. The data analysis strategy will be a meta-analysis. As indicated by Wolf (1986), the procedures used in the meta-analysis allow for quantitative reviews and syntheses of the research literature that addresses a particular phenomenon. The analysis will only cover empirical articles whose data derives from any sector of the economy.

Findings

Expected results are to obtain detailed firm-level empirical data about how firms integrate AI technologies into their innovation capabilities. Evidence from such phenomenon may be recognized through how a firm organizes its resources or mobilize external actors in the development of AI-based innovations.

Implications

This study contributes to extend evolutionary economic theory in order to understand the organizational phenomenon of technological change brought about by AI. The study proposes to outline ways in which companies change their innovation capabilities to integrate such kind of emerging technology. For that reason, this study may be relevant for either managers in private organizations or public policy makers. In the case of managers, the study makes it possible to understand how to organize resources, processes, organizational structure, and people in order to develop innovations using AI. Likewise, understanding the microeconomics factors influencing the adoption of AI to generate innovations allows policy makers to design measures that encourage professional training and the development of capabilities in companies to produce products with greater added value.

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INNOVATION EVALUATION AND IMPACT II

May 2nd: 10h30 am – 12h30 pm

Chair

Zandra Balbinot (University of Quebec, Canada)

Papers

Innovation responsiveness perception of fab labs' managers and users

Marcos Medina-Tabares, Ferney Osorio, Giovanny Arbelaez, Maria Elisa Balen Urrutia, Fedoua Kasmi, Vincent Boly, Mauricio Camargo

Model for the evaluation of innovation spaces in universities

Lorena Delgado, Ferney Osorio, Alaa Hassan, Laure Morel, Pedro Palominos

The B2B sharing economy ecosystem: Co-creating shared value for business and society

Kelvin Wade Ivankovic

The influence of citizen participation in the definition of public innovation policies

Zandra Balbinot, Luiz Marcio Spinosa

Scientific Mapping on the economic, policy and societal impact of research

Evandro Coggo Cristofoletti, Yohanna Juk, Karen Esteves Fernandes Pinto, Emily Campgnolli, Gabriela Tetzner, Vanessa de Lima Avanci

Innovation responsiveness perception of fab labs' managers and users

Abstract ID#319

Marcos Medina-Tabares, Maria Elisa Balen Urrutia (National University of Colombia),
Ferney Osorio, Fedoua Kasmi, Vincent Boly (University of Lorraine) Mauricio Camargo,
Giovanny Arbelaez (University of Strasbourg)

Purpose

The development of Fab Labs has become a major trend in the field of innovation. These innovation spaces provide open access to technologies for producing objects from the initial idea to final production (Fleischmann et al., 2016)). One characteristic is the open and free sharing of knowledge. This concerns students, professors, a large variety of professionals involved in design processes, makers and the general public. The functioning of Fab Labs is founded on community-based digital fabrication workshops that transform design, innovation, production and consumption practices, while describing positive environmental impacts and social goals (Crumpton, 2015; Kohtala, 2017; Kallio-Tavin, 2018; Kasmi et al. 2022). Some Fab Labs are local open spaces while others are managed by companies for their own needs.

Considering this broad range of social and technological impacts, it seems important to study if the dynamic generated by Fab Labs is ethically acceptable and socially desirable.

Then, the problematic of this research is focusing on the personal and collective perception of the managers and users of Fab Lab about their responsibility on their territory and more generally the society. More precisely, the attention is directed toward the correlation between the functioning modes of the people involved in Fab Lab day-to-day operations and their awareness about responsiveness. One final objective is to propose a management stimulating this awareness.

Literature Review

The concept of responsible research and innovation (RRI) is used as a referential of the concept of responsiveness. RRI is defined "a transparent and interactive process by which societal actors and innovators become mutually receptive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a good integration of scientific and technological progress in our society)" (Von Schomberg, 2013). In its publication the EC ((European Union & European Commission. Directorate General for Research and Innovation., 2015)) suggests that RRI highlights six domains: gender equality, public engagement, science education, ethics, open access and governance.

Methodological Procedures

This paper detailed an anthropological approach in a French Fab Lab aiming at a description of the perception of managers and users about the principles of RRI. A three-month integration of a researcher has been conducted. The research approach was based on observations, participation to Fab Lab meetings and also the organization of specific workshops where participants were asked to produce elements (texts, pictures among others) representing their profile toward RRI. All the outcomes were analyzed using criteria relating to the six main domains of RRI by authors and through reflexive meeting with the managers and users themselves.

Findings

Differences between the awareness levels associated to the six domains were observed. Moreover, it was concluded that if some aspects of responsiveness were managed the global concept of RRI remains fuzzy. The environmental dimension was mentioned as to be added in the scope of Fab Lab responsiveness.

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Model for the evaluation of innovation spaces in universities

Abstract ID#239

Lorena Delgado, Pedro Palominos (University of Santiago, Chile) Ferney Osorio, Alaa Hassan (University of Lorraine, France)

Context

In the academic-industrial context, innovation spaces (IS) are positioned as an important actor to the university key activities, such as: the generation of links with industry; the development of projects with an impact on the territory; research and technology transfer; etc. Although innovation spaces in universities (ISU) fulfill the function of supporting teaching processes, they should be projected as a "company" within the university, motivating the development of projects. Therefore, the ISU must develop the capability to establish a management strategy appropriate to its context, make technological and human capital investments in an agile way and establish guidelines to the self-sustainable over time. Research question and objective: Our main hypothesis is that the strategic and multidimensional development of an innovation space positively influences the strengthening of the university's missions. The research question is: How to define an evaluation method that supports the management of an innovation space based on university missions? The objective is to propose a diagnostic tool to assess the maturity of an ISU, providing information that is relevant to the management and decision making of the space.

Literature review

In the last decade, different researches have demonstrated the importance of ISU in the development of projects with social, territorial and economic impact (Gey et al., 2013; Lewis & Moultrie, 2005). Universities, in their role as development managers, have bet on the construction of this type of spaces seeking to support not only learning and research activities, but also, the generation of relationships with the industrial and public sector (Lange, 2016). However, in the literature the thematic of "innovation spaces in universities" has a low level of development, specially to validate the structure, dynamics and processes of this type of spaces. There are no standardized models that objectively support the management of these spaces. To address this limitation, a literature review is proposed to identify the characteristics and factors of IS (Osorio, 2021). Subsequently, the definitions of university missions (UNESCO, 2010) will be analyzed to identify complementary factors to those defined for IS. The purpose of this analysis is to validate the existence of a common area between the definitions of innovation spaces and university missions in order to establish a theoretical framework that characterizes ISU. Finally, the definitions of the "maturity grid" (Grant & Pennypacker, 2006) are analyzed in order to develop an evaluation tool that allows moving from the definition of a theoretical model to an evaluation model of ISU. Methodological procedure: For this study, a systematic review of the literature was carried out, defining a conceptual framework that integrates the characterization of the IS and the characterization of the university's missions (best practices). Subsequently, an evaluation tool based on the maturity grid is established. The construction of this tool will be done through an iteration process, composed of three stages: 1) Definition of the evaluation question for each practice; 2) Definition of the maturity levels described as observable phenomena; 3) Validation with experts.

Conclusions

The literature review presents a real gap when seeking to define the influence of universities on the design and operation of IS. Our hypothesis is based on proposing a literature review of innovation spaces and university missions to validate the existence of a zone of intersection between these two organizations. The result will be a conceptual model based on dimensions defining the structure of an ISU. The validation of this model will be done through interviews with experts from 5 Chilean universities. Thus, the discussion is focused on validating the relevance of the proposed dimensions and the clarity in the definition of the concepts that represent the activities of the IS. The experts agree that the model presented is a tool that provides a multidimensional view of the space and helps to standardize decision making (currently decision making is more intuitive or based on experience). Implications of the research and limitations: The implications of the research are that the model helps decision making and space management, adapted to the context of the university, in terms of supporting its missions. The result will be important input for ISU design and management. The limitations are related to validation. The proposed model and tool correspond to a first approximation to the ISU, a field little explored so far. It is therefore necessary to broaden the range of experts and spaces studied to obtain validation in different contexts. Initial perspectives aim to strengthen the model by analyzing contextual variables (geographical, political, economic, etc.) to validate the influence that the environment has on ISUs. Iteration of the tool on a larger number of ISUs would favor the calibration the maturity grid evaluation.

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The B2B sharing economy ecosystem: Co-creating shared value for business and society

Abstract ID#202

Kelvin Wade Ivankovic (The Western Norway University of Applied Sciences)

Purpose

The sharing economy (SE) has become an increasingly important addition to the modern economy and society; however, thus far, researchers have focused on peer-to-peer (P2P) sharing (Geissinger, Laurell & Sandström, 2020). There is an abundance of research on the SE from a consumer (P2P) perspective, however, there is a significant gap in the literature regarding sharing between businesses.

Laamanen, Pfeffer, Rong and Van de Ven (2018) posit that the SE may have implications for several management theories and practices as it represents a radical shift in how business is organized. Due to the growing significance of the SE, established firms are under pressure to consider how to incorporate the principles of the SE into their business operations. The SE model has the potential to lead to a reorientation of businesses towards a new way of thinking and behavior, in which access to resources is more important than ownership. Business-to-business (B2B) sharing can enable market transactions that are more environmentally, socially, and economically sustainable (Grondys, 2019). However, it is still unclear how the collaborative utilization of resources via the SE may contribute to value creation and distribution, and societal impact.

Recent developments in the SE have heightened the need to understand how businesses interact in this space. However, research on the B2B SE is still in its infancy, and key issues remain unresolved. The overarching objective of this research is to explore the emergence of new types of B2B SE ecosystems. This paper aims to address the following research question: What can we learn about the relationships, challenges and outcomes associated with B2B resource sharing from an ecosystem perspective?

Literature Review

The SE is defined by Laamanen et al., (2018) as a socioeconomic ecosystem that connects different stakeholders to share or access goods and services. The SE can be analyzed as an ecosystem, as it involves several interrelated interest groups that co–exist and interact in a dynamic environment. The B2B SE ecosystem consists of a network of consumers, partners, service providers, competitors, public authorities, and the community. According to Halvorsen, Lutz and Barstad (2021), "investigating the SE from a multi-stakeholder and ecosystem perspective that considers the role of providers, consumers, platforms, regulators, and third parties would enhance our knowledge of the phenomenon."

According to Porter and Kramer (2011) the next transformation of business thinking lies in the principle of shared value. The SE is related to shared-value creation as it enables businesses to create economic value whilst simultaneously creating value for society (Porter & Kramer, 2011). The SE enables the sharing of excess capacity in goods and services available in the ecosystem via a network of actors to create value for numerous stakeholders (Frenken & Schor, 2017). This paper aims to shed light on the dynamics and roles of the multiple actors in the SE ecosystem in co-creating shared value for business and society.

Methodological Procedures

This study followed Yin's approach to case study methodology as an overall research design with an emphasis on qualitative methods. An embedded case study design was used to examine the relationships, challenges and outcomes associated with the B2B SE model from an ecosystem perspective.

A combination of observation, interviews, and document review was used to gather data. 11 interviews were conducted with service providers, platforms, partners, public authorities, competitors, and key informants associated with the B2B SE centre in Bergen, Norway. The interview recordings were transcribed, and thematic analysis was conducted using NVivo 12.

Findings

This research uncovered several interesting findings regarding the complexities and interactions between the actors associated with the B2B SE ecosystem. The research findings demonstrate how B2B SE facilitators act as orchestrators bringing different actors together; promoting collaboration and attempting to address gaps in the existing innovation ecosystem. The B2B SE facilitator acts as a catalyst to enhance relationships between businesses and other stakeholders. Facilitating the collaboration between these actors has the potential to enable value cocreation amongst the stakeholders within the SE ecosystem network.

Although there are many similarities between the P2P and B2B SE, sharing transactions in a B2B context are potentially more difficult to facilitate due to the increased complexity associated with managing B2B relationships. It is essential to ensure that there is alignment between the SE ecosystem actors to facilitate the co-creation of shared value for the businesses and society. Misalignment between ecosystem actors may result in the emergence of negative outcomes due to conflicting interests, regulatory issues etc., such has been the case in many of the P2P SE ecosystems.

Implications

The conceptual framework and research findings presented in this paper add richness to this emerging research stream by shedding light on the dynamics and complexities of the B2B SE from an ecosystem perspective.

The scientific relevance of this research stems from the contributions that are made to the nascent and growing body of knowledge on the SE, whilst broadening the discussion to include a B2B ecosystem perspective.

This study also aims to provide practical insight for companies either currently or seeking to participate in the B2B SE, as well as for SE facilitators, policymakers, and regulators.

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The influence of citizen participation in the definition of public innovation policies

Abstract ID#349

Zandra Balbinot (University of Quebec in Montreal), Luiz Marcio Spinosa (Araucária Foundation)

Purpose and literature review

The application of innovation requires its integration into the society. Society can and must contribute to creating, accepting, and inserting innovation into the economic environment (Freeman, 1995). The discussion has been made by decades. The governmental policies to improve economic development based on the collaboration of three pillars of the society – university-industry-government – started in the end of the 90's (Leidesdorff & Etzkowitz, 1998; Etzkowitz, H., & Leydesdorff, L. (2000; Etzkowitz, 2002), and still have not generated all the expected results. The traditional model is not enough to produce answers to integrate into citizens' realities the innovation created at the universities, applied by the industry, and sponsored by the governments.

More recently, the integration of a fourth helix brought the citizen participation into the process (Carayannis & Campbell, 2010). One essential element to innovate since they are the final users of the whole development. Despite the model, lots of questions about its operationalization remain. This paper discusses the influence of the users/citizens into the innovative process by showing two different approaches used by two governments – Quebec and Parana – to integrate citizens in the public policy definition. In this sense, our research question is how the citizen participation influences the definition of public policies for S&T&I ecosystems. Our main concern is the activation, integration and application of the innovation produced by these ecosystems.

Methodology

We present in this article the results of two different governmental approaches in terms of quadruple helix and the citizens' participation. Two countries, two states and a different way to integrate the citizens into the innovative process and the public policy definition.

We decided to use exploratory research since we need to understand better how this participation works. First, a symposium was organized. Its goal was to help us understand the dynamics of each S&T&I ecosystem and how the citizen participation was developed. Both government representatives and specialists discussed during a few hours the way they see this participation. Social entrepreneurs were asked to describe how they proposed innovations with the citizens' participation. This first discussion gave us several elements to describe two models employed by each state.

Findings

The state of Parana, in Brazil, is shaping their new S&T&I public policy using prospective methodology and collective intelligence. According to them, this approach can be called as middle-bottom-up. They do a first screening of the innovative needs and confirm their findings with the participation of the population through forums of discussion and other participative elements.

In the case of the province of Quebec, in Canada, the local community counts on social entrepreneurs. These persons are normally embedded in small local communities and know better the micro-needs. They propose new products/services based on these needs and doing so help in the decision of the resources budget allocation. We called this approach as a direct bottom-up.

Implications

According to our exploratory study, citizens' participation in the definition of the S&T&I policies shows several advantages. First, it generates more ideas to solve day-to-day problems. Second, there's finally a sense to the innovation because it's based on real population needs. Third, it becomes easier to apply the innovation since it increases people's acceptability of the new. It is a more democratic and optimal way to share and allocate public resources.

Finally, it presents a more transparent form to share the decision-making power. The next step is to interview local entrepreneurs that orchestrated new business with the citizens' participation to understand better the mechanisms these governments are applying.

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Scientific mapping on the economic, policy and societal impact of research

Abstract ID#360

Evandro Coggo Cristofoletti, Yohanna Juk, Karen Esteves Fernandes Pinto, Emily Campgnolli, Gabriela Tetzner, Vanessa de Lima Avanci (University of Campinas)

Purpose

The study aims to show an overview of the economic, policy and societal impact of scientific research from 2015 to 2022 through the elaboration of a scientific mapping, as well as critically discussing it. The scientific mapping considers four main areas: a) thematic evolution, b) methodological approach, c) performance based on traditional bibliometric indicators; and d) performance based on new bibliometric indicators (Equity Diversity and InclusionI). It is important to note that this study is part of a larger project to investigate and develop research impact indicators for several initiatives carried out by the São Paulo Research Foundation (a.k.a. Fapesp) in Brazil.

Literature Review

Over the past years, research funding agencies have demanded studies on the impact of the research financially supported by them to verify how the creation of knowledge relates to improvements in economic, social, and policy-related areas (Aiello et al., 2021; Sandes-Guimarães, Velho & Plonski, 2022; Milat, Bauman & Redman, 2015). More importantly, research funding agencies are concerned about demonstrating the relevance of scientific research and studies to address societal problems, i.e., about producing evidence of the impact of the funded research. This movement is important because it promotes higher accountability and advocacy directed to different types of stakeholders.

Through a brief literature review, we have come across multiple impacts deriving from research. In order to conduct our study, we decided to group them into three clusters, namely, economic, policy, and societal. This division allows us to identify similarities and differences between the many impacts of investing in research according to their specific contexts. In addition to understanding aspects related to the literature on research impact, thinking of the societal impact of research is increasingly connected with discussions on EDI in academia. In this sense, we consider that incorporating EDI indicators in the literature review together with traditional bibliometric indicators is relevant as it sheds light on aspects that are often neglected when discussing the state of the art of a certain topic (including indicators of genre, race, location, and language).

Methodological Procedures

Through a bibliometric analysis carried out in the Web of Science and Scopus databases, we provide the scientific mapping concerning economic, policy, and societal impact. To alll impacts considered, basic bibliometric and literature review techniques will be applied. Common to all is the inclusion of EDI metrics, as well as the identification of articles that address the role of funding in impact evaluation. However, considering the vastness of sub-themes implicit in each of these impacts, we resorted to a few methods to focus on each more effectively.

The economic impacts will be evaluated based on three pillars, namely: university-industry collaboration, focusing specifically on university-industry co-authorship in scientific articles; the relevance of funding for the development of innovation and entrepreneurship ecosystems; and the importance of funding for the creation and development of small business programs.

Regarding policy, we intend to identify how the literature addresses the flows of knowledge from academia to policy (forward tracing method) and the use of scientific knowledge by policymakers (backward tracing method). The following aspects will be emphasized: methodologies for evaluating the different flows and use of knowledge between science and policy-making; the debate on the role of funding and funding agencies and ways to assess and evaluate; and the thematic dimension (public policy area reached) of the articles identified, looking for trends in knowledge areas.

As for the societal impact, we had to make a more delimited cut, as the literature informs that the social impacts encompass several fields. Thus, we chose health and climate change as the societal impacts to be further assessed in this study, since both areas are relevant and frequently cited when it comes to the societal impact of research. Thus, by assessing the main thematic projects supported by Fapesp, we found that the health and climate change issues have received significant financial support in recent years. In addition, the importance of health research was highlighted by the Covid-19 pandemic, while climate change reflects the general concern with global warming, expressed and emphasized by reports like those by the Intergovernmental Panel on Climate Change.

Findings

The analytical exercise of identifying and developing a scientific mapping of the economic, policy, and societal impact of research allow us to identify similarities and differences between recently developed impact assessments. The intercambiation of methodological approaches is a rich contribution of this study as new ways of assessing a certain impact could be limited to a field of knowledge and have not yet overcome the disciplinary barrier. The scientific mapping also provides us with an outlook on research opportunities and points out where contributions can be made to the field.

Implications

Evaluating the state of the art in each dimension based on traditional performance indicators gives us an overview of the status quo of how research impacts are being assessed in recent literature. However funding agencies are concerned about ways to make research practices more open, inclusive and impactful and an effective way of addressing and investigating this topic is to consider alternative indicators while performing a literature review. In that sense, we provide a relevant contribution by stimulating the incorporation of EDI indicators when conceptualizing a study, and also by developing new bibliometric indicators based on EDI.

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SECTORAL INNOVATION II

May 2nd: 10h30 am – 12h30 pm

Chair

Guilherme Camboim (Federal University of Rio Grande do Sul, Brazil)

Papers

Innovation patterns in timber design

Chandini Singh, Schalk Grobbelaar

Food producers in the western cape innovation ecosystem

Carina Pasqualotto, Daniela de Menezes, Cornelius Schutte, Christle de Beer

Post-sale: A case report in the parts department of an agricultural dealership in Rio Grande do Sul - Brazil

Diego Mizael Corrêa Monteiro, Paloma de Mattos Fagundes, Mariane Rubin Deutschmann, Ana Cláudia Machado Padilha, Giulia Rios Gualberto, Mariana Juliani da Silva Portal

Climate tech startups in agriculture industry: Experiences from Brazil

Belmiro N. João

A digital maturity model for agribusiness cooperatives

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Innovation patterns in timber design

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Abstract: This paper presents a systematic literature review of 41 articles relating to the benefits, inhibitors, and innovations associated with timber design. An overview of common timber types is included for background. The majority (13) of the publications originated from Europe. The main topic (25 articles) addressed in the literature was inhibitors, with innovations/solutions being discussed in 22 papers. Generally, articles discuss inhibitors together with innovations and benefits. The categorisation is done based on the detail of the discussion and overall focus within the article. This study aimed to establish global inhibitors and innovations within the mass timber construction (MTC) landscape as a first step to determine their applicability within South Africa. Finally, further research suggestions are made, based on the literature review, as a way forward for the South African MTC industry.

Keywords: mass timber construction, inhibitors, innovation, South Africa

Introduction

The construction industry is one of the world's largest contributors to greenhouse gas emissions, making up approximately 40% of CO2 emissions and 35% of total energy consumption (Younis & Dodoo, 2022). This global concern drove the development of MTC. Cross Laminated Timber (CLT), Glue Laminated Timber (Glulam) and Laminated Veneer Lumber (LVL) are some of the common structural timber types available for use in MTC.

CLT is widely used to construct tall buildings such as the Brock Commons Tallwood House in Canada and multiple commercial and residential buildings within Europe. Timber buildings exhibit many advantages: a substantial reduction in carbon footprint compared to conventional buildings, faster construction, less labour-intensive and lower operational costs in the long run. However, the construction industry remains hesitant to adopt timber as a primary construction material. For example, perceptions regarding durability and flammability result in the slow adoption of timber in construction.

In South Africa, more than 50% of houses utilise wood-based roof-truss systems, but only about 1% of homes can be described as timber structures. Innovations such as "green glueing" (Pröller, 2017) are being pursued to promote using eucalypt and pine for CLT. However, certain aspects, such as the extent of public knowledge and financial viability, remain common inhibitors.

Limited literature is available regarding the current position of the South African timber construction industry. Therefore, this scoping review serves as an initial research step to determine the main inhibitors to expanding timber into the wider construction market and to identify current practices and innovation patterns within the timber industry on a global scale. In addition, the objective is to accurately suggest further research areas within the South African industry to encourage knowledge-sharing and expansion.

The following literature review questions will be used to fulfil the objective of this paper:

a) What are the main inhibitors of mass timber in the structural landscape?
b) What innovation paths/ideas may increase the adoption of mass timber in construction?

Review Method

Search Strategy and Keywords

The article search was carried out using Boolean search operators and keywords. The database used for the literature search was Scopus. Examples of the keyword searches included:

Boolean Search syntax	Formal Syntax	No. Hits
"Timber" AND ("plasterboard" OR "fire")	TITLE-ABS-KEY ("Timber" AND ("plasterboard" OR "fire")) AND PUBYEAR > 2014 AND PUBYEAR < 2023	1 178
"Timber" AND "innovation"	TITLE-ABS-KEY ("Timber" AND "innovation") AND PUBYEAR > 2014 AND PUBYEAR < 2023	422
"Timber" AND "concrete" AND "emissions"	TITLE-ABS-KEY ("Timber" AND "concrete" AND "emissions") AND PUBYEAR > 2014 AND PUBYEAR < 2023	188

The keyword searches produced a wide range of articles. Abstracts and keywords of the articles were skimmed over to determine compliance with inclusion/exclusion criteria.

Inclusion criteria included:

- Peer-reviewed journal articles
- Written in English
- Published 2014–2022
- Reference to the following timber types: CLT, LVL or Glulam
- Advantages/disadvantages and innovation in the context of MTC

Exclusion criteria included:

- Paid membership articles
- Studies referring to bamboo
- Conference Proceedings
- Reference to timber characteristics outside of construction

Screening and Selection

A screening table was populated to scan and further filter article data. The screening table consisted of the following data:

- Literature review question(s)
- Inclusion and exclusion criteria. This is as determined in the search strategy
- Author and journal name
- Topic/ title of the article
- Indication of inclusion/exclusion decision
- Notes or comments about the article

This table assisted with identifying compliance with inclusion/exclusion criteria and the removal of duplicate data.

The inclusion/exclusion process can be seen in Figure: 1 below.

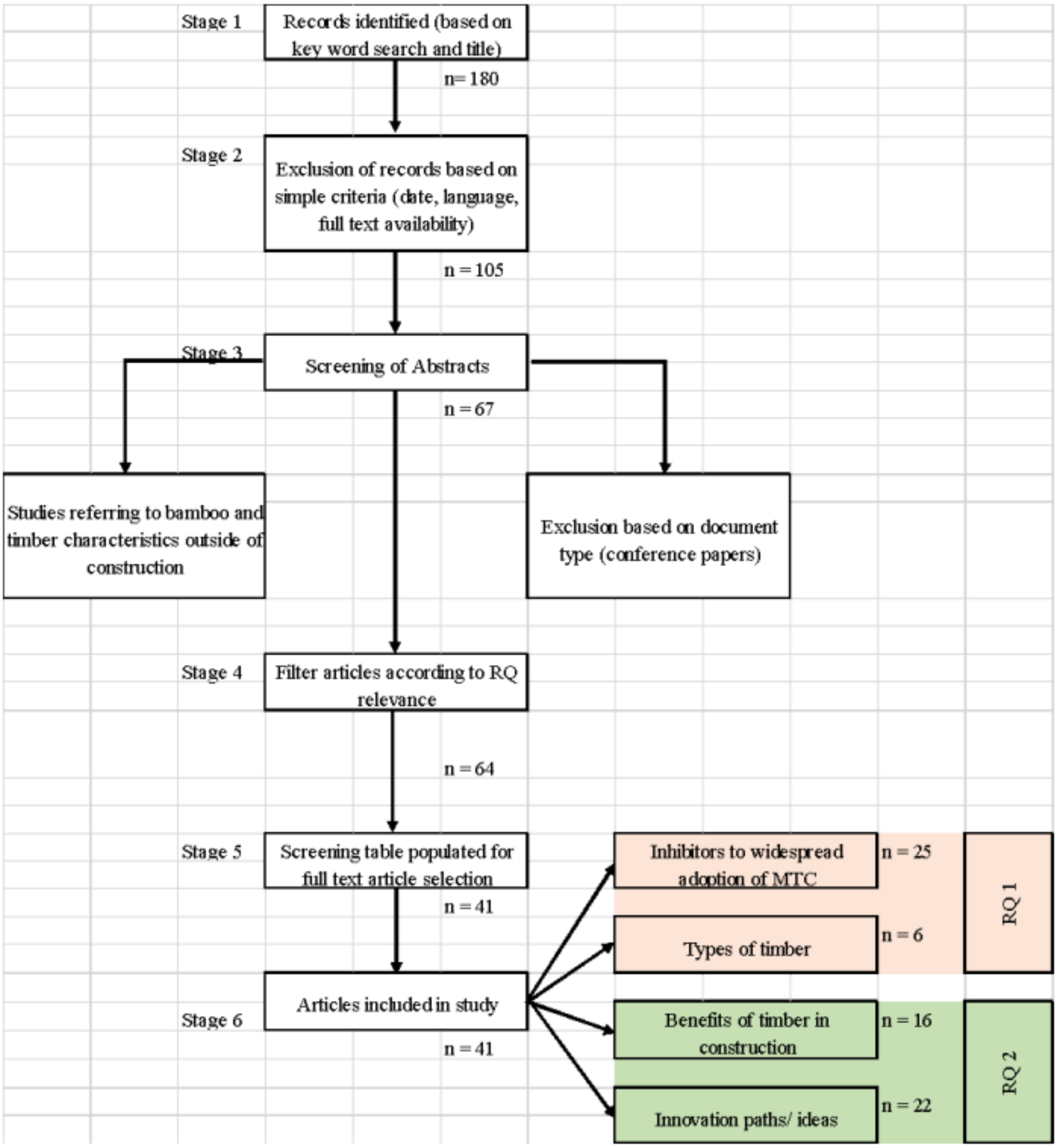

Figure 1: Literature selection process flow

Data Extraction and Quality Assessment

The data extraction tool used for this literature study was Atlas.ti. Through correlations made by reference coding, Sankey diagrams were compiled, which allowed the visualisation of code frequencies and relationships. Some of the codes used during the study included:

- CLT
- Flammability
- Durability
- Carbon sequestration

An author matrix was used to categorise article data for pattern identification and noting down important ideas. This matrix included:

- Author(s) and year of publication
- Topic/focus of study
- Conceptual/ theoretical framework of the study
- Research methodology used
- Context/ setting of the study
- Main ideas, findings and conclusions
- Gaps in research/ shortcomings/ alternative areas of research

The articles' quality was evaluated in more detail regarding the analysis method and conclusions reached. In addition, the limitations of completed studies were considered to assess the conclusions' applicability.

To thematically group selected literature, a concept matrix was used. This matrix included:

- Author(s) of each article
- Article title
- Main ideas/findings
- Aspects for further discussion
- Recurring themes/concepts

Results

Year of Publications

The publication year distribution is shown in Figure: 2. The keywords: "**Timber construction**" OR "**mass timber**" yielded 1 219 results in the Scopus database when indexed between 2014 - 2022, with the oldest literature dating back to 1968 and displaying 1 827 results (Scopus, 2004).

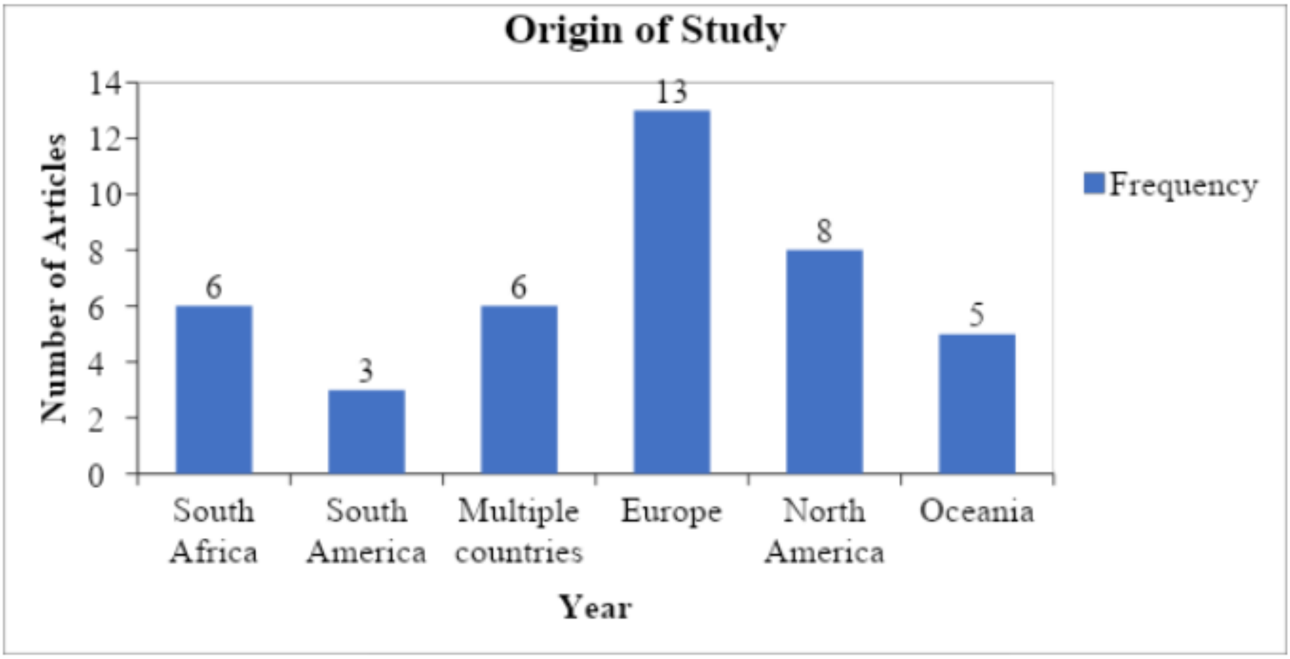

Figure 3: Origin of study

Due to the rapid and continuous development within the timber sector and the increase in available literature through the years (Scopus, 2004), data between 2014 – the present was deemed most appropriate for the study. South Africa is still in the early stages of MTC adoption; thus, past challenges and solutions may prove helpful.

Figure 2: Publication year of literature

Geographical Origin of Study

The timber residential home market share in Germany increased from 6%-18% between 1990–2017. In the United Kingdom (UK), in 2015, the percentage of new timber homes reached 27.6% (P. Crafford & Wessels, 2020). This increase in timber housing indicates the rapid development within the European timber industry and is a possible reason for the majority of literature relating to Europe.

In North America, strides were also made in the timber industry with the Ascent Building (Milwaukee). Six studies were based on multiple countries, and seven were from South America and Oceania.

The "Multiple Countries" bin included articles which refer to multiple countries in different continents (such as Canada and Germany) within one article. Literature referencing South Africa is limited. The "South Africa" bin was not grouped per continent as South Africa is a focal country in this review.

Highlighted Concepts Present in the Literature

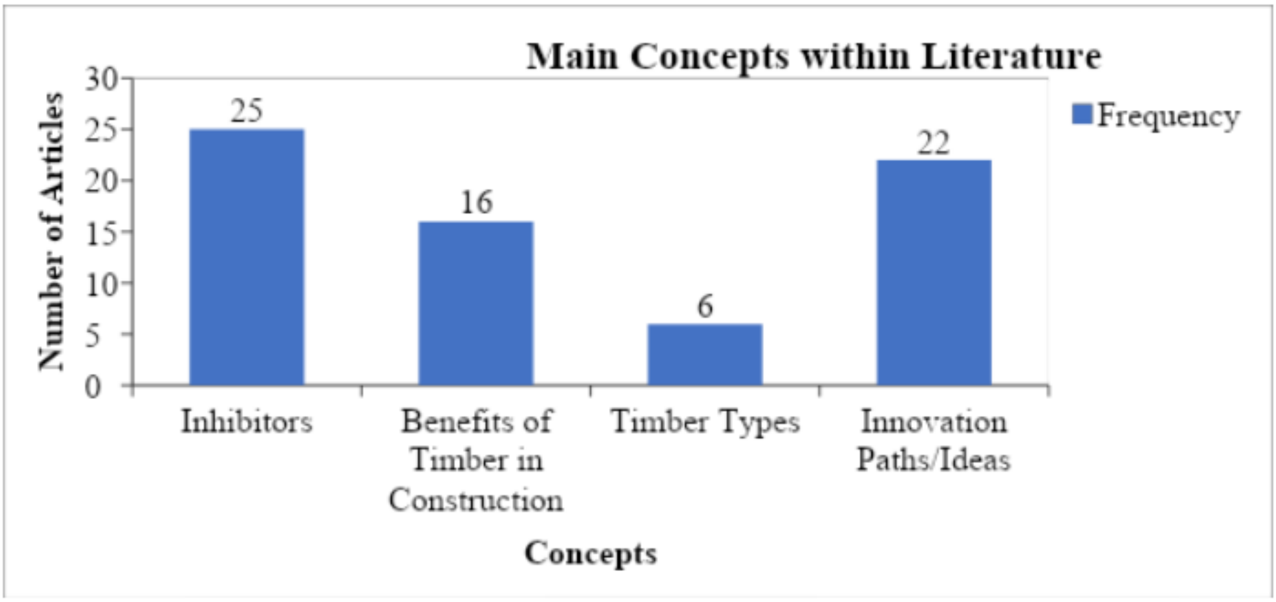

Figure 4: Main concepts identified in the literature

The main topic of discussion relating to timber construction is the inhibitors and concerns. Numerous articles discussed the benefits and innovation paths for the broader adoption of timber. Timber types are discussed to provide a topic background.

Benefits of Timber Construction

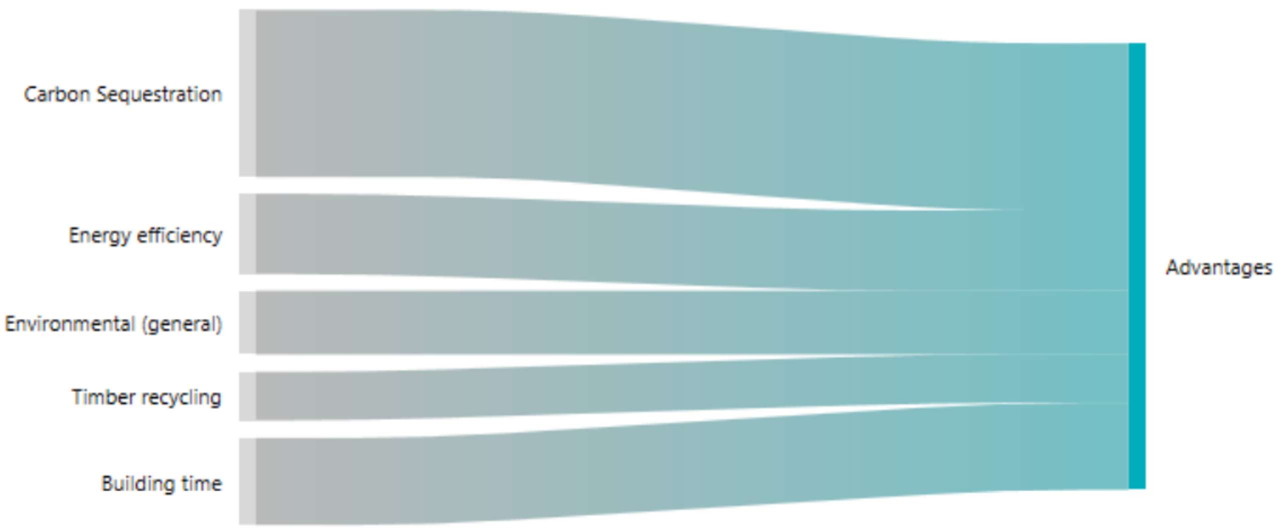

Figure 5: Benefits of using timber in construction

The advantages are relevant in the context of comparing MTC to traditional buildings. The majority of benefits presented were associated with CLT. However, advantages such as carbon sequestration, environmental (general) and energy efficiency are assumed to be advantages for all timber considered.

Main Inhibitors and Concerns Relating to Timber Construction

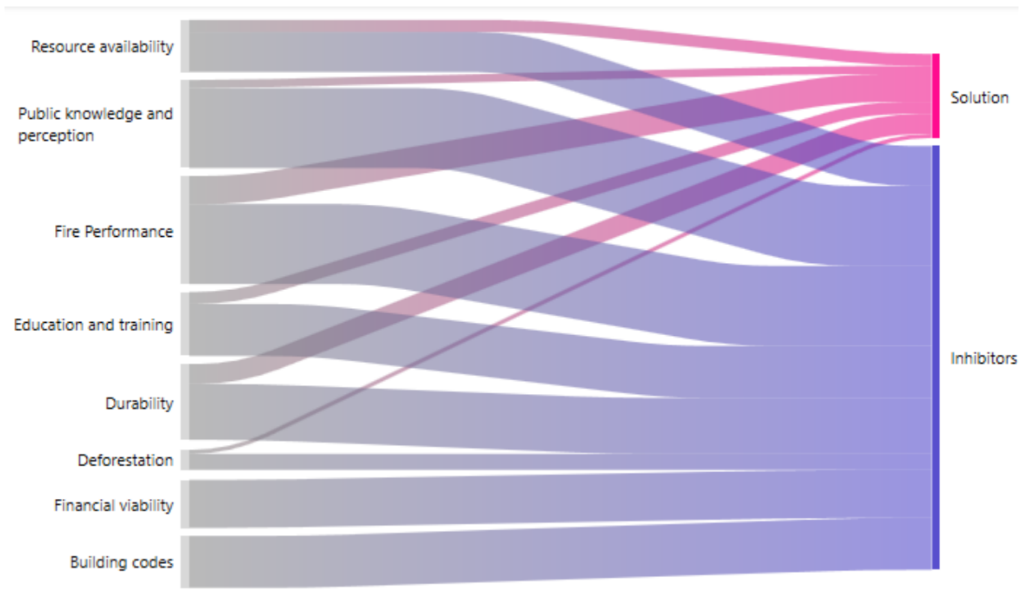

Figure 6: Main inhibitors/concerns relating to timber construction and corresponding solutions

Figure: 6 displays the main inhibitors to the widespread adoption of MTC. Some inhibitors are addressed through innovative solutions.

Innovation Pathways/Ideas for Expansion of the Timber Construction Industry

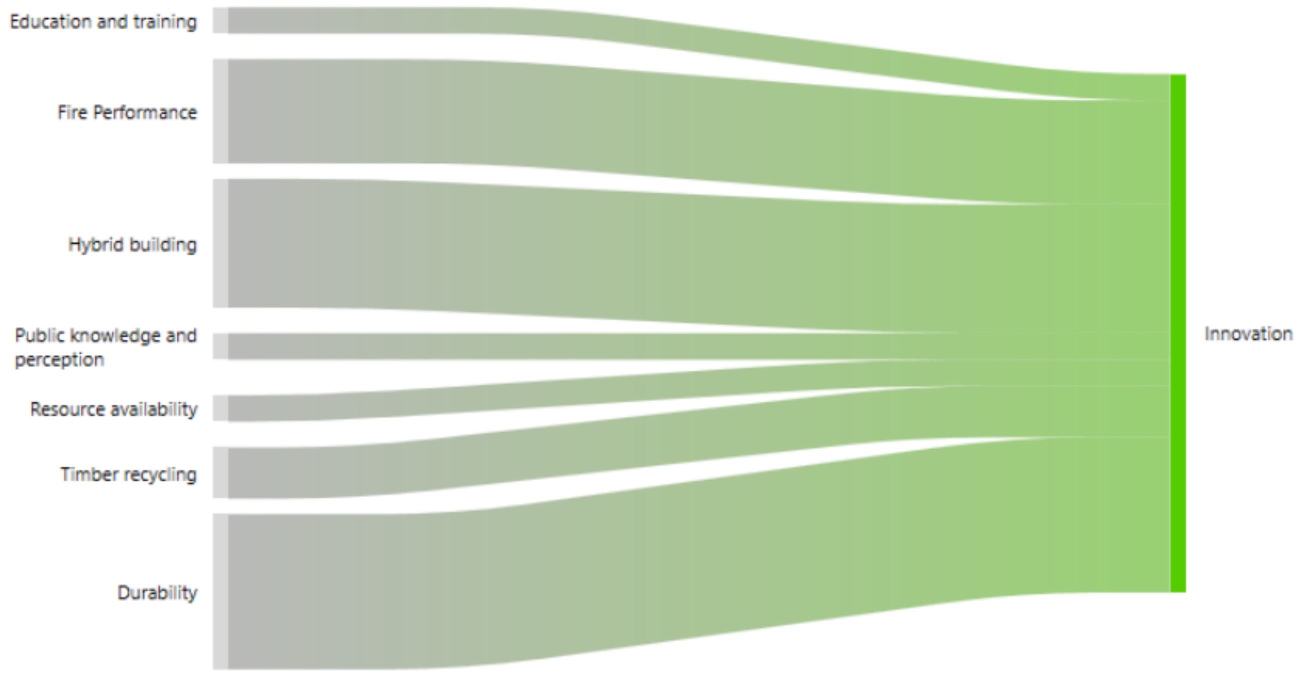

Figure 7: Innovation paths/ideas within the timber construction industry

Numerous innovation ideas have been tested and suggested to address MTC concerns. The main strides are related to durability and fire performance. Investigations into hybrid materials also occurred frequently.

Discussion

Timber Types

CLT comprises perpendicular lumber layers bonded together using a structural adhesive. Before production of CLT panels, the felled wood is dried to a lower moisture content and cleared of defects such as knots and stress tested. Afterwards, the wood is finger-jointed and fabricated to produce a CLT panel. Advantages of CLT include high strength, stiffness, dimensional stability and high dimensional accuracy of panels due to the production process, resulting in reduced waste and increased production speed. (Abed et al., 2022). The popular wood type for commercial CLT is softwoods bonded with polyurethane (PU) adhesives (Llana et al., 2022).

Glulam is produced from several layers of individually strength-tested wood bonded with a moisture-resistant adhesive. The grains of the bonded pieces lie parallel to the wood length. Glulam is widely used in Europe and North America. A significant advantage of Glulam is the size and shape flexibility which may be changed to fit the building design and use. In addition, the strength-to-weight ratio of Glulam can be superior to that of structural steel. Therefore, Glulam is appropriate for columns and beams (Abed et al., 2022).

LVL is composed of thin wood veneers glued together with the grain in the direction of the length of the product. Noted advantages include a lower likelihood of shape changes such as warping, strength and reliability. As a result, LVL is ideally suited for low-rise construction (Abed et al., 2022).

The typical wood resource used for structural timbers in Europe originates from coniferous forests (Ramage et al., 2017). In South Africa, S5 and S7 SA pine are generally available from sawmills, with S10 SA pine being more difficult to source (F. S. van der Westhuyzen & Wium, 2021). Pine or young eucalypt trees can be used to produce CLT in South Africa (P. Crafford & Wessels, 2020).

Benefits of Timber in Construction

Carbon Sequestration

Reducing the carbon footprint in the building industry is among the most substantial benefits of building with wood. Trees absorb carbon dioxide, release oxygen, and capture carbon during their lifetime. If forests are managed sustainably, the wood formed during their lifecycle can provide a carbon sink over the useful life of timber buildings (Younis & Dodoo, 2022), (Laguarda Mallo & Espinoza, 2015).

A life cycle assessment (LCA) describes a methodology for quantifying environmental impacts during production stages and assesses options for lessening environmental impacts (Andersen et al., 2022). Recent LCAs were conducted in various European countries and the United States (US), which compared the carbon emission rate between reinforced concrete (RC) and mass timber buildings. These studies showed that through adherence to sustainable forestry practices, the use of mass timber could reduce cradle-to-construction emissions by 35–47% and space-conditioning energy by 30-40% over the useful life of the building (Felmer et al., 2022). A study described by Rinne et al. (2022) noted that a cradle-to-grave LCA comparing a multi-storey building to an RC building showed a reduction in building mass of 33.2%, a reduction in concrete carbon of 20.6% and building emission reduction of 70% (Rinne et al., 2022). P.L. Crafford et al. (2017) compared the LCAs for three roof truss systems: SA pine, Biligom (produced from finger-jointed eucalypt trees) and light gauge steel (LGS). The LGS system exhibited approximately double the environmental impact of timber systems (P. L. Crafford et al., 2017).

Building Time

CLT panels exhibit a high degree of dimensional accuracy due to using a Computer Numeric Control (CNC) machine to cut panels to size. This allows for offsite prefabrication and modular construction of buildings, significantly reducing the time and cost required to erect a timber building. In addition, carbon emissions are also reduced due to the reduction in the necessary transport of material and machinery (Abed et al., 2022), (Laguarda Mallo & Espinoza, 2015), (Lähtinen et al., 2019). Van der Westhuyzen and Wium (2021) conducted a development cost comparison study between multi-storey mass timber and RC buildings. Based on estimates made by a focus group of industry professionals, the RC structure's building duration was approximately 42 weeks, while the timber structure was approximately 21 weeks (F. S. van der Westhuyzen & Wium, 2021). Younis and Dodoo (2022) noted that a CLT structure's building speed could be as efficient as 4–7 days per floor, while in the case of an RC building, it could take up to 21–30 days (Younis & Dodoo, 2022).

Environmental and Energy Efficiency

MTC offers the benefit of reducing the pressure on freshwater resources. For example, in a literature study, Abed et al. (2022) noted in some cases, 30 times less water was used per cubic meter in the production of mass timber when compared to RC (Abed et al., 2022).

MTC products are recyclable. Widespread use can assist in reducing process waste and landfill waste and increasing the recovery of scrapped products (Krueger et al., 2019).

A reduction in operational energy use and non-renewable resources was also found (Felmer et al., 2022). The lower thermal conductivity of wood results in superior insulation capability when compared to a conventional building. This results in less energy required for space heating and -cooling (Zaman et al., 2022). Due to the biological structure, wood insulation is superior to concrete and steel by 15- and 400 times more, respectively (Manninen et al., 2014). During the manufacturing process, it was found that LGS consumes at least 6.65 times more energy than wood (P. L. Crafford et al., 2017).

Timber Recycling

Re-purposing used MTC wood into lower-grade products is the suggested end-of-life avenue, as decomposition in a landfill or incineration releases stored carbon back into the atmosphere, reducing the environmental benefit. Re-purposing capitalises on carbon sequestration and reduces the production of new wood resources to an extent (Abed et al., 2022). High-grade CLT is a good candidate for timber recycling. If the reuse of timber is impractical, the wood may be burnt as biofuel (P. L. Crafford et al., 2021).

Main Inhibitors and Concerns Relating to Timber Construction

Durability

The airtightness of CLT envelopes impacts their durability. If leakages occur, energy consumption will increase, and the wall will be at risk of mould growth. It has been shown that a reduction in indoor relative humidity (RH) results in cracks and leakages in CLT indoor panels. Kukk et al. (2021) found that a high initial moisture content (MC) of ≈ 20-26% decreased airtightness (Scotta et al., 2018). Panels with ≈13% moisture performed significantly better. Wetting of CLT during construction must be avoided (Kukk et al., 2021). The method recommended for moisture management during MTC entails the 4D's rule: "distance, deflection, drainage and drying"(Schmidt & Riggio, 2019). Schmidt and Reggio (2019) also concluded that factors such as local climate conditions, wall positioning (North/South-facing) and construction details (for example, connections and coatings) played a role in the moisture response of timber walls. Moisture absorption from the base of a wall due to incorrect waterproofing is another concern, which may result in decay damage which is costly and difficult to resolve (Scotta et al., 2018).

Resource Availability and Deforestation

The growing popularity of MTC resulted in a higher demand for wood resources. While the global inclination is towards deforestation, this is due to clearing areas for agriculture rather than MTC resources. Forests must still be managed sustainably (Ramage et al., 2017). If forestry is not sustainably managed, the result could be a reduction in global forest resources. Illegal logging practices still pose an issue (Abed et al., 2022), (Andersen et al., 2022).

Fire Performance

Resistance of timber structures to complete burnout is an issue requiring a solution. During or after a fire's decay phases, structural failure poses a risk to occupants and emergency workers (Gernay, 2021). Polyurethane adhesives are commonly used for CLT production in South Africa, which perform poorly in fires and provide poor delamination resistance when used to bond Eucalyptus (S. van der Westhuyzen et al., 2020). It has also been argued that adhesives frequently fail at temperatures between 200–400 ºC (Pettersson, 2020).

Public Knowledge and Perception

A survey of 518 global professionals (Marfella & Winson-Geideman, 2021) determined that respondents mentioned issues such as insurance premiums and maintenance costs relating to financial aspects but gave an overall positive response regarding the economic viability of timber construction. This supports results found in the US (Laguarda Mallo & Espinoza, 2015), arguing that "opinionated knowledge" was much higher than technical knowledge. Many respondents associated MTC with a reduction in wildlife habitat and deforestation (Marfella & Winson-Geideman, 2021). A survey of 38 construction professionals noted durability, lack of demand and maintenance costs as the three main inhibitors to MTC (Zaman et al., 2022). Multiple articles also mention the perception of poor fire safety in timber buildings as a barrier (Abed et al., 2022), (Lähtinen et al., 2019), (Laguarda Mallo & Espinoza, 2015), (Hadden et al., 2017). The surveys also indicated a perception of high maintenance costs as an inhibitor (Zaman et al., 2022) (Laguarda Mallo & Espinoza, 2015). This perception could be due to the issue, as mentioned above, of opinionated knowledge over technical knowledge. In South Africa, Windapo et al. (2021) noted that traditional construction is viewed as an employment opportunity due to its labour-intensive nature. Based on this, it could be misconceived that MTC, due to reduced labour requirements, may further increase the unemployment rate (Windapo et al., 2021).

Education and Training

In the same study described above by Zaman et al. (2022), industry experts noted that a shortage of industry experience, mediocre promotion of MTC building strategies and lack of tertiary education are barriers when considering MTC projects (Zaman et al., 2022). In addition, the shortage of local skills, particularly in design and construction, was noted to be present in Australia and New Zealand (Evison et al., 2018). In general, this is a global theme, including the US (Penfield et al., 2022), South Africa (Windapo et al., 2021) and even Europe (Marfella & Winson-Geideman, 2021).

Financial Viability

Some publications describe MTC's financial viability as a benefit, while others refer to it as a limitation. Penfield et al. (2022) stated that CLT is perceived as costlier and noted a 20% increase in upfront costs of a CLT building as compared to a traditional building (Penfield et al., 2022). Abed et al. (2022) discussed two studies whereby (Abed et al., 2022) building costs were higher when using CLT than RC. The study says that cost-savings may be realised where multi-storey buildings are concerned and during operation. Resource importation further increases building costs (Abed et al., 2022). The monopolisation of the timber industry may also lead to higher costs for MTC (Zaman et al., 2022).

Building Codes

Fernandez et al. (2020) reviewed the Ascent high-rise building in Milwaukee (Fernandez et al., 2020). The authors noted differences between design codes in Europe and the US, complicating the use of imported material. Consensus relating to testing standards is required in the global industry to ensure consistent compliance with imported/exported timber. The issue of lack of technical standards and regulations poses a barrier. This blanket issue covers leading continents such as North America and Europe (Marfella & Winson-Geideman, 2021). In New Zealand, existing building codes and support offered limited support to MTC, resulting in increased design costs and effort for compliance with the (at the time) new technology (Evison et al., 2018). Similarly, the survey by Laguarda Mallo and Espinoza (2015) found that a perceived barrier was the compatibility of MTC with building codes (Laguarda Mallo & Espinoza, 2015). While further development in building codes is still required due to the rapid adoption of timber, traditional codes are increasingly compatible with MTC, and policies are becoming more accommodating (Penfield et al., 2022).

Innovation Pathways/Ideas for Expansion of the Timber Construction Industry

Durability

Technologies are available to enhance airtightness. This includes (a) the use of sealing products between elements, (b) covering joints with bitumen or tape and (c) the use of airtight membranes covering the wall. (a) and (b) are the most common and cost-effective (Kukk et al., 2021). Chang et al. (2021) suggested and successfully tested using extruded polystyrene for a thermal insulation layer in CLT, stating that this type of insulation was safe from moisture problems based on a study conducted in eight US cities (Chang et al., 2021).

In research intended to prevent dampness from affecting wood at the base of pillars, tests were performed using an extruded aluminium billet in a foundation fixed to a concrete slab using mechanical or chemical anchors. The billet allows the placement and fastening of CLT panels atop its surface, reducing the contact with the slab and preventing dampness from the foundation contacting with the CLT panel. In addition, the beam was tested and confirmed the load-bearing properties to support vertical loads associated with two- to three-storey timber structures (Scotta et al., 2018). Boron and copper chrome arsenic (CCA) treatments may also be used to extend the durable life of structural timber to different extents. However, CCA exhibits various health and environmental concerns (Altaner, 2022; Singh et al., 2019).

Timber Recycling

Wood-plastic composites (WPCs) are a low-cost product developed from alien trees in South Africa and recycled low-density polyethene. Mohammed and Meincken (2021) investigated the production of WPCs for the proposed use in low-cost housing within South Africa for cladding and ceilings. The material required no additives and minimal processing steps. The authors found that the board product met the properties for non-structural interior applications, including high humidity level areas such as bathrooms and kitchens, without the concern for decay, due to the low water absorption and thickness swelling performance. Boards containing 60% biomass pressed at 180ºC for 30 minutes yielded the most promising properties for interior environments (Mohammed & Meincken, 2021). In

Europe, Llana et al (2022) experimented using timber pieces recovered from demolishing a 200-year-old Spanish oak house. Unwanted materials such as nails were removed, and twelve CLT panels were fashioned from the rubble wood, some composed exclusively of recycled timber, others from a combination of new and used wood. High knottiness was a defect on the recovered timber panels, and subsequently, the bending strength of the used timber was lower than new but still met certain structural applications' requirements. However, the authors stated replication of the experiment on a larger scale is required to validate the results (Llana et al., 2022).

Resource Availability

Existing forests require sustainable management to embrace their benefits entirely. Understanding aspects surrounding tree farming and quantifying factors affecting carbon sequestration (for example, tree species and location) may assist in determining and justifying the extent of afforestation required to impact carbon emissions significantly (Ramage et al., 2017).

Reduced impact logging (RIL), forest certification, DNA tracking and appropriate tree felling can result in long-term carbon absorption, reduce the likelihood of forest fires (due to less damaging cutting practices and waste) and satisfy the timber demand. RIL is a practice that entails good planning and a trained crew to cut down trees at the correct time in their maturity cycle. While RIL may be costly, it substantially decreases the residual forest damage (Sasaki et al., 2016).

The Eastern Cape and KwaZulu Natal have possible afforestation areas in South Africa. If pursued, it may yield an additional 1 million m3 of timber within 24 years if the yield is sawlogs only. Another potential area includes the Western Cape coastal areas for dryland forestry (P. Crafford & Wessels, 2020). "The glueing of wet, unseasoned lumber above fibre saturation point is often referred to as "green glueing" (Pröller, 2017). Pröller (2017) investigated the use of "green-glueing" using a PU-adhesive on eucalyptus wood to improve properties. The study yielded improved results, and further research into edge-bonded Eucalyptus as an alternative structural timber was suggested (Pröller, 2017).

Hybrid Building

The welding of softwood timber using "high-frequency oscillating or linear friction" (Ramage et al., 2017) was investigated and confirmed to be successful in an article published by the University of Cambridge (Walters, 2021). In addition, using fibres (such as carbon) was also investigated to reinforce timber for increased resilience (Ramage et al., 2017).

Rinne et al (2022) conducted a study comparing a full timber, traditional concrete and timber-concrete hybrid (timber top-floor, concrete for loadbearing members) five-storey buildings using LCAs. For the majority of the modules, the timber building showed superior performance. However, the hybrid building displayed good performance compared to the concrete building. This is an important finding, as it provides a maintainable step towards greener buildings, especially in countries with limited wood resources (Rinne et al., 2022).

Heyner et al. (2021) investigated LVL-steel hybrid products for components subjected to vehicle crash loads (for example, a door impact beam). While certain performance factors improved, such as higher deformations and bending capability, the hybrid beam could not yield the reference steel beam's maximum deformation and target weight. However, the hybrid may be optimised and reconstructed to resemble the reference member more suitably and re-tested for further results (Heyner et al., 2021).

Weiss et al. (2020) noted in a literature study that in 2010, there was a need for affordable housing in Europe linked with greener building awareness. This led to prefabrication and lean timber production (Weiss et al., 2020). For example, Koronaki et al. (2021) proposed solving the demand for schools in the UK using prefabricated timber buildings. The article describes a roadmap for successfully implementing the idea (Koronaki et al., 2021).

Fire Performance

Wood and most adhesives used in manufacturing mass timber are combustible. Non-combustible timber wall linings, such as drywall, can enhance fire performance (Zaman et al., 2022), (Kang et al., 2021). CLT panels produced with thicker lamella exhibited better fire performance than those with thinner lamella by forming a thicker char layer (Wade et al., 2018). Adhesives such as melamine-based fire-resistant adhesives can limit delamination panels during a fire. Further research into the thermal deterioration of adhesives will benefit the continuous development of adhesives (Chorlton & Gales, 2020).

Public Knowledge and Perception

Marfella and Winson-Geideman (2021) proposed that the knowledge and perception of the public, beyond industry stakeholders, must be altered (Marfella & Winson-Geideman, 2021). This includes the general public and those within the property and construction industry. This can be done through the propagation of information, promotion of successful MTC structures and other marketing strategies. Sharing environmental benefits with property buyers, targeting the correct age group with articulated messages and debunking safety concerns such as fire performance are proposed approaches to altering public knowledge and perception (Evison et al., 2018), (Lähtinen et al., 2019).

Education and Training

Education extends beyond a learning institution to knowledge sharing between professionals within sectors such as design and construction. Increased awareness of available technologies mitigating MTC concerns can encourage investment in these areas for further research. Government intervention may also inspire buy-in from professionals and policy-makers by revising building codes and regulations and creating technical, design and material standards, catering more readily to MTC. Governments may also offer financial support to MTC projects to promote a greener society and encourage further skill development within the industry (Marfella & Winson-Geideman, 2021), (Windapo et al., 2021). An incentive programme favouring timber construction may also prove useful (González-Retamal et al., 2022).

Conclusions

The scoping review presents widely used timber types and global benefits, inhibitors and innovations to recommend development paths for South Africa within the MTC sector. The timber types referenced included: CLT, Glulam and LVL, exhibiting benefits such as carbon sequestration, improved building and energy efficiency and environmental effects and timber recyclability.

The literature illustrated inhibitors solved through rapid innovation and review, such as fire performance improvement through plasterboard, building code compatibility, financial viability and durability improvement through various construction additions and treatments.

However, South Africa is not accustomed to an MTC culture. Therefore, while inhibitors such as financial viability and building codes may no longer be considered limiting in other countries, they may still hold weight in South Africa. Thus, inhibitors and their solutions are important topics of discussion in this context.

The issue of public perception and lack of skills is currently one of the largest inhibitors to MTC adoption. This could be due to insufficient intervention from governments and institutions to promote the use of MTC through incentive regimes, training programs and investment in greener alternatives. However, public opinion also depends on factors such as age and interests, which require personal changes.

Limitations

- The use of a single literature search engine. MTC is a vast topic; thus, using multiple search engines may have provided a wider scope of data.
- Limited literature relating to the position of South Africa within the MTC industry – this could likely be due to South Africa being relatively unestablished within the market.
- The research focus is related to the main concepts considering this is a first-stage review of issues and solutions relating to MTC. This could have limited the scope and depth of the analysed literature.

Recommendations for further research in South Africa

- Use of MTC in the construction of low-cost housing and schools.
- Development cost comparison between single-family timber homes and traditional homes in the context of the average South African income.
- Use of “green-glued” eucalyptus wood as CLT (as discussed by Pröller (2017).
- Detailed investigations regarding the environmental impact of adhesive production and increased mass timber demand.
- Surveys of industry professionals to establish the current perceptions towards MTC in South Africa.
- Evaluation of product diffusion strategies for MTC.

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Food producers in the western cape innovation ecosystem

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Abstract: This study aims to understand the role of small food producers in the development of the Western Cape Innovation Ecosystem (WCIE). A qualitative approach was used. Data were collected through in-depth interviews with small food producers and specialists and through secondary data. The results show a clearer understanding of quadruple helix actors in the WCIE. Finally, it seems small food producers have a role as a civil society rather than as a company.
Keywords: Innovation ecosystem actors, quadruple helix model, small food producers, South Africa.

Introduction

It is assumed that the formation of an innovation ecosystem, through a network of actors to generate innovation, can contribute to the generation of profit for shareholders and value for society (Bittencourt & Figueiró, 2019). The literature emphasizes that networks of interrelated companies are determinants of the innovative capacity of an organization (van de Vrande et al., 2009) or a territory (Spinosa, Schlemm & Reis, 2015). According to Adner and Kapoor (2010) the coordinated performance of a group of actors in an ecosystem and the expansion of its diversity can enhance the value generated by it. Innovation ecosystems have gained strength in the academic arena, especially when it comes to the characteristics of innovation networks that connect various actors to produce innovation cycles (Giannopoulos & Munro, 2019). Gao et al. (2020) comment on the need for innovation research with multiple partners working together.

Cape Town, a city in South Africa, has emerged as a region of high technological growth and innovation, according to the African Tech Ecosystems of the Future 2021/2022 report. Identified as the Innovation District, Cape Town and the surrounding region direct their efforts to the development of a technological and innovation economy, presenting a territorial ecosystem of the Western Cape that has resulted in a "technological hallway" between Cape Town and Stellenbosch (where two of South Africa's leading Universities are based).

This region has a diversified agro-industrial sector, promoting South Africa's economic growth, establishing itself as a hub to produce beverages and food from conventional and organic production. Urban agricultural production and agri processing are key economic components of the Western Cape economy, making the Western Cape, one of the most productive and competitive provinces in South Africa in terms of the manufacturing and production of food and beverages (Wesgro, 2022). Agriculture is one of the primary pillars of the Western Cape economy, with about 11 commodities contributing significantly to production, having fruit, poultry and eggs, winter grains, viticulture and vegetables comprise more than 75% of total output (Wesgro, 2023). With an aim to be sustainable, the "technological hallway" provides technologies, among other sectors, for agritechs and rural producers to seek the best use of resources.

It is understood that there is a common purpose for technological and sustainable development in the region. Also, among rural producers, organic food producers are well aligned with the sustainable values shared by the ecosystem. Incidentally, according to Wesgro (2023), many farmers in the Western Cape are turning to organic production methods. So, to understand innovation ecosystems, according to Yaghmaie and Vanhaverbeke (2020), specific attention is needed to different actors and their roles in the ecosystem, and to consider new forms of role management, such as orchestrators, instigators and implementers in the ecosystem. Thus, this study aims to understand the role of small food producers in the WCIE.

Theoretical Background

An innovation ecosystem consists of the collaboration agreements through which companies combine their individual offerings into a coherent solution focusing on the customer (Adner, 2006). According to Gomes et al. (2018) an innovation ecosystem involves creating value, i.e. developing a collaborative process to create value for the customer and other stakeholders. The concept of innovation ecosystems, according to Ritala and Almpanopoulou (2017) should be used in systems focused on activities involving the logic of interdependence of actors within a spatial context. For Granstrand and Holgersson (2020) innovation ecosystems are considered as evolving sets of actors, activities and artifacts. Furthermore, institutions and relationships are important for the innovative performance of an actor or a population of actors. According to Jacobides, Veloso and Wolter (2014) ecosystems are not hierarchically managed, so that each actor seeks his own goals within the network, generating competitive advantage to the ecosystem. The concept of the innovation ecosystem is widely debated in the literature among innovation networks (Ritala & Almpanopoulou, 2017) and can be described as a complex network of connections and interactions between different actors who act collaboratively to produce cycles of innovation, under the rules, regulations and legislation existing in the environment, and the boundary of the ecosystem can be geographical or virtual(Giannopoulos & Munro, 2019).

In this way, the literature about innovation ecosystems shows two conceptual approaches. The first one regards the platform dimension, where innovation ecosystems are organized around a shared focal point, in a firm (Adner & Kapoor, 2010) or even in a technology platform (Gawer & Cusumano, 2014).

The second approach is the territorial dimension, where actors, elements, institutions and organizations interact in a regional and industrial context, consolidating innovation ecosystems that can be local, regional and national (Spinosa, Schlemm & Reis, 2015) or industry/sector specific. Thus, they are related to cities, industry types or sectors concentrated in specific regions, although a geographical limitation is not necessary (Cohen, Almirall & Chesbrough, 2016). This space brings together actors who can be grouped according to the quadruple helix model, formed by academia, companies, government and civil society that share objectives, seeking to create and capture value (Carayannis & Campbell, 2009). According to dos Santos, Zen & Bittencourt (2021, p. 28):

> The academia group is composed of institutions that contribute to the ecosystem, mainly through the qualification of human capital, production and dissemination of knowledge, such as universities and other institutions of higher education and research. The group of companies includes startups, large companies, science and technology parks, incubators and accelerators, angel and risk investors and commercial banks. Theactors engaged in transforming knowledge into new products and solutions. The governmental group of actors is responsible for the institutional conditions thatinfluence and guide the ecosystem; these actors are government agencies, regulatory agencies and public development banks. Finally, civil society covers all individuals and organizations that benefit from innovation and help achieve it, such as creative class professionals, early users, professionals who support innovation and entrepreneurship, famous icons, opinion makers, experienced entrepreneurs, family and friends.

Innovation ecosystems by territory have influences from territorial approaches that consider the spatial context of network development as an important aspect on the sustainability of the ecosystem (Dedehayir et al., 2018).

Innovation is seen as the fundamental element for the transformation and revitalization of cities, being necessary for the transition from a competition scenario to a cooperation scenario, the substitution of polarization by collaboration and the sum of efforts between society, government, academia and companies for the city to prosper (Zen et al, 2019). Joint engagement of quadruple helix actors for the development of the innovation ecosystem is very important (Bittencourt, Santos & Mignoni, 2021). Calamel et al. (2012) stress the need for coordination between multiple actors in innovation projects. According to Bittencourt & Figueiró (2019) it is necessary to understand the value generated for different audiences, in order to ensure the formation and sustainability of an innovation ecosystems, generating benefits to all actors involved. Bittencourt, Santos & Mignoni (2021) mention that collaboration among the actors is a critical resource that can be improved through orchestration processes. The participation from different actors is mentioned by Bittencourt and Figueiró (2019) as essential to the ecosystem development and to generate innovation.

Regions are increasingly being seen as ecosystem agglomerations of organizational, social and institutional entities or stakeholders, converging goals, priorities, expectations and behaviors that seek development through entrepreneurial development, exploration and implementation actions, as well as interactions (Carayannis et al, 2018). Inserted in a context of crises, it is important to consider innovative proposals, in which companies assume co- responsibility in transforming the region in which they are inserted (principle of shared value creation), involving different actors in this process (Bittencourt & Figueiró, 2019).

The territorial approach highlights the fact that a region can share an entire value chain among local partners of diverse types (firms, research centers, or universities) and of different sizes of companies (large firms or SMEs) (Scaringella & Radziwon, 2018).

Territorial approach partners share various tasks, whereas in ecosystems, the members develop strong interdependence, offering synergistic interactions between complementors and competitors (Scaringella & Radziwon, 2018). Furthermore, the interdependence and the evolution of participation from different actors in the ecosystem allows the creation of combined knowledge flows considered drivers to develop collaboratively and also commercialize innovations (Chesbrough & Bogers, 2014).

When firms establish cooperation and work together for shared business objectives, the interdependencies between them start to become more visible, and proper management and risk mitigation strategies allow them to reduce uncertainty. Nevertheless, only through knowledge exchange and spillovers can innovative products and services be created (Scaringella & Radziwon, 2018). Generating shared value will involve new and superior forms of collaboration.

There is an engagement among actors on the dynamics of knowledge within the network, generating flows of knowledge in and out, which produces collaboration and competition necessary to produce synergy among actors, and increase opportunities for intra- network innovation (Scaringella & Radziwon, 2018).

To achieve the objectives of this research, it will be used the classification of Santos, Zen & Bittencourt (2021) as presented in Figure 1.

Figure 1: The roles of each ecosystem actor

Actors	Roles
Academia	Promote qualification of human capital. Produce and disseminate knowledge.
Companies	Transform knowledge in products and solutions.
Government	Promote institutional conditions that influences and guide the ecosystem.
Civil Society	Individuals and organizations that benefit from the innovation. Help achieve innovation.

Source: prepared by the authors (2023)

Methodological Procedures

This research is characterized as exploratory research of a qualitative nature to understand the participation of actors in the WCIE in South Africa, particularly of food producers (Malhotra, 2012). This research follows some criteria for reporting qualitative research from Tong, Sainsbury & Craig (2007).

The Western Cape region was defined as units of analysis because this region is recognized for its high level of technology and innovation, working to develop a technological and innovation economy in the "technological hallway" between Cape Town and Stellenbosch. Agriculture is one of the primary pillars of the Western Cape economy (Wesgro, 2023), and South Africa's agriculture and agribusiness sectors remain key priorities, with the national government implementing several measures to stimulate these sectors in recent years (Wesgro, 2022).

For data collection, in-depth interviews were conducted with representatives of the actors of the quadruple helix emphasizing the food producers, since there is still no clear understanding of how they fit into this dynamic, whether as companies or as a civil society. The first author conducted all interviews, and there was no relationship established prior to study commencement between the first author and the interviewees. In the beginning of each interview, the author introduced herself, presented the project and the goals of the research. All interviewees are based in the Western Cape region. They were selected by convenience, according to the study goal.

Two semi-structured scripts with open questions were elaborated for date collection. One specific script for the rural producers and another one for other actors (specialists). Individual and small group interviews were carried out in person, except with interviewee 8, which was online through Google Meeting. Fifteen people were interviewed from November 26th, 2022 to February 16th, 2023. All interviews were recorded with previous authorization from the interviewees. The interviewees were identified from number 1 to 15, as presented in Figure 2, and will be named using the letter I and the related number.

In addition to primary data, secondary data was used for mapping the innovation ecosystem, identifying actors and their roles. Some websites from important actors were used as a source of information, such as Wesgro, LaunchLab, Innovus, Winetech and the Universities based in the Western Cape.

The collected data were analyzed using the content analysis technique (Bardin, 2011) and Santos, Zen & Bittencourt (2021) classification as categories.

Figure 2: Systematization of the actors interviewed

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#	Interviewee	Gender	Place of the data collection	Date	Recorded time	Interview way
I1	Organic herbs plants producer	Male	Blaauwklippen Family Market (Stellenbosch)	November 26th, 2022	30:05	Individual
I2	Organic olive oil, olive pastes and balsamic vinegar producer	Male	Blaauwklippen Family Market (Stellenbosch)	November 26th, 2022	25:45	Individual
I3	Conventional strawberry farmer	Male	Farmstall (Stellenbosch)	November 27th, 2022	9:50	Individual
I4	Organic vegetables farmers	Female	Vegetable Farm (Stellenbosch)	December 5th, 2022	1:11:00	Small group
I5		Male				
I6	Organic vegetables farmer	Male	Vegetable Farm (Stellenbosch)	December 5th, 2022	50:00	Small group
I7	Organic wine producer	Female	Organic Winery (Stellenbosch)	December 7th, 2022	46:30	Small group
I8	Professor from University of Cape Town	Female	Google Meeting	December 1st, 2022	55:00	Small group
I9	Professional from Research Contracts and Innovation (UCT)	Male	University of Cape Town (Cape Town)	December 6th, 2022	1:09:00	Small group
I10	Professional from LaunchLab	Male	LaunchLab (Stellenbosch)	December 8th, 2022	1:16:00	Small group
I11	Professional from Innovus	Female	Innovus (Stellenbosch)	December 8th, 2022	48:25	Small group
I12	Professional from Winetech	Female	Winetech (Paarl)	December 9th, 2022	1:10:36	Small group
I13		Male				
I14	Founders of Agri Startup	Male	LaunchLab (Stellenbosch)	February 16th, 2023	55:45	Small group
I15		Male				

Source: Prepared by the authors (2023)

Results

Food Producers Partnership

It's possible to affirm that small producers don't use to create partnerships with diversified groups to develop their activities. They prefer to work with few producers, sharing experiences and knowledge, or even work alone avoiding unreliable relationships, or information exchange. As some of them mention, I1 has a partner and they talk to each other to sell new plants, creating small innovations in their business, but "I try by myself" (I1) highlighting his solo working; "I work alone, I do everything by myself, I have no employees […] It is just me and my business partner" (I2). A commercial relationship was identified in I7 practices, buying grapes from other producers to produce his own wine, but it doesn't include information or practices exchange.

It's possible to perceive that the customers are considered a safe source of information, as I1 told, "The city of Cape Town does the Cape Town Summer Market in the Company's Garden. I have done that […] organized by the city of Cape Town government, it was great; It is good if they could do more of these events. Also participate in a festival on the coast of the Cape of a Good Hope" (I1).

In a different way, some organic producers take part in the PGS group. The Participatory Guarantee Systems (PGS) is a group of organic producers and consumers supported by IFOAM

(International Federation of Organic Agriculture Movements) - Organics International. It is a program developed for small and local farmers, which allows one organic producer from PGS group to certify another organic producer, with no costs involved. This is a group which involves producers and consumers, but there is no involvement with the government. “The governmental side of organic certification in South Africa is very underdeveloped. We don't have any organic standard yet” (I6). It is a close group where producers and consumers share knowledge and organic practices. They have regular meetings, and they communicate with each other systematically. “It is getting bigger, which is so nice” (I4). Organic producers can have their organic stamp without cost (I5). “We are proud to be a part of the Western Cape Farmers’ Participatory Guarantee System” (I6). I6 is a highly active member of the PGS group, he has joined the PGS committee in 2022. “I am a junior member there” (I6). According to him, PGS started from independent groups that couldn't have funds for certification.

Another characteristic of PGS is that each producer has its own specific products, and they sell from each other, so, it's possible to have a variety of products in farm shops. There is a collaboration network among organic producers. According to I6, their group started to interact with other PGS groups, to see how they do things and share knowledge.

In a distinct way, diversifying partners, I5 has a partnership with a soil biologist who helps them to improve their process. But it's a singular practice.

The small food producers were questioned if they have any kind of partnership with universities, considering they are in the region of two of the most important universities in South Africa, and they replied no. I3 have just received students from college, to visit and learn. I4 and I5 did not receive students at their farms, but they are open to receiving. I4 contacted Stellenbosch University offering their farm to do some research, but they informed that all projects have already been allocated. She would like to have a partnership with a university. “We have to learn every day. I am absolutely open to anybody who wants to come and see what we do (I4).

WCIE´s Actors Partnership and Structure

There are four universities involved in the WCIE: University of Cape Town (UCT), Stellenbosch University (SU), Cape Peninsula University of Technology (CPUT) and University of the Western Cape (UWC). Each university from Cape Town (UCT, CPUT and UWC) has a technology transfer office and research development support, but all three universities make use of a central business incubator in Cape Town, called CITI (Cape Innovation and Technology Initiatives).

Despite being well known inside the WCIE, most small food producers had not heard about CITI, just I3 had heard about that, but he wasn't involved with them.

UCT has a relationship with the other universities in Western Cape. UCT participates in SARIMA (Southern African Research & Innovation Management Association), which is a strong network in Southern Africa. SARIMA is a membership organization of practitioners managing and supporting activities in the continuum from research to innovation, focused on the Southern Africa region at an institutional, national, and international level (Sarima, 2023). “We do some case studies and training for the new people coming […] It is a very useful network where you experiment problems and solve them” (I9). They have conferences with paper presentations and talks about specific subjects. “It is a good opportunity to talk together and see each other […] That is an information sharing network” (I8). They have, also, relationships with other universities and TTOs, especially in the Western Cape. “We have a regional forum quarterly” (I10). There are four TTOs (Technology Transfer Offices) involved in the WCIE, from SU, UCT, CPUT and UWC, working together on research projects (I9).

There is also a relationship among universities in the Entrepreneurship Development in Higher Education (EDHE) program. The EDHE Program is people-focused, intended to develop the entrepreneurial capacity of students, academics and leaders, with the intention that students become more successful in terms of becoming economically active during and after their tertiary education (EDHE, 2023). There is a governmental movement, encouraging all 26 universities in South Africa to develop entrepreneurship at the university level.

Regarding agri research, Stellenbosch University has more programs focused on agriculture and agribusiness than others, but UCT also works in terms of animal health, vaccines (I9). UCT doesn't have specific projects for small food producers, but it comes out in other projects.

> "We have a guy that develops stuff out of commerce where he was looking at community gardeners […] he designs some specific sort of equipment […] We also have something called the knowledge co-op which is very much for NGOs (non-governmental organizations) who bring the needs of communities to be developed […] There are also, not only for agri, a lot of work in IT going on to set up local networks,it runs just for the community, we don't charge for that" (I9).

As SU is further away from the other three universities, it ended up creating its own innovation hub. It has the LaunchLab (business incubation) and Innovus responsible for the administrative part of innovations (sells, negotiates technologies). The differential of this innovation hub in Stellenbosch is the existence of wine farms, which means more income and more investors (I8).

One of main areas at LaunchLab is climate, agri and health, where they work with early- stage business. I10 mentioned some agritechs from LaunchLab. One of them works with commercial farmers using artificial intelligence machine learning to help them with their crops. I14 and I15, from an agri startup, mentioned that they were students from Stellenbosch University and, through LaunchLab help, they have developed their business, becoming part of the WCIE. Another main area is innovation, which develops entrepreneurship among SU students. "The engagement this year has been phenomenal, we have seen amazing things from students" (I10).

LaunchLab doesn't have specific projects to small food producers and direct access to them, but the entrepreneurs are interested in it and, LaunchLab helps them in the analysis of the business (the needs, the problem etc). Even the agri startup from I14 and I15, who works on agriculture field, their customers need to have a large-scale production. A I10 mention, an early-stage startup developed an App that works with small farmers trying to connect them with local retailers to sell their products.

> "It was identified that as these farmers are in disadvantaged areas, they have difficulties in delivering and storing their fresh produce. [...] Also, they don't have the demand power and capabilities to move things around that are able to serve the community. This App shows the products that small farmers have, and the local retailer gets on it to purchase the products" (I10).

LaunchLab promotes some community events, where everybody is invited, so brings entrepreneurs, university students, stakeholders, and the audience for the event, which might be some small farmers. "This kind of event provides joining small rural producers, the funding investors, the customers, the entrepreneurs, all in the same place" (I10).

Innovus is a division of Stellenbosch University that is responsible for technology transfer, entrepreneurial support and development, and innovation. The TTO manages the University's innovation and intellectual property portfolio through seeking relevant intellectual protection for the university's intellectual property portfolio such as patenting, trademark, design and other forms of protection, and also, responsible for managing the portfolio and commercialize innovation through licensing and the formation of spin-out companies (Innovus, 2023). Innovus offers some short courses and supports the students, their advisers and research groups to develop their ideas. They have a network to make the bridge between students (entrepreneurs) and the companies, but not for all kinds of technology. For instance, they have few contacts in their network for agricultural industries, for this reason, they have a partnership with Wesgro, the official tourism, trade and investment promotion agency for Cape Town and the Western Cape. It can help uncover these opportunities, by assisting investors and businesses looking to branch out into the province (Wesgro, 2023).

One of the nine sectors worked in by Wesgro is Agribusiness. According to Wesgro (2023), as the agribusiness sector is a key component of the Western Cape's economy, Wesgro's Agribusiness Investment Unit aims to attract and facilitate foreign and domestic investment into the Western Cape's agricultural sector and, also focuses on retaining existing investments and supporting their expansions in the agricultural space. According to I8, Wesgro can be considered an important actor from the WCIE, which is maintained with government and private sector resources.

There are also some specific actors for the agri sector, like Research Institute for Innovation and Sustainability (RIIS), Vinpro and Winetech (Wine Industry Network of Expertise and Technology).

RIIS works with a range of private and public sector organizations helping the acceleration of innovation programs through collaboration and partnerships across organizations' value chains (RIIS, 2023). RIIS has built innovation platforms for both public and private sector organizations, international development agencies and government departments (RIIS, 2023).

Winetech is an independent South African non-profit company that receives and manages the research statutory levy from the South African wine industry (Winetech, 2023). "We do research from the soil to the bottle" (I12). It has four core functions: Research and Development, Knowledge Transfer, Innovation, and Learning and Development (Winetech, 2023).

According to Interviewee 12, Winetech has industry partners to do technology transfer in all regions for them. Also, they sit around the table with researchers and wine industry people to analyze critical things that must be done in South Africa, focusing on water scarcity, climate changes and breeding programs (less pesticides use). They have an innovation committee that is looking specially on innovation projects.

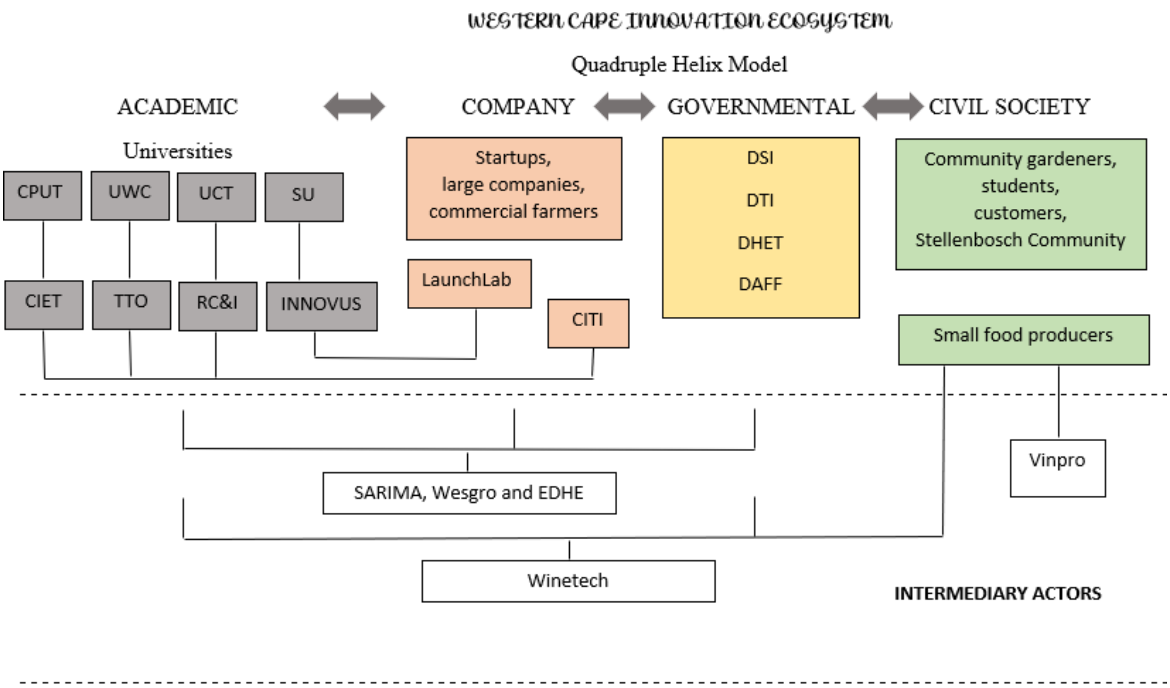
Winetech has an Innovation Ecosystem for Industry to translates academic research into commercial ventures and grows the industry through innovation; attracts start-ups and students to participate in pitching dens and open innovation competitions; delivers outcomes that lead to process, product and business model innovations; and attracts investment for innovation in the wine industry (Winetech, 2023). It operates as a network of participating institutions and individuals that have a strong interest in improving the competitive position of the South African wine industry by funding research and knowledge transfer (Winetech, 2023). Some research partners in Winetech network include: ARC-Infruitec-Nietvoorbij, CPUT, Confronting Climate Change, South African Society for Enology and Viticulture, SU, UCT, University of Pretoria, UWC, Vinpro and Wineland Media (Winetech, 2023).

Winetech works more generally in terms of sustainability but also works specifically with organic producers. They are working with Vinpro and Western Cape Departments of Agriculture on some ideas regarding the energy problem in South Africa.

Vinpro is a wine producer organization. It is a non-profit company which represents close to 2.600 South African wine grape producers, cellars and wine-related businesses, while providing strategic direction, rendering specialized services and prioritizing people development (Vinpro, 2021). The organization liaises closely with government and industry role players on issues that have an impact on the profitability and sustainability of its members and the industry as a whole, keeping its members and the broader industry informed of industry trends and technical expertise and renders specialized services ranging from soil science to viticulture, agricultural economics and transformation and development (Vinpro, 2023). According to I13, most of the wine producers in South Africa are associated with Vinpro.

In Figure 3, a mapping of the WCIE with the actors is presented.

Figure 3: Mapping of the Western Cape Innovation Ecosystem



Source: Prepared by the authors (2023)

Discussion

Food Producers Partnership

Regarding the small food producer's partnership, it was observed from the study interviewees that they have contact with their customers and exchange information with them.

Some of the respondents don't have any partnership, and as I10 mentioned, people think if the business is going well, why they would have to change. I10 suggests that they have to have an open mind, the mind opened to ideas, we call disruptive innovation. This is a big challenge in the innovation process. Partnership leads to a joint evolution and co-creation of value that none of the partners would be able to create alone (Scaringella & Radziwon, 2018).

From the other side, as I4, I5 and I6 (vegetables organic producers) take part in the PGS group, they make relevant exchanges and contact with other organic producers. It was observed that they have a good flow of information inside this group, generating knowledge, corroborating with Serenko et al. (2010) when they mention that knowledge is a result of human interaction. Furthermore, Saenz and Perez-Bouvier (2014) mentioned that interorganizational collaborative relationships can enable access to a large amount of knowledge for innovation processes.

The small food producers mentioned that they have never received students from university, but I4 and I5 are open to receiving and exchanging knowledge. According to the study from Bittencourt and Figueiró (2019), the university can help the ecosystem with the technical knowledge and linkage to build the ecosystem. So, having the universities involved with the small food producers will help to develop knowledge. Following Bittencourt and Figueiró (2019), the interviewees I14 and I15 got support and technical knowledge from Stellenbosch University to develop their business, becoming part of the innovation ecosystem.

WCIE´s Actors Partnership and Structure

The study shows that, according to the quadruple helix model (Carayannis & Campbell, 2009), there are many actors involved in the WCIE. In the academic group, four universities, their research centers and TTOs participate in the WCIE: UCT, SU, CPUT and UWC. In the group of companies, the WCIE is formed by startups, large companies that invest in the projects and research, CITI (from UCT, CPUT and UWC) and LaunchLab (from SU) as business incubators and commercial farmers. The governmental group of actors is responsible for the institutional conditions (Santos, Zen & Bittencourt, 2021). The actors from this group are the Department of Science and Innovation (DSI), Department of Trade and Industry (DTI), Department of Higher Education and Training (DHET) and Department of Agriculture, Forestries and Fisheries (DAFF). Finally, civil society covers all individuals and organizations that benefit from innovation and help achieve it (Santos, Zen & Bittencourt, 2021). Some actors were identified in the WCIE, like community gardeners, students, customers and the Stellenbosch community.

Regarding the small farmers and food producers, considering the quadruple helix model (Carayannis & Campbell, 2009), it is important to point out that it looks like they have a role more as a civil society than as a company. It´s perceived in different moments that interviews indicate that ecosystem programs and actions are not focused on rural producers, but on agritechs. So they benefit of what is developed in WCIE, but they are not part of the group that transforms the knowledge generated into solutions for the ecosystem challenges.

It was identified that there are some intermediary actors which are not active in WCIE, but are particularly important for a specific sector (wine): SARIMA, EDHE, Wesgro, RIIS, Vinpro and Winetech.

It was observed that the actors from the WCIE are engaged to develop innovation. The participation from different actors is essential to develop the ecosystem and to generate innovation, as it was pointed out by Bittencourt and Figueiró (2019).

LaunchLab and Innovus have partnerships with agri companies, but they don't have anything specifically with small food producers. Although they do try to make connections with small food producers, the information does not reach the small food producers interviewed in this study.

It was identified that the main actors from the WCIE are university, government and companies. This result is aligned with I8 view and also with Calamel et al. (2012) when mentioning the need for coordination among multiple actors in innovation projects.

Also, it was observed that there are some specific actors for the agri sector, like Research Institute for Innovation and Sustainability (RIIS), Vinpro and Winetech, specially for the wine industry, which is well developed in the region. In this scene, it can be noted that it could have sub ecosystems within the WCIE, as it was mentioned by I8. For instance, a specific ecosystem for the wine sector.

In the end, considering the adopted classification, it's possible to point out who belongs to each quadruple helix actor group (Figure 4).

Figure 4: Identification of the ecosystem actors

Actors	
Academia	Universities: UCT, SU, CPUT and UWC Innovus CIET (Centre for Innovative Educational technology) RC&I (Research Contracts and Innovation) TTO (Technology Transfer Office) RIIS (Research Institute for Innovation and Sustainability) Winetech (Wine Industry Network of Expertise and Technology)
Companies	CITI (Cape Innovation & Technology Initiative) LaunchLab SARIMA (Southern African Research & Innovation Management Association) Knowledge-based firms Technology firms
Government	DSI (Department of Science and Innovation) DTI (Department of Trade and Industry) DHET (Department of Higher Education and Training) DAFF (Department of Agriculture, Forestry and Fisheries)
Civil Society	Vinpro, PGS, small food producers, members of Cape Town and Stellenbosch community.

Source: Prepared by the authors (2023)

Conclusions

Based on the secondary data, it can be affirmed that Cape Town, as well as the Western Cape region, develops a series of actions for the development of technological innovations and startups. In 2019, Cape Town made the top 30 global tech cities in the Savills Tech Cities Index, the only African city on this list (FMT, 2020).

Agriculture is one of the primary pillars of the Western Cape economy (LEAD, 2021). The South African government recognizes agriculture and agri processing as critical drivers of economic growth, employment, and a platform to increase exports through various strategic governmental plans. To this end, despite challenging global economic conditions and rising input costs, South Africa's agriculture and agribusiness sectors remain key priorities, with the national government implementing several measures to stimulate these sectors in recent years (Wesgro, 2022).

In this way, based on in-depth interviews with organic and conventional food producers and specialists, it was possible to identify and have a clearer understanding of quadruple helix actors in the WCIE. Furthermore, it seems small food producers have a role more as a civil society than as a company. It´s perceived in different moments when interviewees indicate that ecosystem programs and actions are not focused on rural producers, but on agritechs. Finally, it was observed that there are some specific actors for the agri sector, which is well developed in the region. In this scene, it can be noted that it could have sub ecosystems within the WCIE, for instance, a specific ecosystem for the wine sector.

This research of innovation ecosystems in rural environments is an important topic of study, since a good part of the research in territorial contexts is carried out in urban environments.

The development of this research in the WCIE advances in the knowledge of the theme, also allowing the exchange of knowledge between countries. It was concluded that there wasn´t a pattern to develop an innovation ecosystem and occasionally, some actors cannot have just one role, working more as facilitator to join the actors inside the innovation ecosystem. As Bittencourt and Figueiró (2019) suggest, it is important to consider innovative proposals, where companies take on the co-responsibility of transforming the region in which they are inserted, involving different actors in the innovation process.

From the conclusion that ecosystem programs and actions are not focused on rural producers, some practices should be implemented trying to bring these actors inside the innovation ecosystem, in order to develop them. It was observed that they are open to innovation, and they just need an opportunity to take part in the innovation ecosystem. The university can help the ecosystem with the technical knowledge and linkage to build the ecosystem (Bittencourt & Figueiró, 2019), in this scene, the four universities from the Western Cape could develop actions specifically for small rural producers. They don´t have access to this kind of knowledge space and sometimes there are far from them. The small rural producers, becoming part of the innovation ecosystem, will be seen as companies instead of civil society.

Additionally, some support from the government is suggested, like some policy implemented specifically to the small rural producers.

This study also is aligned with the Western Cape's agribusiness opportunities, pointed out on Wesgro research (2022). It was mentioned as opportunities to develop organic production methods and to extend production of organic products for domestic and export markets (Wesgro, 2022).

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POST-SALE: A CASE REPORT IN THE PARTS DEPARTMENT OF AN AGRICULTURAL DEALERSHIP IN RIO GRANDE DO SUL - BRAZIL

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Abstract: This study aims to analyze the customer relationship in the after-sales at an agricultural dealership in Palmeira das Missões - RS - Brazil. Based on the IDIC (Peppers andRogers, 2001) and the 4R's of relationship marketing (Barnes, 2002) methodologies and the development of a model, the IDRR, a questionnaire consisting of 35 questions was applied to 27 customers of the agricultural machinery company Guarita Comercial Agrícola LTDA. As results, the study presented aspects of differentiation such as planted area and types of culture,in sequence the relationship with the customer highlighted as agile service and cost x benefit of equipment and the dynamics of retention highlighted for the care of employees and loyalty after the warranty period. It also presents the IDRR model of the researched company. Finally,it showed that customers are satisfied with the after-sales department, however, improvementsmust be sought from management to the delivery of a product or service to the customer, so that it meets the immediate and future demand following the evolution of the sector and beingside by side with the producer, maintaining the quality and the best cost x benefit.

Keywords: IDIP, 4R´S, Customer Relationship Management, CRM, agricultural machinery

Introduction

Technological advancement and in agriculture boosted agricultural productivity rates in Brazil, impacting the use of smarter machines, genetically modified cultivars and improvedsoils in aspects of fertility. As modernization and the process of new macroeconomic policies were consolidated, Brazil became a major world player in food production (ARAÚJO, 2007).Between 1977 and 2017, grain production grew more than five times in Brazil, going from 47million tons to 237 million tons. While the planted area grew only 60%, the soybean crop doubled its yield, wheat and corn had even more significant increases, producing 240%, according to records of the National Supply Company (CONAB, 2018).

Agribusiness accounted for about 27% of the national GDP (Gross Domestic Product)in 2022, according to the Center for Advanced Studies in Applied Economics (CEPEA/ESALQ/USP). In 2022, the production of grains in Brazil was estimated at 271 million tons, even in the face of unfavorable weather conditions. It is evident that agribusinesshas evolved significantly in recent years, as well as the technology embedded in the equipment.Technological innovation presents itself as an alternative to improve flexibility, adaptability, and productivity in agribusinesses, as well as to reduce production costs and working time (YANG et, al., 2021). Machines work collaboratively, with efficient, sustainable, productive and intelligent processes (KUMAR et al., 2021; LEE et al., 2015). The new paradigm of industrial production extends to the agricultural sector. Industry 4.0 comes to the countryside in the form of Agriculture 4.0. Technologies, therefore, change agriculture, increase efficiency,productivity, and reduce environmental impacts, among other benefits. In the case of agricultural machinery and implements, they bring more automation and precision in farm services (BOLLINI et al., 2019; MUKHERJEE et al., 2021; MÜHL et al., 2022). As for example, tractors, planters, sprayers, and harvesters that over the years have undergone major changes, machines currently equipped with systems programmed to develop faster work and in a short period of time.

Precision farming, specifically with regard to agricultural machinery, including Global

Positioning Systems (GPS), autopilot, area mapping, grain moisture and quantity harvested, brought the producer a great level of quality in work, allowing cost reduction and time management, which can be used in other activities. Thus, precision agriculture is not only in agricultural equipment, but also in farm management (LING et al., 2017; SCHIMMELPFENNIG, 2016).

For the farmer to achieve his goals, the agricultural machinery industry must also be aligned with his needs. Companies in this sector, have always had a great importance within agribusiness, even in the midst of the COVID-19 pandemic, it was one of the activities that. While commerce and other activities had to close their doors, agribusiness was operative, making products and solutions reach the consumers, elements that were essential to maintain the relationship with the clients.

For Nunes et al. (2017) the explosion of technification and agricultural mechanization,as well as precision agriculture, has stimulated higher levels of competitiveness in the agricultural machinery sector. A factor that encouraged agricultural implements and equipment dealers to recognize the importance of knowing and building customer loyalty, customer retention has become synonymous with high profitability. The authors also point out that quality and price cannot be adequate differentiators for customer loyalty and relationship management. Relationship strategies have become crucial for the survival of organizations, knowing how to meet customer needs and expectations contributes to effective economic results. Moreover, with the evolution of agriculture 4.0, the buyer also collaborates in the improvement of products and processes (MUKHERJEE et al., 2021). In this sense, CRM (Costumer Relationship Management) tools have emerged as business strategies to understandand impact customer behavior (MISHRA; MISHRA, 2009).

Thus, in the context of agricultural machinery and the constant search for customer retention in competitive scenarios, is the company Guarita Comercial Agrícola Ltda - Valtra Dealer, in Palmeira das Missões, northern region of Rio Grande do Sul, authorized and specialized in reselling Valtra agricultural products. With the increase in demand, the companyseeks strategies to conquer new customers, keep the ones it already has, and win back those who for some reason were dissatisfied.

When the customer buys a machine to add to his fleet, he expects to have fast and efficient assistance from the spare parts department, which is quickly identified and available for replacement in his machine, avoiding more time without working. Besides offering genuineparts with quality, the company must focus on training for technicians, this ensures that the part is assembled according to standards, minimizing downtime and obtaining customersatisfaction. It is important for companies to emphasize after-sales, as it is a crucial aspect fornew business. Any failure that can stop a machine and not having the part to replace it, makesit a reason for dissatisfaction between customer and company. Knowing the need for strategicreplacement to meet the demands of harvests and inter-harvests is valuable for the relationshipwith the customer.

Given the need for constant improvement in customer service and standardization in the services provided to build customer loyalty to the company, the study aims to analyze the customer relationship in the after-sales in an agricultural dealership in Palmeira das Missões -RS. Therefore, it is sought to answer the following research problem: "How is the customer relationship in the after-sales with the Guarita Comercial Agrícola LTDA company?"

Theoretical Background

IDIC Model (Identify, Differentiation, Interaction and Customization)

An instrument that helps the management of the CRM process is the IDIC model proposed by Peppers and Rogers (2001). IDIC means identification, differentiation, interaction and customization. These steps are a sequence that can happen simultaneously or not, the maingoal is to create an interaction cycle that consolidates CRM (Table 1).

Table 1 - IDIC Model

	Identification	Differentiation	Interaction	Customization
Source of benefits	Clean data about customer Single Customer View	Understand customer	Customer satisfaction and loyalty	Customer satisfaction and loyalty
Benefits	Help sales force Cross selling	Cost effective marketing campaign Reduce direct mailing cost	Cost effective customer service	Lower cost of acquisition and retention of customer Maximize share

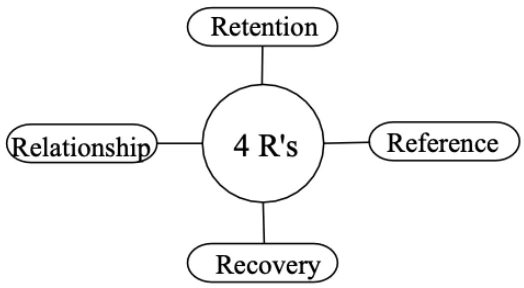
Source: Lendel, Viliam. (2008). The decision-making about the selection of CRM information system. Journal of Information Technology Control and Management Systems. 6.

The first step is to identify the customer, this should be done by recording informationabout his identity, demand, objections and preferences, so that the company can always providecontinuity of service. Knowing that each customer is unique, the service should be standardized among all departments of the company, aligning the exclusivity for each service, regardless ofthe sector that will meet the demand. In the differentiation stage, the customer can be classifiedby the value added to the company, or even by the need, still the authors report that the addedvalue is the sum of all volumes of profitability that it provides the company, while the needs refer to the customer's expectations regarding the products. The interaction with the customer is the evolution of each new conversation, advancing in the identification of a need and alwaysmoving towards a new negotiation, interacting goes beyond knowing the customer, it is a constant learning about their demands and exiguities. Customization offers what the customerreally needs, for this to be possible it must already be differentiated, so it is possible to identifyyour preference for price, time and product, offering what exactly approaches your desire. Themore personalized the service, the greater the constancy of sales (PEPPERS; ROGERS, 2001).

4R's of Marketing Relationship

Just as basic marketing has the 4Ps, relationship marketing is based on the 4Rs, these elements were created as an alternative to improve the relationship with the customer. Regarding the 4Rs, Figure 1 shows the process.

Figure 1 - 4 R's



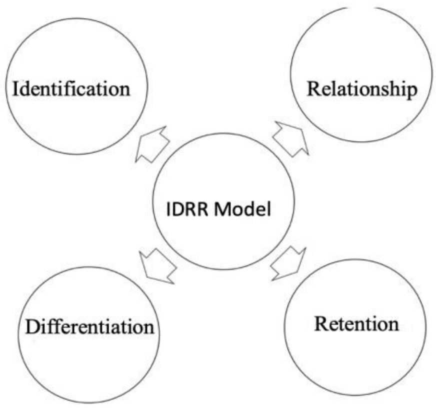
Source: Adapted from Barnes (2002).

Retention is a way to keep customers through differentiated attitudes, not only having their expectations fulfilled, but also exceeded. The author also points out that retention is less costly than seeking to attract new customers (Claro, 2006). The relationship happens when thecustomer is loyal to the company, due to the service they received and remains satisfied, evenin the long term. The feeling of not being just a client, but part of the company, makes the customer feel part of the company and not just an ordinary consumer (Pavoni et al., 2009). Barnes (2002), proposes that reference is to obtain customer satisfaction with the services and/or products that the company offers, the effect of this customer satisfaction makes the customer share the experience he obtained with acquaintances, thus making more people become customers. Claro (2009) emphasizes that to recover is, practically, to perform recoveryactivities of customers lost due to some dissatisfaction. To Pavoni et al. (2009), he says that mistakes made can become opportunities to impress the customer and consequently recover hisloyalty, but it is not only reclaiming the customer, it is showing that he is important in the context of the company.

Theoretical analytic structure to be explored in the study

In relation to the theoretical analytical framework explored in this study, Figure 2 presents the elaboration of the IDRR model (identify, differentiate, relationship and retain).

Figure 2 - IDRR Model



Source: Adapted from Barnes (2002) and Pappers and Rogers (1994).

In this study, we highlight the IDIC and 4R's methodologies of relationship marketing,each of the methodologies mentioned present 4 variables. However, for this study, 2 variablesfrom each methodology will be used. In IDIC methodology, the following variables will be considered: 1) customer identification and profile; 2) customer differentiation. In the second methodology (4R's of marketing), the following variables will be used: 3) customer relationship; 4) customer retention. Thus, integrating the use of the aforementioned methodologies and concepts, the model called IDRR (identify, differentiate, relationship and retention) was developed in this research, where each of the variables selected are fundamentalto the analysis of the results.

Identifying the customer is the first step within the post-sale, knowing who the customeris and what he expects is paramount for the company, differentiate each customer is essential for those who will serve them, because through this they will know what the customer really needs from the service to a sale, relationship is to know how to understand the customer, listenand meet their expectations, retention seeks to maintain customer loyalty within the company,achieving their goals and also the goals of the organization.

Methodological Procedures

The questionnaire was built based on the IDIC model (Pappers and Rogers, 1994) and the 4R's of relationship marketing (Barnes, 2002). It was divided into five blocks: 1) classifiedthe customer profile with four multiple-choice questions; 2) aimed at differentiating the customer through four questions, also multiple choice; 3) looked for the identification of thesecustomers, with twelve questions, some multiple choice and others on a Likert scale; 4) addressed the relationship, consisting of eight multiple choice questions and also on a Likert scale; and 5) focused on retention with seven questions.

The study universe were customers of the company Guarita Comercial Agrícola LTDA,with headquarters located in Palmeira das Missões - RS, totaling sixty customers who made new acquisitions within a period of two years, i.e., active customers in the company. Inside thisuniverse, a sample of twenty seven participants resulted, using the non-probabilistic sample, since the interview criteria determined the participation of active clients only, being a sample by convenience and reference (snowball).

The survey was conducted in the months of October and November 2021 online for customers who make use of the WhatsApp tool, obeying the rules defined for social distancing.The questionnaire sent was developed through Google Forms, through an access link, and sentto the target audience of this study. The data was tabulated with the help of Microsoft Excel tobuild dynamic tables and graphs for a better understanding of the results found. The data analysis was carried out descriptively, based on the literature and theoretical models.

Results and Discussions

IDRR Model of Guarita Comercial Agrícola Ltda Company

Identification and Guarita Comercial Agrícola LTDA Customer Profile

For any relationship, the first step is to identify and get to know the customer, which goes beyond knowing his name and address. It means understanding what he needs and attending to his expectations according to his profile. In this item, the identification of the customer and profile variables will be addressed.

Although many women are already present in the field, not only in the administrative part, but also in front of the production and even of the decisions, in this research it is observedthat in relation to the decision to buy machines it is still made by the man. The questionnaire sent to customers encompassed female and male customers, however, there was no return in the research in relation to the female gender, presenting 100% of male respondents.

Regarding the age of the respondents of the questionnaire, most respondents are in therange of 35 to 44 years and 45 to 54 years, amounting to a percentage of 62.93% of respondents.The minority is between the age brackets of up to 24 years and 25 to 34 years, totaling a percentage of 22.2% of respondents.

As for how long you have been working in the agricultural area, 66.67% has more than21 years of performance in the agricultural area, between the ranges of 6 to 10 years and 11 to20 years, the total percentage obtained is 29.63%. The lowest percentage obtained in the surveywas 3.70% where some respondents act in up to 5 years within the agricultural area.

It can be analysed that almost 70% of respondents have more than 20 years of experience in agricultural activity, which shows that the succession in agriculture is made from generation to generation, being a cultural aspect of passing the responsibilities to the children heirs, even if in many cases there has not been a preparation of these young people, to take over the command of the inherited property.

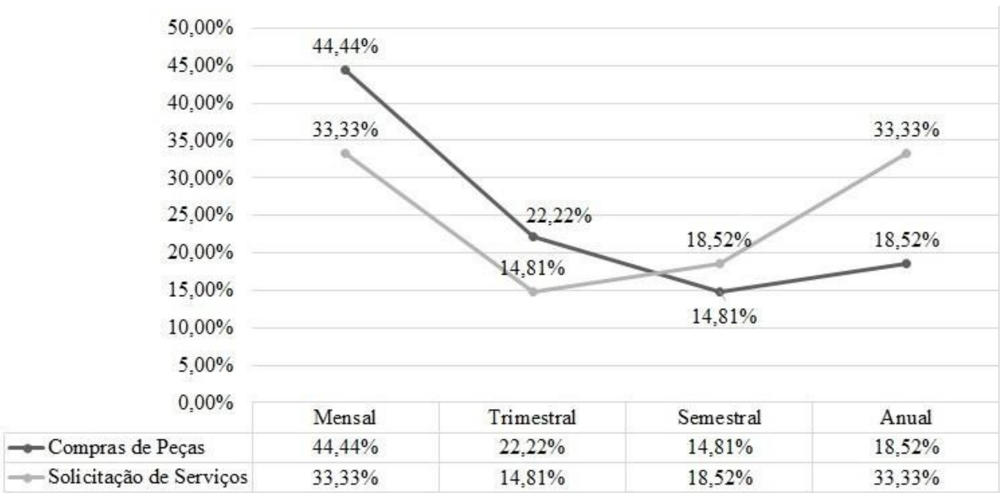
When it comes to the respondents' schooling, 44.44% have completed high school, theportion of higher education had a result of 33.33%. The lowest indices presented in the surveywere of post-graduate and primary education, with the percentage of 11.11% of each level. Thedifficulty of attending higher education was due to the fact that the municipality had a university less than 15 years ago, which made it difficult for the producer to seek a degree, even knowing that courses in the region are offered, the daily commute or even the change of city is something difficult, and often because the family itself does not support the completionof a higher education course.

However, the percentage of 33.33% presented in the survey, highlights the younger audience of this study, through opportunities even financial and family incentives to obtain higher education, where the focus is the search for knowledge so that it can optimise their productivity within agriculture, aiming for new concepts and putting them into practice. This is possible because in the last ten years the municipality and the region were contemplated withthe establishment of universities and technical courses, providing greater opportunities for young people seeking to improve their knowledge.

With regard to the purchase of new machines at the dealership, 33.33% of the respondents buy new machines at the dealership within 3 years, while some respondents buy new machines on average from 4 to 7 years, totaling a percentage of 29.63%. The lowest percentage obtained in the survey was 14.81%, where respondents buy new equipment on average from 8 to 11 years.

Given that these are products that have a long useful life and involve major investments, machine sales are often renewed after years of use and, even so, when acquired, price, quality, technology and other aspects that are essential to meet each customer's demand are researched.A complex purchase requires long negotiation processes and demands that all aspects of the product be informed to the acquirer until the sale is concluded. The objective of renewing the equipment in the property in up to 3 years aims to possess the newest technological machinery,reducing the number of maintenances that, consequently, it will reduce the expense with the exchange of parts and services, in addition to obtaining guarantee of the product which reducescosts to the producer. Regarding the frequency of purchases of parts and services, Figure 3 presents the results.

Figure 3 - Frequency of parts purchases and service requests



Note that the frequency of purchases of parts is higher in relation to the request for monthly and quarterly services, this is because many customers choose to make the replacement of parts in a more practical way. The request for services is higher in relation to the biannual and annual period, this is due to the fact that in certain periods there is harvest andplanting, which requires specialized technical work, with less demand for counter sales and increased sales through services.

Regarding the problems faced when purchasing parts at the counter, most respondents 44.44% never had problems when purchasing parts at the dealership counter, a large result thatdraws attention is in relation to the price of parts, about 37.04% reported that a problem facedis the price of parts, however, the price issue is something cultural of the region, where producers always aim to get the most discounts possible in the acquisition of parts for maintenance.

In terms of maintenance, 51.85% of the respondents perform maintenance on their own property, around 37.04% seek services at authorised dealerships and, the lowest index in the survey was 11.11% who seek multi-brand mechanics to perform maintenance. Many customers, for having an empirical knowledge about the machines, choose to perform some maintenance on their equipment at their own risk, but the lack of specific tools for the equipment makes the producer need a specialised workforce, demanding service at the dealership.

Guarita Comercial Agrícola LTDA Customer Differentiation

Being able to distinguish each customer is offering a personalised service, which seeksto deliver products and solutions that are in accordance with their reality, optimising business for customer and company. This item will address the aspects of differentiation of thecustomers of Guarita Comercial Agrícola Ltda.

Regarding the amount of planted area, over 55% of respondents have more than 900 hectares and regarding the types of plant crops on the property, it appears that 100% of respondents are soybean producers, 96.30% of customers say they plant oats and 85.19% growwheat as winter crops, 77.78% grow corn and only 11.11% grow some area of beans.

The percentage of soybean shows how much the producer invests in this type of crop, because it is a profitable and lucrative crop, much of the summer crop is focused on soybean, not leaving corn aside, as a profitable and high-production crop. According to data from IBGE(Brazilian Institute of Geography and Statistics, 2020) the planted area in Rio Grande do Sul
of soybean production, reaches the mark of 5,996,371 hectares with estimated production of 11,294,683 tons of soybeans.

Subsequently, in relation to types of Valtra equipment on the property, it is noted that 100% of respondents said they have Valtra brand tractors on their properties, for 62.96% said they have Valtra planters, 48.15% said they have Valtra brand harvesters and 29.63% reportedthat they have Valtra brand sprayer on their property. Valtra is highlighted in the world, Braziland in the state of Rio Grande do Sul. As it is a brand with solidity in the market, every day itis innovating and growing in its portfolio, never leaving aside the robustness and technology that are essential in the field.

Considering the choice for replacement parts, the respondents affirm that 37.04% seekto replace the parts according to the cost X benefit of each part, another factor 33.33% opt foronly the price variable, 25.93% use only genuine Valtra parts in their equipment, and 3.70% ofthe respondents did not know how to inform. The market has several options of parts similar to the original, however, using genuine parts goes far beyond maintaining the original characteristics of the equipment, it is in the useful life of the machine and also in the longevityand quality of the parts, optimizing the work in the field with less stops for replacements.

Regarding information about the execution of the service, it can be noticed that 77.78%of the respondents are informed about the progress of the service being executed within the company, but 14.81% said that sometimes they are informed about the maintenance and 7.41%were never informed about the progress of the service. Being aware of the service progress is fundamental for the customer, both to know the status of his machine and to be informed of what is being replaced in the overhaul for the equipment to operate normally again.

According to Almeida (2001), the ideal for an institution is to make all possible channels available to the customer and for all these channels to be interconnected in a single database. Technology makes the proximity between customer and company become frequent,therefore, using tools that can inform the customer about each step in the realization of the service, becomes a differential within the segment.

With regard to the service conclusion during the estimated timeframe, 61.54% stated that the service was not concluded according to the forecasted timeframe. For 30.77% of the respondents informed that the service was concluded within the deadline, 7.69% did not knowand 3.85% said that the service was concluded within the deadline. The non completion of theservice within the stipulated period, leads to customer dissatisfaction and delay in other services, being able to solve the problem is something essential to the concessionaire, but thereare several variables that may interfere with the delivery of equipment in operation within thestipulated period.

But creating an expectation of the customer in relation to the delivery deadline may bring benefits to the company if the goal is met, or even, losses if the promise is not achieved.For Kotler (2006), satisfaction consists of the feeling, pleasure or disappointment, compared tothe perceived performance of a product on the expectations of the buyer.

In addition, it is worth noting that, according to the results of the technical visit, 51,85%of the equipment problems were solved in the first technical visit, 37,04% informed that the problem was not solved at the first consultation and 11,11% did not know how to inform. Theequipment problems that were solved on the first visit are due to the mechanics' technical knowledge regarding the solution of the problem, involving the necessary tooling for use and available parts for replacement.

However, it is important to point out that 44,44% of the respondents do not know the real reason for not having the problem solved on the first visit, for 37,04% of the respondents, they say that the real reason was the lack of parts to solve the problems. For 11,11% of respondents the lack of technical knowledge and 7,41% lack of tools to perform the work. Thelack of parts is something that causes the dealership to lose market share. This is due to the factthat equipment stops working and there is no part to replace and start operating again, makingmanagers focus special attention on the replacement of parts stock.

Regarding the probability of making new acquisitions through Guarita Comercial Agrícola Ltda., 70,37% would make new acquisitions through the company. For 14,81% of therespondents, they did not know whether or not they would do new business, and about 14,8% would not do more business through the firm.

With regard to service delays due to lack of parts, 48,15% of respondents said that theservice stopped because there was no genuine part available in stock for the equipment to operate normally again. Also, 37,04% suffered from the lack of parts, but it was solved in an agile time to return to work normally. Of the respondents, only 11,11% did not suffer with thelack of parts and 3,70% could not inform. When the customer seeks service from the dealership,is in search of a quick and effective solution, when a service performed by the technical team is paralyzed by the lack of parts makes the customer feel aggrieved in relation to his choice forthe brand, making it necessary a strategy to improve this failure.

The lack of parts involves several variables that often are not controllable by the purchasing department, logistics is one of the key parts to have the part available to the customer, but the raw material is the first step to obtain a part, the lead time between request and arrival of the part is something that should always be analyzed, from the minimum stock until the arrival of new items to make up the stock.

Regarding the error in the purchase of parts, 74,07% of customer purchases made at theparts counter of Guarita Comercial Agrícola LTDA, were sold and separated correctly, while 14,81% of respondents said that the seller sold the wrong part and 11,11% said that the separator packed the wrong part. The research pointed out that it is necessary to improve the salespeople of parts, giving new courses on machines and handling catalogs, in view of the factthat human failures can be avoided with improvements to avoid simple errors such as a separation of parts.

Guarita Comercial Agrícola LTDA Customer Relationship

Obtaining a good relationship with the customer is essential for any company, in this aspect knowing how to listen to the customer is crucial to achieve their expectations. In this item, we will address issues about the customer's relationship with Guarita Comercial AgrícolaLTDA.

In relation to the characteristics of Valtra products, 66.67% said that the most outstanding characteristic is the cost X benefit ratio, for the two variables Valtra Equipment Performance and Product Quality had the same percentage of 16.67%, The reliability variablepresented 12.50% of the most outstanding characteristics in Valtra products. In regards to the characteristics that most please customers in the after-sales, the variable agile service attendance presented the largest share of after-sales characteristics, with a percentage of 44.44% of the respondents, for 33.33% the main characteristic is the warranty variable, followed by the quality of genuine Valtra parts with 18.52% and with 3.70% the parts availability variant.

This study evidenced that the speed in the execution of the service is something essential for the customers of Guarita Comercial Agrícola LTDA, optimizing the production inside the property and reducing the time of machine stop for presenting some mechanical problem, being fundamental for the manager to understand the process since the request of theservice until the delivery of the equipment in operation. Moreover, within the post-sale, it is possible to know each customer and understand his needs, at this very moment it is possible toraise new negotiations because it is known the lifetime of the equipment and before that a newsale may arise.

The respondents reported that the lack of parts availability is something that disappointsin the after-sales, with a percentage of 51.85%, the warranty variable presented 25.93% of disappointment among the respondents, followed by the lack of agile service attendance with 14.81% and 7.41% of the respondents emphasize that the variable lack of quality of Valtra genuine parts disappoints them in the after-sales.

The absence of a part not only disappoints the customer but also brings him harm because a stopped machine for lack of a part can cause big losses to the customer and make theproducer feel damaged when he can not get a replacement part within a short period. Analyzingthe demand for parts is something important within the company, focusing on the analysis of demand is something primordial within this context, especially when it comes to equipment that needs to be always operational.

Concerning the characteristics that most disappoint in Valtra products, it can be noticedthat 37.04% of the respondents affirm that the cost X benefit is something that disappoints in Valtra products, for 22.22% the lack of quality in products, 18.52% affirm that the lack of trustin the brand disappoints and 11.11% state that the equipment commercialized by Valtra and the lack of equipment of the brand.

Analyzing the level of customer satisfaction, according to each product or service requested, it is noticed that the levels of satisfaction among these variables oscillate in percentage, the variable buying machines and implements obtained a percentage between satisfied and totally satisfied of 74.07%, however, the index of dissatisfied and totally dissatisfied obtained a percentage of 18.51%, the lowest percentage obtained in this variable was where respondents could not say whether they were satisfied or not with the purchase of their machine or implement.

The variable of purchase of parts presented its lowest index between totally dissatisfiedand dissatisfied, where it reached the mark of 7.4% of respondents, the variables of higher percentage, concentrated between satisfied and totally satisfied, totaling 66.67% ofrespondents, the percentage of respondents who could not say whether or not satisfied obtained a percentage of 25.93%.

With regard to the service request variable, 70.37% of respondents said they were satisfied and totally satisfied, 14.82% said they were totally dissatisfied or dissatisfied with theservice, and 14.82% could not say whether or not they were satisfied. In the variable technicalassistance via services, the percentages obtained in the survey were higher between satisfied and fully satisfied, obtaining a total of 62.94% of respondents, the variables of totallydissatisfied and totally satisfied obtained a total percentage of 22.22% and the variable where the respondents did not know whether they were satisfied or dissatisfied, had as obtained a percentage of 14.81%.

It can be analyzed within these variables that the percentages of both oscillate betweentotally dissatisfied to totally satisfied, obtaining a need for customization of the portfolio offerand an exclusive service in sales of parts sales and service provision. The company must knowwho its customers are, get the best way to conquer them and have their loyalty. Customers need to be identified and understood, seeking satisfaction and loyalty as instruments for strengthening in the market (BOGMANN, 2000).

Guarita Comercial Agrícola LTDA Customer Retention

Retaining the customer within the company after a sale is important for theorganization's health, hence, keeping the customer active is to optimize the company'srevenues and target customer loyalty to the brand. In this item, aspects of retention of GuaritaComercial Agrícola LTDA. In terms of the highlight, a large part of the respondentsemphasized as a positive point the customer service of employees, with a percentage of 59.26%of respondents, the lowest percentage obtained in the survey was the easy negotiation as apositive point. Through the analysis, it can be noted that the cordial service of the collaboratorsare fundamental to attract, maintain and retain customers, being one of the highlighted points.Regarding the reason for choosing the company for new acquisitions, the respondents reported that the best price offered, cost X benefit and ease of negotiation, totaling a percentage of 77.79% of respondents. In terms of recommending the brand to friends or acquaintances, 59.26% of the respondents would recommend the brand to their friends or acquaintances, while29.63% were unsure about such a recommendation and only 11,11% said they would notrecommend the brand to their friends or acquaintances. The result of this questioning raisesconcerns about customer loyalty, since less than 60% of respondents would recommend thebrand, even being the majority, the percentage who do not know or who claim not to recommend is reasonably high and represents a risk to the longevity of the company.

In relation to the guarantee, 66.67% said that the processes and deadlines wereexplained clearly, while 25.93% informed that they received no guidance regarding deadlinesand guarantee conditions and only 7.41% did not know how to inform. Also for 48.15% of therespondents, they state that when they requested the guarantee the part was replaced, while 33.33% informed that Valtra denied the part guarantee and 18.52% did not know how to inform. The warranty of the equipment makes the customer confident and supported by the dealership, explaining the process is the technician's duty at the time of technical delivery heldat the customer's property, some reasons for denying the warranty may be factors such as misuse, or even that it is not the defect of the part but wear.

With regard to customer loyalty after the warranty period the results show that 59.26%of the respondents, even after the warranty period continue performing maintenance with Guarita, already 25.93% of the respondents, inform that do not perform maintenance with the dealership after the warranty period and, 14.81% said that depending on the problem occurredin the equipment request services of Guarita Comercial Agrícola Ltda. Keeping the customer after the warranty period makes it necessary to structure a quality post-sale service, where support concerning revisions and emergency repairs can be provided. This makes the customerseek the company whenever necessary and offering rewards for customer fidelity is essential to help loyalty. Therefore, Valtra has created the Valtra Dealer Portal Platform.

Valtra, thinking of customers, has created the Valtra Dealer Portal platform, where thesite is accessible to all Valtra customers. In this portal, purchases made by customers inside thedealership are converted into points, these points are cumulative and expire within 365 days after the purchase date. Therefore, the customer has the opportunity to redeem these points forgifts inside the dealership itself, purchases in the sites directed by the portal and even a credit card with credits to be used in any way he wants. The platform aims to reward customers through their purchases, where each purchase scores points.

Valtra Dealer Portal is something that all customers can have access to, however, of the respondents 55.56% said they are unaware of this platform, 22.22% said they were introducedto it and did not register, and the same percentage 22.22% could not inform. The percentage ofcustomers who are not aware of this platform is high, since the platform has been active for about 4 years, and customers do not score points through their purchases when they are not registered, causing the dealership to see the need to conduct a better presentation of this platform to the customer.

Regarding suggestions for improvements, complaints or suggestions, most of them highlighted the three items as lack of parts, prices of parts and technical assistance. These threeitems are primordial within the after-sales, keeping a stock of parts to meet the customer, get competitive prices and have technical assistance is fundamental to the company's health.

Conclusions

It was evident in the research, that the agility in the services, especially in the renderingof services is something requested by the great majority, especially because in these cases theagility is totally linked to the gain or loss of production, either by the downtime or even by theclimatic effects that can aggravate even more their losses. To avoid this type of inconveniencethe company needs to invest in more employees, training and specially to increase the stock ofparts according to the quantity of machines sold within the region. The request for services is something different from the purchase of parts, where many times the solicitation of atechnician ends up being only in times of planting or harvesting. In these periods are decisive phases for each customer, because in agriculture everything has its right time to plant, to manage and to harvest.

Regarding the value perceived by customers, the survey revealed a high level of satisfaction in relation to the cost x benefit of the products sold by Guarita Comercial AgrícolaLtda. However, even though the customer recognizes the quality of the products and services provided, the old culture of complaining about the price list of the dealership continues. Part of the respondents are satisfied with the after-sales department. However, for an effective related management, as well as to maintain competitiveness, improvements must be sought tomeet the demands and gaps evidenced in this study.

Among the limitations of this work, the COVID-19 pandemic moment stands out, sincethe survey had to be carried out through an online platform. Many producers had difficulties inaccessing the platform or did not organize available time to answer the questionnaire. Anotherlimitation was the concept of "after-sales" in the literature, which does not yet address all aspects related to the term, thus making it difficult to explore the topic. In addition, the term "after-sales" appears linked to CRM, limiting the theoretical basis for this study.

Finally, it is suggested that there are new studies within this theme, especially with emphasis on customer satisfaction of agricultural machinery and implements, through the after- sales relationship. Understanding customer needs and growth opportunities are fundamental aspects for the survival of organizations; being close to the customer and monitoring and evaluating information are essential attitudes for the emergence of internal and external improvements.

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Climate tech startups in agriculture industry: experiences from Brazil

Abstract ID#338

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Purpose

Climate tech (CT) presents a wave of disruption caused by climate change and enormous opportunities for future development. It is one of the real opportunities of history. It presents a disruptive technology and a potential for business models. The most significant innovation challenge humanity has ever faced global greenhouse gas emissions (GHG) and reach zero net emissions by 2050. In this research, we show case studies of CT solutions in Brazil that help this transformation and are attracting the growing interest of international investors. With this research, we aim to contribute to the literature on the location determinants of climate tech startups. We try to give answers to two questions. First, how relevant are technological relatedness and variety in fostering the creation of climate tech startups? Second, is the creation of climate tech startups influenced by the local knowledge base and firm creation in Brazil?

Literature Review

The research works on the Knowledge Spillover Theory of Entrepreneurship (Acs et al., 2006, 2009) for CT in the agriculture industry in Brazil and is relevant for tech startups. We can define CT as any product, service, or process that delivers value using fewer resources and producing less pollution than current standards stipulate (Cooke, 2008). CT applications can be grouped into three groups: 1. Those that directly mitigate or eliminate GHG emissions. 2. Those that help us adapt to the impacts of climate change. 3. Those that improve our understanding of climate change. The term CT is purposely broad to incorporate many technologies and innovations used to deal with GHGs across a broad spectrum of industries in which they can be applied. CTs describe clean technologies, which investors increasingly turn to as the next big wave in technology. CT is any new business model or technology that increases production performance, productivity, or efficiency while minimizing negative environmental impacts. It includes the business of decarbonization, clean energy, clean air, water treatment, transportation, recycling, supply chain improvement, waste reduction, manufacturing, and more. CT deals directly with new business models and technology that mitigates the impacts and drivers of global GHG emissions. The analysis of the innovative business model of climate-tech firms is a prerequisite for its appraisal and embeds scalability options. Despite the great potential of CT startups in Brazil, few studies on the Brazilian innovation ecosystem and research concentrated in the northern hemisphere, particularly in China.

Methodological Procedures

The initial universe of CT was 29 startups from the agriculture industry from "Mapping of Startups Ecosystem Cleantech in Brazil - Partial Report" (GVCes, 2019). The execution of the research has two distinct phases: the first consists of documentary research followed by case studies. The preliminary research was based on consultations with the companies' websites to identify their purposes, strategies, investors, and organizations that could be selected, according to the research framework, and in semi structured or in-depth interviews, with experts in the sector of the selected companies. The professionals interviewed have worked for the public and private sectors and held management positions in their organizations at the time of the research. As a result, it was possible to identify innovative experiences in the face of the challenge of providing solutions to the issue of climate change. From this inventory, four relevant CT startups were selected for the researchers to prepare the case studies of this research. The second phase consisted of data collection. Primary data were collected through in-depth interviews, including videoconferencing, with critical people, managers, and administrators, observation, and visits to organizations, while secondary data was collected from organizational documents.

Findings

Firstly, the current findings highlight the importance of knowledge spillover theory. As climate techs can be considered a subset of technology-based startups, results extend our understanding of spillover theory by showing that the availability of knowledge close positively impacts the number of climate tech startups in Brazil. In a nutshell, climate techs have an above-average demand for technological expertise, funding, and knowledge. Crop monitoring and irrigation systems control by remote pivot management are examples of solutions provided by companies in the agriculture segment. In addition, there are recent efforts to collaborate on projects aiming to promote sustainable energy development in Brazil with a focus on innovation. It was led, for example, by the participation of leading institutions and experts in Brazil's innovation ecosystem, including universities and The Brazilian Agricultural Research Corporation (Embrapa).

Implications

The theme of climate change alone directs us to a concern of greater magnitude that presents economic implications but simultaneously negotiates with aspects of extreme temperatures, flooding, sea level rise, storms, and water scarcity, among others. From a sectoral point of view, food, agriculture and land use, biodiversity, buildings, coastal areas, disaster risk reduction, energy, financial services, forestry, health, mobility, transport, industry, manufacturing and resource, and water management. In particular, we present Brazilian companies that are certainly mitigating the effects of climate change from GHG emissions but presenting innovative models for critical industry as agriculture and food, in which Brazil is one of the major global players.

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A digital maturity model for agribusiness cooperatives
Abstract ID#269

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Purpose

The process of Digital Transformation (DT) stems from the increasing application of digital technologies to facilitate communication, data transfer and business transactions. In the field of the digital revolution in the Agribusiness Sector, Brazilian cooperatives may play a major role. Since many such cooperatives have complex and even verticalized production chains, digital maturity measurement models can be applied as sectorspecific management tools. The objective of this study was to develop a model to measure the digital maturity of agribusiness cooperatives. This required the identification and assessment of existing models, leading to a specific model to assess the degree of digital maturity that best suits agribusiness cooperatives.

Literature Review

Digital Transformation (DT), in its literal sense, means encoding data into digital formats. However, DT success will depend less on the technologies themselves and more on the organization's ability to implement them in an innovative way, rethinking strategy, culture and talent (Kane et al., 2015). DT is induced by digital innovation and the exploitation of digital technologies, with the power to transform business models. Tools and guidelines are often lacking to help operators negotiate this change (Valdez-de-Leon, 2016). Interconnectivity allows the control of processes, making them programmable, addressable, sensitive, communicable, memorable, traceable and associable. This integration of all physical and virtual resources is often called Cyber-Physical Systems (CPS) and is connected to global production networks (Kagermann, Wahlster and Helbig, 2013). Organizations began to perform autonomous decision procedures, communicate with each other, interpret available data, and trigger actions. Models of digital readiness are usually defined through a scale of maturity levels, which describes an adequate set of company resources (Macchi & Fumagalli, 2013). The levels represent the organization's stages of progression on its TD journey (Valdezde-Leon, 2016). Maturity models are important tools that help managers assess the degree of development of their organizations for the digital journey, establish priorities and action plans, promote successful organizational change and meet the demands of various stakeholders. The three basic types of maturity models (descriptive, prescriptive and comparative), emphasize the focus on the purpose to which the model will be applied (Berghaus & Back, 2016).

Methodological Procedures

The research was divided into three stages. The first stage was a bibliographic and bibliometric analysis. The keywords for the search for articles and theses were those that refer to the development of digital maturity models, e.g., “digital maturity”, “digital maturity model”, etc. In the second stage, content analysis was performed with the support of Atlas TI software. Subsequently, the architecture of the model was established according to a three-phase approach (Becker et al., 2009): 1) a clear definition of the scope of the model, 2) an initial design or architecture of the model; and 3) a step-by-step approach to validate the model design with experts in the field. The process involved the identification of 47 areas of knowledge related to DT. Further analysis grouped them into seven domain areas. In the third Stage, the Delphi technique was applied with specialists from twelve cooperatives, chosen for their economic representativeness.

Findings and Implications

The model was developed to serve as a diagnostic tool, that is, a descriptive model of the path toward digital maturity. It can contribute as a selfassessment framework, indicating an evolutionary path to follow or to improve processes, technologies, and training. The final result was the identification of 47 DT subcomponents and related areas, grouped into 7 dimensions and 23 constructs. The following are the dimensions of the resulting model and their respective constructs: 1. Digital vision and strategy (Value Generation, Digital Commitment, Strategic Alignment; 2. Digital culture (Digital Affinity, Organizational Agility, Error Culture, Readiness to Take Risks, Change Management); 3. Digitalization (digital process and technologies, IT Expertise, Data-Driven Business, Digital Supply Chain, Performance Measurement, Process Management, Project Management); 4. Strategic Innovation (Innovation In Business Model, Technological Innovation, Testing and Learning, Budget for Innovation; 5. Digital leadership (Knowledge Management, Collaboration Skills, Talent Management; 6. Digital governance (Digital Governance, Stakeholder Value Approach, Compliance; 7. Customer Orientation (Customer Experience, Integration With Analytics, Digital Marketing and Communication, Content Management). The proposed model suggests that placing digital strategy at the center of business strategies is more important than the technology itself. It is also clear that DT cannot be dissociated from innovation. In addition, the model confirms the principle of customer centricity. Within the context of cooperatives, the members are encompassed by the perspective of customer centrality in cooperatives. The model can be used as a support tool for internal or external use, for analysis, evaluation, and decision-making by executives, managers, auditors and other cooperatives. The areas of knowledge reflect the current environment, but the speed of technological change is a challenge for updating the model. Its application and validation in the field is suggested through the application of quantitative methods to identify groups of cooperatives and characterize roadmaps for the evolution of digital maturity. In the future, migration from a "descriptive" to a "prescriptive" model would be possible.

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INTERNAL AND EXTERNAL COLLABORATION I

May 2nd: 10h30 am – 12h30 pm

Chair

Aurora Zen (Federal University of Rio Grande do Sul, Brazil)

Papers

Hermeneutics of open innovation

Ricardo Gallego Burgos, Luciano Gallon, Marthe Prada Molina, Nicolas Molina Saenz

Proposal of a conceptual structure for the implementation of open innovation in family SMEs

Luis Angel Viteri, Mercy Escalante-Ludena

The role of industry 4.0 and open innovation practices in the renewal path of an industrial cluster

Aurora Zen, Carlos Alberto dos Santos, Everson Splinder, Jose Luis Hervas-Oliver

Approaching the collaboration of intraorganizational competition in a public bank

Darci de Borba, Rafaela Nascimento Bühler

Hermeneutics of open innovation

Abstract ID#168 | Full Paper ID#437

Ricardo Gallego Burgos, Luciano Gallon, Martha Prada Molina, Nicolas Molina Saenz
(Pontificate Bolivariana University, CO)

Abstract: The absence of a hermeneutical approach, given the lack of an interpretive process that analyzes open innovation (OI) in a global context and its integration with the characteristics ofSMEs of the software sector in Colombia (SMESSC) . Specifically, from the theory of businessstrategy, limits understanding of OI by those responsible for the management (RFTM) in the SMESSC. From this perspective, the purpose of this paper, using Hermeneutic Philosophy (HP), focuses on presenting an interpretive way that provides the elements for understanding the concept of OI in its own meanings and manifestations in the context of business management. Under a multi-method approach, the aim is to learn about the experiences, beliefs, manifestations, meanings and meanings of the way in which innovation is managed in this typeof SME. It also includes the analysis of data at the corporate level in different SMESSC, to know indicators and results associated to the innovation processes, according to the domains identified. Based on these results, a hermeneutic approach (HA) to OI is established. It is expected that the results obtained to date in this study using HP, provide a new lens for understanding the OI and guide the academic, social, and practical debates.
Keywords: Open Innovation, SME, Business strategy, Hermeneutics, Industrial Development.

Introduction

Throughout history, several studies have explored the importance of external sources of innovation for the firms. This is the case of Freeman (1974,1979) with his work in the chemical industry. The Sappho project (Achilladelis, Jervis and Robertson, 1971; Rothwell, Freeman, Horlsey, Jervis, Robertson and Townsend, 1974), the sources of information for technical invention (Gibbons and Johnston, 1974). Also, the studies of Allen (1977), in which technology transfer in research and development (R&D) laboratories is analyzed. These describe the laboratory as an open system, which depends on the external environment to generate ideas for innovation. Studies on the role of users in innovation processes were decisive. In this von Hippel, (1976, 1978, 1986), highlights the users of a firm, who are normally outside of it, as permanent sources of innovation. On the other hand, other studies focused on analyzing how internal R&D investment in the firm increases the ability to adopt external knowledge (Allen, 1977; Cohen and Levinthal, 1989; Rosenberg, 1990; Chesbrough, 2006). In the past, several industrial firms focused on developing new technologies internally and incorporating them into their own products (March, 1991). They had total control of their innovation process. This paradigm is known as closed innovation (Chesbrough, 2003; Lindegaard, 2010).

For past two decades some firms in various sectors began to acquire technologies and knowledge from external agents. Chesbrough (2003) defines this phenomenon as OI. In this phenomenon, organizational boundaries are porous, and its purpose is focused on incorporating external ideas and technologies to accelerate the product and service development process (Chesbrough, 2006). According to West and Gallagher (2006), OI allows exploring a wide range of sources of opportunities, integrating the capabilities and resources of the firm. The OI process involves multiple internal and external technology sources and marketing channels (Christensen, Olesen, and Kjaer, 2005; Lettl, Herstatt, and Gemuenden, 2006; West and Gallagher, 2006).

OI has been studied in multiple areas: foundations and theory of OI (Dahlander and Gann, 2010; Dahlander, Gann and Wallin, 2021, Bogers, Foss and Lyngsie, 2018); OI and its business application (Bogers, Chesbrough, Strand, 2019); OI management (Bagherzadeh, Markovic and Bogers, 2021); OI management from the perspective of dynamic capabilities (Bogers, Chesbrough, Sohvi and Teece, 2019); Research, Practices, and Policies (Bogers, M., Chesbrough, H., & Moedas, 2018; Enkel, Bogers, & Chesbrough, 2020).

Under an open approach, firms actively interact with their environment (Gassmann, 2006; von Hippel and von Krogh, 2006; Cooper, 2008). According to West and Gallagher (2006), OI allows exploring a wide range of sources of opportunities, integrating the capabilities and resources of the firm.

Several studies have been conducted to evaluate the impact of OI on SME's, which have confirmed various benefits for these firms. These benefits include OI's contribution to their survival and business performance. However, the absence of a hermeneutical approach has limited SME managers' understanding of the OI concept, given the lack of an interpretive and reflective process that analyzes OI in a global context and its integration with the characteristics of SMEs, specifically from the theory of business strategy.

Research has been conducted in relation to hermeneutics in the field of management. Hatch and Rubin (2005) studied brand hermeneutics to explain how the meaning of a brand changes over time. Similarly, Timmermans and Blok (2021) used critical hermeneutics to outline the paradigmatic beliefs and assumptions of the narratives of responsible innovation. Other studies have focused on analyzing the approaches associated with practical application and hermeneutics, such as the research conducted by MacLeod, McCaffrey, Wilson, Zimmer, Snadden, Zimmer, Jónatansdóttir, Fyfe, Koopmans, Ulrich, and Graham (2023)

From this perspective, the purpose of this article, using HP, focuses on presenting an interpretive way that provides the elements for understanding the concept of OI in its own meanings and manifestations in the context of business management by the managers of SMESSC. Improving the understanding of this concept is necessary because OI is a broad concept that requires diverse organizational capabilities and resources. However, for the practice of OI, there is less consensus among SME managers on how to promote it and maximize its benefits.

The lessons learned from this hermeneutical work may, first, give birth to an academic debate enabling a temporary and evolutionary interpretation of the way in which the theory of business strategy determines the mechanisms of OI in the firm, and secondly, the purpose of this article focuses on presenting the results of a validation of the domains established in the hermeneutics of OI in SMESSC.

This research is divided into four parts. The first part presents the theoretical background associated with the object of study. The second part illustrates the methodological procedures used to achieve the research objectives. In the third part, the results are presented, showcasing the elements of the proposed open innovation hermeneutics framework. Finally, the last part provides the final discussion and conclusions of the research exercise.

Theoretical Background

The object of study of this research involves issues related to business strategy, innovation management, HP, OI in the SMEs. This article presents the most relevant concepts that are part of the development of this research.

Business Strategy

The field of industrial organization has been transformed over the last fifty years. In the 1980s, several theories emerged in the field of strategic management to analyze the way in which firms generate competitive advantage.

By this time the predominant model was Porter's (1980) competitive forces model. It emphasized the actions that a firm must take to respond to competitive forces. The model was based on the structure, behavior, and performance paradigm of the industrial organization of Mason (1949) and Bain (1959).

In Porter's (1980, 1991) competitive strategy, industry structure determines the rules of competition and influences the capabilities potentially available to the firm (Teece, Pisano and Shuen (1997). However, strategic management researchers have recognized the complementarity between the market-oriented (competitive forces) and resource-based perspectives of strategy (Henderson and Mitchell, 1997; Spanos and Lioukas, 2001).

Dynamic Capabilities

Many technology-based companies throughout history have incorporated strategies for developing sustainable competitive advantage. Most of these, many firms have adopted a resource-based strategy to accumulate valuable technological assets, often protected through an intellectual property strategy. However, the resource-based perspective recognizes, but does not explain the nature of the mechanisms that enable the firm's business performance and competitive advantage to be maintained. In this sense, Teece, Pisano and Shuen (1997), establish the dynamic capabilities approach. In which the firm's specific competencies can be a source of competitive advantage. The combination of these internal and external competencies with resources enables firms to cope with changes in the environment. The foundations of this approach are based on the concepts of Schumpeter (1934, 1942), Penrose (1959), Nelson and Winter (1982), Prahalad and Hamel (1990), Hayes, Wheelwright and Clark (1988).

Innovation Strategy

Most innovation theories base their starting point on the firm (Baldwin and Scott, 1987; Cohen and Levinthal, 1989; Scherer, 1984, 1991; Dosi, 1988). In these theories, firms are exogenous. Their performance supported by technological change is endogenous (Scherer, 1984, 1991; Cohen and Klepper, 1992; Arrow, 1962). The bases on innovation strategy are based on points of view with some historical antecedents. For Rumelt (1996). Strategic thinking is a necessary element for the generation of new knowledge and the ability to react quickly and intelligently to it. In many industries, technological innovation has become the most important driver of competitive success (Schilling, 2010; Barczak, Griffin and Kahn, 2009). The advance of information technologies has played an important role in the acceleration of innovation at the business level (Womack, Jones y Roos, 1991).

Open Innovation Process

The various studies on OI are classified into schools of thought (Gassmann, 2006), actors and processes (Chesbrough, Vanhaverbeke and West, 2006; Gassmann and Enkel, 2004; Prahalad and Ramaswamy, 2004). In the latter, Gassmann and Enkel (2004) defined the processes of OI as outside-in, inside-out and coupled.

In the outside-in process, the firm's own knowledge base by integrating capabilities from external agents (suppliers, customers, allies). It seeks to improve the firm's innovation competencies

(Laursen and Salter, 2006; Lettl, Herstatt and Gemuenden, 2006; Piller and Walcher, 2006). In this process innovation networks play an important role (Dittrich and Duysters, 2007; Chesbrough and Prencipe, 2008).

In the inside out process, the firms obtain benefits from the commercialization of ideas, knowledge and innovations, licensing of their products or services, intellectual property, and transfer of technological capabilities (Gassmann and Enkel, (2004); Lichtenthaler and Ernst, 2006). Some of the value-generating practices and ways of generating money in this process are business entrepreneurship (Vanhaverbeke, Van de Vrade, Chesbrough, 2008), new business models, creation of new companies and spin-offs (Chesbrough, 2006), and the commercialization of proprietary technologies in new markets called cross-sector innovation (Enkel and Gassmann, 2010).

In the coupled process goes beyond the outside-in and inside-out processes identified by Chesbrough (2003) (Gassmann and Enkel 2004; Enkel, Gassmann, Chesbrough, 2009). It is defined as working in alliances with complementary partners of the firm. It combines the outside-in process (to obtain external knowledge) with the inside-out process (to bring ideas to market). To achieve this integration, firms cooperate with others in strategic networks (Gassmann and Enkel 2004).

Open Innovation in SMEs

Studies have been conducted to evaluate the results of OI in SMEs, confirming some benefits for these firms, including the contribution to their survival and business performance (Lichtenthaler, 2008, van de Vrande, de Jong, Vanhaverbeke, and Rochemont, 2009). However, SME-type firms often lack the resources, focus, and structure to manage the innovation process, either traditional or open (Bianchi, Campodall'Orto, Frattini, & Vercesi, 2010; Brunswicker & Ehrenmann, 2013; Gurau & Lasch, 2011). On the other hand, Bougrain and Haudeville, (2002), and Parida, Westerberg and Frishammar, (2012), consider that the incorporation of management practices in SMEs is usually a complex task, due to the challenges associated with their business culture and the limited resources to make investments and distribute risk. In contrast, the incorporation of OI practices in SME-type firms shows some degree of adaptability and diverse benefits for them, including the contribution to their survival (Cefis and Marsili, 2006; Golovko and Valentini, 2011; Huang, Lai, Lin, and Chen, 2013). By cooperating with other firms, SME-type firms can access low-cost inter-company resources that help bridge their technological, financial, or human capital gaps (Chesbrough, 2003; Wynarczyk, Piperopoulos and McAdam, 2013).

Below we introduce an overview of the basic concepts on hermeneutics that are relevant in this research; then we discuss how these concepts support our hypothesis that a HP used for the review of the validity of the concept of OI and analysis of its integration with the theory of business strategy contributes to the repositioning of SMESSC.

Contemporary Hermeneutics

Hermeneutics has historically been related to the theory of interpretation of meanings. However, in the early 19th century, hermeneutics became a central theme in the branches of philosophy of social science, art, language, and literary criticism. This has become known as contemporary hermeneutics (Bleicher, 1980). This is based on human expressions and their meanings. In the contemporary hermeneutics three distinct strands can be distinguished: hermeneutic theory, critical hermeneutics and hermeneutic philosophy.

Hermeneutic theory

Hermeneutic theory focuses on interpretation as a methodology for the human sciences, including the social sciences. Through the analysis of understanding, as an appropriate method to rethink what the author had originally felt (Bleicher, 1980). In this line, Betti (1955) focused his studies on establishing a general vision of the process of understanding. His intention was to explain whether the human being can transpose a complex meaning created by another person to our own understanding and that of our world. For Bleicher (1980), the human capacity is intuitive, and serves for the acquisition of relatively objective knowledge. It approaches a set of established meanings, which are known, and which facilitate the interpretation of objectivations of human expressions. In this sense, Betti (1962) hermeneutic theory is linked to that of Schleiermacher (1959). Bleicher (1980) establishes a discussion of linguistics as a universal medium of humanity that enters the hermeneutic circle. In this, the individual parts acquire their meaning. In this sense, in this research, the hermeneutics of OI will allow the resignification of this concept, achieving a common dialogue that facilitates the understanding in its meanings of application by those RFTM in the SMESSC.

Critical Hermeneutics

Apel (1967) and Habermas (1967) establish critical hermeneutics, which combines a methodical and objective approach with the search for knowledge relevant to practice. For Bleicher (1980), critique refers to any assessment of existing states of affairs, from the viewpoint of norms derived from knowledge of something better previously established; it is guided by the principle of reason as a demand for communication and unrestricted self- determination. Apel (1985), argues that the senses for speakers of the world are to be found in the totality of the meanings of the words of their language.

Hermeneutic Philosophy

HP is a theory of interpretation that deals with the understanding of texts (Gadamer, 1976; Ricoeur, 1981, 1984). It then focused on comprehension in general (Ramberg and Gjesdal, 2009). The HA has evolved from texts to the field of spoken words. In addition to being useful for interpreting actions in general (Alvesson and Sköldberg, 2008).

The initial goal of hermeneutics in the 19th century was to reconstruct the original meaning of a text (Schleiermacher, 1838|1998). Similarly, Dilthey (1985-2002) argued that interpretation theory aims to imaginatively recreate the original meanings and experiences of others. These views were challenged by twentieth century philosophers, notably Heidegger (1927|2002) and Gadamer (1976).

The truth of a situation can only be reached through understanding, as in interpretation, and not through the methods of objective measurement established in modern science (Gadamer, 1976).

For Heidegger (1927/2002), the vision of hermeneutics goes beyond a methodology for understanding meaning. He also considers that understanding is not only a cognitive process, but the practical mode of human existence. As Barrett, Powley, and Pearce, (2011), consider that hermeneutics is grounded on a set of practices based on experience, which lead to knowledge.

Methodological Procedures

The methods, instruments, and procedures used for the analysis of the results achieved to date in this research lie in the social sciences. The most frequently associated methodology with the creation of meanings is hermeneutics (Verganti and Öberg, 2013). This research is based on the interpretive perspective of the meaning and sense of OI. It intends to validate how the hermeneutic philosophy, allows the reconceptualization of OI from the integration with the theory of business strategy.

The form of this research is basic (Sampieri, Collado and Lucio, 2014; OECD, 2015), its purpose is to produce knowledge, which contributes to the academic, social, and practical debate on the understanding of OI in the context of SMESSC. It involves the historical exploration of the foundations, evolution and change of the concept of OI in various times. It also comprises the perceptions, meanings, and experiences of the subjects responsible of this SMEs. The research approach is qualitative (Sampieri, Collado and Lucio, 2014; Sparkes and Smith, 2014; Savin-Baden and Major, 2013), it is based on the interpretative perspective on the meaning of OI.

The case study was employed as a research strategy to understand the phenomenon of open innovation in the context of small and medium-sized enterprises (SMEs) engaged in software development. The unit of analysis comprised companies in this sector located within the Colombian territory. To gain a comprehensive understanding of this phenomenon, data was collected through a systematic literature review, surveys, interviews, and workshops with the managers of these SMEs in Colombia. Approximately 60 interviews were conducted with these professionals.

To select participants for the study, a call was made through the ICT clusters of the main cities of Colombia. Through a process of socialization of the research purpose, a sample for the study was selected.

Using the HP, whose approach is multimethod, it has been possible to investigate to date the phenomenon of OI in SMESSC. Specifically, the understanding of the OI by SME managers. Given the qualitative approach of the research, several methods were used to obtain data: semi-structured interviews with the SME managers, using tools such as the storytelling (Lewrick, Link y Leifer, 2018) y visual storytelling (Brand, 2021), to establish conversations about the meanings of OI, surveys with open and closed questions, content analysis (Berelson, 1948; Krippendorff, 1982), creative workshops to establish shared vision, create empathy and precise meanings about OI, using design thinking techniques (Brown, 2009; Lewrick, Link, Leifer, 2018).

Results

The methods used in this research have made it possible to identify the system of relationships and elements immersed in OI, thereby establishing the hermeneutic circle, derived from the meanings, traditions, and manifestations that authors have transmitted in their publications throughout history. On the other hand, to distinguish the change and evolution of the concept of OI, to establish their domains from its own hermeneutics and its integration with the theory of business strategy in SMEs.

The experimental phase of the study focuses on the Colombian territory and includes SMEs of the software sector. Most of these firms belong to business networks and technology cluster associations in the most important cities of Colombia. .The sample included interviews, surveys, and the use of instruments for the diagnosis of technological innovation capabilities in 53 companies dedicated to software development, analytics, and automation.

According to the systematic review of the literature and the historical analysis of the evolution of the concept of OI, the following domains have been established: Innovation strategy, innovation culture, absorptive capabilities, co-innovation, co-creation, knowledge management and innovation processes

The hermeneutic framework established by Verganti and Oberg (2013) on the meaning of radical innovation, and the works of Betti (1955), Ricoeur (1984), Gadamer (1976) in the context of hermeneutic theory are taken as reference. Some of the results achieved with the progress of this research, are presented below.

Hermeneutics of open innovation Framework

Table 1 shows two dimensions that allow us to establish the meaning of OI: experience and understanding and the re-conceptualization. The second column shows the natural characteristics of OI. From the dimension of experience and understanding, the meanings of OI depend on the context in which it is presented. Likewise, the meanings cannot be optimized since they are not constant. From the re-conceptualization dimension, OI has taken different forms and meanings. The meanings of OI are also co-developed. These depend on the experience and relations that establish the RFTM in the SMESSC.

The third column shows the relevant domains of OI theory. In the dimension of experience and understanding, context plays a fundamental role in the performance of SMEs. These firms must adapt to permanent changes in the environment, and the identified domains of OI and its integration with management theory are the following: innovation strategy, innovation culture, absorptive capabilities, co-innovation, co-creation, knowledge management and innovation processes.

The fourth column shows the elements of the hermeneutic framework of OI. In the dimension of experience and understanding, the main concept within hermeneutics is that the parts of an action or situation can only be understood if they are placed in context. Vice versa, the context can only be understood if the parts are understood. This duality is represented by the "reflective circle", which consists of the interpretation of both details of a particular situation and the general situation. On the other hand, in the dimension of re-conceptualization, the adoption of a critical stance makes it possible to evaluate the concepts and their previously established relationships with OI.

Table 1. Hermeneutics of OI framework

Dimensions	**Characteristics of OI meanings**	**Domains of OI theory**	**Hermeneutics of OI**	**Comprehensive horizons of OI**
Experience and Understanding	The meanings of OI are context-dependent	Innovation strategy, innovation culture, absorptive capabilities, co-innovation, co-creation, knowledge management and innovation processes.	The parts and the whole	Adaptability and flexibility of the meaning of OI
	The meanings of OI cannot be optimized	Accelerate product and service development process/limited business resources and capabilities	Iteration and reflection in the hermeneutic cycle	Contribution to the academic, social, and practical debate on OI.
Reconceptualization	OI has taken various forms and meanings	Development of new capabilities (openness approach)	Adoption of a critical stance	Development of critical capabilities
	The senses of OI are co-developed	Focus and specialization	Resignification	Understanding of new senses

Source: author's own elaboration based on the work of Verganti and Oberg (2013) about radical innovation hermeneutic.

The approach of the hermeneutics of OI implies the analysis of the historical, cultural, and social dimensions of the RFTM in the SMESSC. The individuals give meaning to things, not only through social interaction, but also through individual reflections on the purpose of life (Gadamer (1976). In the same way, the meaning of innovation also includes inter- subjectivist values (Cunliffe, 2010). At the business level, the meaning of innovation for RFTM is not only based on sociological dimensions, but also on philosophical ones, as is the case with the meaning of life. The decisions of the subject RFTM in the SMESSC are based on the manifestations related to their own experiences, practical performance, and history. Thus, the proposed HA to OI considers two dimensions: Experience and Understanding dimension and Reconceptualization

Dimension of experience and understanding

In this dimension, an analysis is made from the very experience of the subject, who has been trained and qualified to think about the way in which SMESSC perform, relate, innovate, and conduct business in their own context. It is necessary to know the types of conversations that take place within the SMESSC relationship system, in which customers, competitors, government, allies and other influencers are found. Hermeneutics allows to arrive at the interpretation and from there to the understanding of the concept of OI.

In this dimension, the comprehensive horizon established is the adaptability and flexibility of the OI meaning. The socio-cultural context conditions the meaning of OI for SME managers. This can vary considerably over time, considering the times and traditions in which the SME operates. The HA proposed for OI conceives interpretation as a constantly moving process between the parts (innovation capabilities and the SMESSC) and the whole (the SMESSC environment). In this line, the narratives identified with those RFTM in the SMESSC in this study, adaptability and flexibility are essential characteristics in the meanings of OI. Through the different multi-method instruments used in this research, the most relevant domain for SMEs is the external environment. Some of the most important variables:

- The strategic planning of the SMESSC must be based on a system for capturing environmental signals that provide timely information and efficient decision making.
- Need to establish mechanisms that favor the transfer of external knowledge within the SME.
- Knowing the latest trends and technological advances worldwide relevant to the SME's business.
- Establishing a baseline of technological framework priority for the SMESSC to accelerate the development of products and services.
- Developing collaborations and establishing national and international partnerships with various stakeholders for the exchange of information on research, development, and innovation projects.

Other comprehensive horizon establish in this dimension is the academic, social and practical debate. This is required in OI theory, given the active participation between large companies and SMESSC. In this debate, external networks play a fundamental role, since the established hermeneutics of OI suggests that external actors can be considered as an important source of new arguments. In the sense and meaning of OI, external agents present different ideas and create different perspectives. These interpretations are combined and give rise to new ones, emphasizing some of them and abandoning others. Thus, it contributes to the permanent re-signification of the concept of OI for the SME manager. The results obtained, made it possible to identify the following most relevant variables in the context of working with external agents:

- Providing spaces and opportunities to stimulate the bonds of trust between internal and external agents in the SME to develop collaborative activities.
- Encouraging collaborative work between external agents and the internal unitsof the SME to achieve the defined strategic objectives.
- Open communication so that all SME collaborators are aware of alliances and agreements between the SME and external agents.
- Recognizing the importance of collaborative work with external agents by the SME's collaborators.

Reconceptualization Dimension

In this dimension, HP, is shaped from a conceptual reconstruction. In this regard, to understand the discourse that has been given in the last 20 years on OI, it is reconstructed from the system of related concepts. From the hermeneutic approach, the concepts are not a tool, they arise from the comprehensive need and innovation arises from the necessities of history. Therefore, a temporary distance from the concept of OI is established. A historical review is conducted to understand what happened to this concept at various times, allowing to see the conformation of the present and actions for a better future, that is, to make a reconceptualization.

In this dimension, the comprehensive horizon established is development of critical capabilities. In the HA defined provides an insight to analyze the concept of OI. To advance in the understanding of the meanings of OI, SMEs must adopt a critical stance on its applicability in the business context. The SME's competence to question its current environment allows it to build critical capabilities. And in the process of understanding the concept of OI and its application, it enables the SME to recognize external networks and their resources, not only to integrate flows and capabilities that complement the processes of product and service development. Homever, to be used as a source to critique its current situation and support the innovation ideas and initiatives developed by the SME. This approach is in line with that proposed by Ricouer (2010), where external interpreters can help find underlying messages and contribute with an immediate interpretation of market dynamics. For Verganti and Oberg (2013), external partners can act not only as experts in new domains, but also as critics of the current domain. The critical capacity in SMEs allows for convergence, whereby they can look at things from different perspectives. The convergence condition is aligned with the proposal of Brown (2009), in his vision of design thinking as a means of transforming organizations. This condition allows considering the most influential inputs coming from the external environment, for their respective analysis and convergence in a single response.

Another comprehensive horizon establish in this dimension, is understanding of new senses. The meaning of OI depends on the context in which the SMESSC operates. Also, the role that external agents have in the interpretative process of innovation through the provision of new arguments. Most OI practices are based on co-creation (Prahalad and Ramaswamy, 2004), design thinking (Brown, 2009), crowdsourcing (Howe, 2008; Poetz and Schreier, 2012), among others. However, it is necessary to advance in an understanding of OI in SMEs, it involves taking a step back from the current needs in the SMESSC and propose a vision of this concept.

Discussion

HP allows the resignification of innovation in the field of OI and its relationship with society and business. The concept of OI is redefined according to the life world in which the SME operates, where sustainability and technology are fundamental. The lack of understanding of OI limits communication and the possibility of correct application by SMEs. Therefore, the importance of establishing a comprehensive framework, starting from the minimum to understand the concepts immersed in OI.

OI is within the orbit of innovation. When the concept of OI is understood, it will be possible to make sense of its application in the SME context. Under the approach of identity and diversity (always together and indissoluble), OI implies working together and networking, it includes many and diverse ways of managing innovation. For SMESSC, OI means permanent adaptation to the conditions of the environment, it requires the interpretation of signals of great relevance for the firm. Its purpose is focused on flexibility when incorporating capabilities, technologies, and knowledge flows that have greater value for its strategy or business model. To date, this study has managed to clarify the importance of giving meaning to OI applied to SMESSC. The use of HP provides a new lens for understanding the concept of OI. In addition, it can also guide the academic, social, and practical debate on the application of the concept of OI in the management context of these SMEs.

Overall, the results achieved to date have allowed this work to provide a new interpretative lens that contributes elements to understand the concept of open innovation.

Conclusions

The understanding of OI is hermeneutically conditioned by a strategic and business management language, which is spoken in SMEs and in all their relationship scenarios. HP allows establishing the meanings, forms of manifestation, and comprehensive horizons of OI throughout history. For the subject RFTM in the SMESSC, the meaning of OI is conditioned by the ability to interpret this concept and its system of relationships. The philosophical dimension of hermeneutics considers language and ways of thinking as fundamental elements for understanding the concept of OI.

This research has shown that the concept of OI is in constant re-signification. The hermeneutics of OI Framework established have approximately seven main domains. Through work applied with SMESSC, the validation of these domains has allowed those RFTM in the SMESSC to have their own sense of OI.

Historicity in the context of this study refers to the situational determinability (historical, cultural, and social) of thinking about the concept of OI, i.e., its logical form. In this sense, OI is relative, it depends on the context experienced by SMESSC.

This article is a first step, it has allowed to date to give a direction to the purpose of this study. The main objective has been to propose a first approach to this approach for future research on OI. Therefore, this article does not have a definitive conclusion, it has rather succeeded in opening a debate inspired by HP.

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Proposal of a conceptual structure for the implementation of open innovation in family SMEs

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Abstract: Open innovation (OI) is one of the forms of innovation with the highest and best performance in modern management. It supposes the creation of multiple opportunities for the companies, without restrictions on their diverse typologies. SMEs, therefore, are organizations that must be committed to understanding, developing, and implementing applications derived from open innovation. However, the lack of studies in the literature about OI implementation in family SMEs has motivated this research. The objective of this work proposes a framework for O.I implementation on family SMEs, that allows them to improve their skills, and recognize the challenges and opportunities of this process; in this way, they can guarantee a successful process of implementation. The methodology used for this research has been exploratory and with a qualitative approach. The proposal identified 4 dimensions: Baseline, OI Ecosystem, Early OI, and Capital OI. This research has highlighted the importance of OI in family SMEs as a contemporary paradigm of survival and competitiveness in new uncertain environments and continuous change. Similarly, OI is presented as a tool that helps continuity and succession in family businesses, thus ensuring the sustainability of the entrepreneurial project. As future work, we are going implement this proposal in Peruvian SMEs.
Keywords: Open innovation, family SMEs, implementation model, innovation ecosystems, ambidextrous innovation.

Introduction

Companies currently live in an uncertain and even disconcerting environment. According to Cascio (2020), the current environment is brittle, anxious, nonlinear, and incomprehensible also called the BANI world. Thus, it becomes imperative for organizations to change and adapt to the new environment, looking for new strategies and tools to survive the great market turbulence (Granzotto et al., 2015).

Many authors share the opinion and importance of the innovative process as a means of adaptation and developer of opportunities. Open innovation offers us a paradigm with a broad context, the same one that has been revalued and expanded over the years; currently, it includes the innovation of the business model, products and services of the company, thus giving greater relevance to the multiple collaborations, communities and integral ecosystems, in the same way, as a paradigm it supposes the integration of a vertical model by which innovation initiatives they are part of the culture of the entire company (Chesbrough, 2017).

For this reason, we observe the importance of investigating the impact and implementation of such a novel and important paradigm in small and medium-sized family businesses. There are various models for the implementation of open innovation, mainly in large firms; although there are also various proposed application models in SMEs (Granzotto et al., 2015; Van de Vrande et al., 2009). However, the existing models for implementation do not contemplate or include the particularities of a family business.

Family businesses, and especially SMEs, have their own characteristics, a culture enriched by the family culture itself, and very unique challenges (Casprini et al., 2017; Fries et al., 2021; Gallo, 2021) The dynamics of the family business, as well as the interest in business continuity and the entrepreneurial spirit share interests with the OI paradigm; because this represents an opportunity for change, improvement, and development of opportunities that allow the sustainability of the family business project.

This is the case and with the interest of contributing to overcoming in some way this existing gap in the literature, this research has the objective of proposing a conceptual framework to implement OI in family SMEs.

This article is organized as follows, after the introduction are the methodological procedures, section 3 includes the conceptual framework of the research, and then section 4 presents the conceptual proposal for OI implementation in family SMEs, finally, in section 5 the final reflections and future work are considered.

Methodological Procedures

This research is exploratory (Vergara, 2005) because it is a subject that has not yet been studied in the literature. Based on existing data, an extensive literature review was performed. For this research, we used academic databases like Web of Science, Scopus, Emerald, Scielo, and Google Scholar. This research uses as a baseline study the paper by Van de Vrande et al. (2009), from this one we searched for several papers with similar issues and also information to explain the particularities of family firms' management.

The analysis of this literature was qualitative and we used the content analysis technique considering a mixed grade of analysis – category (Vergara, 2005).

As limitations of the study, we consider the fact that the proposal has been based exclusively on an intense review and analysis of literature from secondary sources. The proposal intends to be applied in the future in Peruvian family SMEs.

Theoretical Background

The current environment poses challenges for all organizations; however, this reality is faced in different ways and magnitudes for many experts; the smaller company usually faces a more uncertain external environment than a larger company (Arenhardt et al., 2018). Likewise, within this important business group we can distinguish a particular segment, family businesses. The same as in terms of Tàpies (2011) are the majority form of ownership and management throughout the world. In response to this, the literary review of this research addresses an analysis and interrelation of binding concepts for the development of strategies applied to family SMEs and their adaptability to the new environment.

Paradigm of open innovation in SMEs.

In this scenario of constant challenges, innovation has become increasingly important for the survival of SMEs and to establish a competitive advantage over their competitors (Arenhardt et al., 2018; De Massis et al., 2018). Indeed, innovation is a transcendental management tool for SMEs to excel in this changing and challenging environment; even more those that are familiar.

The latter are associated with certain peculiarities, one of which is their value in the business field. The same that transcends beyond the financial evaluation, being for family businesses an addition, its ability to continue and preserve itself over time. In the words of Elo et al. (2018) "While family business research has focused intensely on the business-family relationship, the time factor has been largely overlooked. We understand time not only as a sequence of events and economic results; but also, as the generational step towards a path-dependent notion where family history: its milestones, failures and restructurings matter". Therefore, the innovation paradigm takes on more than relevant importance to implement in family SMEs, it is a model that ensures its continuity (De Massis et al., 2018).

In particular, open innovation (OI) is a new concept that embraces, in the words of Chesbrough (2017), the integration of a vertical model, by which innovation activities are directed towards the internal development of products and services that are distributed by the company. ; In this way, open innovation is also defined as a distributed process of deliberate innovation in the administration of knowledge, which flows throughout the organization, being able to use or not pecuniary mechanisms for its development, facilitates the co-creation of various business actors.

The OI paradigm can be implemented in any type of company in the world (Mortara et al., 2009); however, SMEs innovate differently from large companies as they have fewer resources and often face more uncertainty, as well as barriers to innovation; these deficiencies can be partially overcome by their integration into innovation systems (Arenhardt et al., 2018; Duran et al., 2014; Elo et al., 2018; Gallo, 2004). Many authors also agree that, in order to achieve an efficient implementation of the innovative paradigm, as well as for its ecosystem, support is required from the Government in its role as promoter of attractive policies for innovation, in the same way a change in the organizational culture of the SME; restructuring that involves the incorporation of new actors and transactional thoughts to encourage innovation (Arenhardt et al., 2018; Granzotto et al., 2015).

In terms of leadership and organizational culture, the literature is abundant. Table 1 summarizes the main approaches for both SMEs and innovation management. Thus, various interrelationships detected in both fields of interest for the present investigation are presented. In general, it is concluded that the leadership, commitment, team management and change management required by family SMEs to achieve their continuity in the market and time are very similar to those demanded by innovation management (Fries et al., 2021). It is inferred, therefore, that there is a high degree of correlation between the approaches analyzed; however, this correspondence must be subject to a more in-depth and technical analysis to be verified. See table No. 1 Interrelation of contributions on topics of leadership and organizational culture for family SMEs and innovation, on the next page.

Leadership and organizational culture in innovative SMEs

Table 1
Interrelation of contributions on topics of leadership and organizational culture for family SMEs and innovation.

Family SMEs management	Interrelationship	Innovation management
TEAM BUILDING Entrepreneurs who successfully build good family businesses are, without a doubt, masters of COEXISTENCE. Coexistence is that which exists between the members of the family who work in the company, with the rest of its employees and with the other members of the family. (Gallo, 2021) With a focus on creating potential advantages of the family business, insistence must be placed on the development of mechanisms to be able to transform them into real advantages and minimize the risks of this ownership structure. For example, the adoption of professional work teams made up of family and non-family members, where meritocracy and value of knowledge prevail over the level of familiarity: Design of good governance, clear rules between the three spheres: family, property and company. (Tápies, 2011)	Family businesses that prevail over time demand the creation of multidisciplinary, efficient and organized teams under a professional scheme. That favors coexistence and suitable recognition for both family members and non-family members. This condition is, in the same way, an ideal condition in the management of teams immersed in open innovation.	TEAM MANAGEMENT Regarding the procedures that support an implementation of open innovation, it is possible to observe that because it is an SME's there is no structure for a team focused on innovation; however, all the members of the organization must act as actors of a team that is open to innovations, thus, a strategic management of the company towards the collaborators and encourages them to promote ideas and act as facilitators of the same. (Caio, 2015)
COMMITMENT Since the passage of time can promote its erosion as family members evolve and change their preferences and intentions, achieving the necessary level of unity and keeping it alive requires a significant and increasing input of energy. This energy in family businesses is the double COMMITMENT of all those involved. Gallo, 2021) The F-PEC scale model measures the level of commitment of the family with the company. Associating a correct balance between power, management and experience with a high level of commitment measured by the involvement and active participation of family members. (Tapies, 2011)	Both the efficient management of innovation and the management of family businesses require a high level of commitment from senior management.	COMMITMENT The internal culture of the company allows us to verify the willingness of its managers and employees in their commitment to innovation. The culture of the external environment must favor innovations. (Caio, 2015)
LEADERSHIP If there is no leader, team management is given, which is always difficult, since the team is made up of people with very different abilities and similar political rights. The leader of the family business must be prepared to constantly adapt, both to changes in the business and in the family. (Gallo, 2004)	SME and innovation management demand an adaptive and transactional leadership style.	LEADERSHIP Innovation requires hard leadership work, mainly of a transformational style that allows for paradigm shifts throughout the organization as well as the integration of diverse opinions and behaviors regarding innovation. (Koziol-Nadolna, 2020)
KNOWLEDGE MANAGEMENT The acquisition of knowledge in the company implies trusting the information and intentions of others; understanding that this can be collected by both family and non-family members. Knowledge, acquired through one's own effort and sustained by trust, and will, putting love for the project into practice, are closely linked. Well united they give rise to the virtuous positive spiral of "knowing more to love more". (Gallo, 2021)	In both theoretical lines we observe a vital trend in valuing the sources that generate knowledge and innovations. Being these of a transactional nature in the organization.	KNOWLEDGE MANAGEMENT To implement open innovation it is necessary to use one of the following leadership approaches in knowledge management; top down and bottom up. Where the first is referred to the initiatives conceived by the top management of the company and the second occurs mainly due to the interest of the collaborators. (Mortara et al, 2019)
CHANGE MANAGEMENT "One of the great advantages of family businesses is their agility to change" (Gallo, 2004) The matrix: family size, family business size. He insists on the need to ensure that the family business grows and evolves, especially when the family grows and you want all of it to be united in your family business. Therefore, this growth will necessarily be linked to change and adaptation, characteristics widely practiced in family businesses. (Gallo, 2004)	Family businesses carry in their DNA the ability to adapt to change and reinvent themselves in an agile way. This feature allows you to adopt the innovative management model in a much more efficient and early way compared to other organizations.	CULTURAL CHANGE For these organizations to survive, it is necessary to innovate and this includes innovation not only in products and services, but also in their business model, as well as in the way they build new relationships. (Caio, 2015). SMEs innovate differently from large companies. they have fewer resources and often face more uncertainty and barriers to innovation. these deficiencies can be partially overcome by their integration into innovation systems. (Arenhardt et al, 2018) SMEs using an innovation model can typically be quickly up and running to produce quick returns. (Arenhardt et al, 2018)

Challenges for innovative family SMEs

Family businesses, as we have already mentioned, focus their attention on innovation as a model that allows them to quickly adapt to changes in the environment, thus increasing their chances of continuing to function over time. According to Gallo (2021), continuity does not mean staying in the same business for decades and even centuries, but it does mean continuity in entrepreneurship, job creation, professionalization of the business model, and investment opportunities.

Under these premises, family SMEs must consider a change of focus in their management and/or the maturity of some capacities in order to successfully implement an innovation management model (Diaz-Moriana et al., 2018; Kammerlander et al., 2015).

The academics propose that family SMEs must develop an adequate organizational structure, as well as formalize and institutionalize their processes and procedures, in order to be able to know and establish an adequate strategy that favors growth and success in the market. (Arenhardt et al., 2018; García-Vidales et al., 2019; Maldonado-Guzmán et al., 2019; Olaru et al., 2015).

One of the great challenges of family businesses is the fight against nepotism. The possible lack of skills (talent or inadequate and insufficient training) of family members, the family's unwillingness to develop social capital due to mistrust towards outsiders, family conflicts that could affect the image of the company, and the family using the company (and its financial assets) for personal purposes, draining company resources (Tàpies, 2011). For this reason, an early construction of a clear, objective and accepted family protocol by the whole family will facilitate the construction of an organic scheme that favors transactional innovation, development of multidisciplinary teams and continuity of the company over time. As Gallo (2004) mentions, it must be borne in mind that good family businesses, those that become multigenerational and successful, both in each type and in the evolution from one to another, do not fall into the trap of confusing the capacity of the members. of the family to carry out the responsibilities that correspond to them with the fact that they are owners, at the time of their incorporation and the assignment of responsibilities.

Challenges for SMEs in innovation ecosystems

Ecosystems as frameworks related to the generation of networks, strategic alliances and cooperation were established by Moore (1993); however, it was Chesbrough (2017) who coined a more precise definition of innovation ecosystems "Companies must associate with other companies, universities, government and other partners of interest so that they can innovate more dynamically and safely; sharing risks and results, adding value for the company and society, thus co-creating an ecosystem of innovation.

Innovation ecosystems are these days, the ideal environments for the generation of OI; Although their participation in these environments is a necessity for SMEs, they represent a great challenge. According to Arenhardt et al. (2018) the lack of resources and low bargaining power make it difficult for SMEs to appropriate the results of innovation when collaborating with larger partners; It is for this reason that the performance of SMEs in these environments must be carried out responsibly, and in the opinion of this research, when the skills required for professionalization have been matured.

Even so, it is undeniable that participation in these networks offers SMEs many opportunities, including: Properly managing knowledge, complementing strategic resources with other actors in the environment, technological development, risk reduction, business growth. (Arenhardt et al., 2018; Chesbrough, 2017; Granzotto et al., 2015; Kingle & Bünker, 2018; West & Bogers, 2013).

In the same way, the participation of the Governments is vital under an active role and main promoter of national innovation in all branches. Therefore, states must legislate attractive policies for all business sectors in terms of innovative development. Multidisciplinary innovation is the tool that will allow the creation of new opportunities for national development (CONCYTEC, 2016; Lopez Gomez, 2014).

Opportunities for family SMEs with OI

From the literature reviewed and commented on in the previous paragraphs, we embrace the idea of the advantages that OI can offer to family SMEs that manage to successfully implement an innovation management model.

SMEs should strive to develop externally oriented organizational learning and knowledge-related skills, thus using external knowledge to build a broader body of knowledge; companies must invest in their technological capabilities or take advantage of the capabilities of suppliers through collaborations (Arenhardt et al., 2018; Duran et al., 2014). Under these premises, the OI offers, according to Chesbrough (2017), 2 variants in the use of SMEs: Inbound, the company allows access to innovative knowledge from external sources; Outbound, the company allows unused and underused knowledge to be externalized for other businesses or business models. This variable has been little studied and less understood.

Inbound opportunities must be aimed at the internal improvement of the SME. Through tools such as crowdsourcing and startups, SMEs can develop their R&D, obtaining better chances of success in development and reducing costs outside the core business (Christensen & Karlsson, 2019; Davenport, 2005; Duran et al., 2014; Vander Schee, 2009). These initiatives could be directed towards the development of AI Data Driven that facilitates the decision-making of senior management; In this way, the SME will be able to specialize its processes and improve its performance in the market.

On the other hand, Outbound initiatives should be considered and developed when the SME has a broad level of maturity in terms of OI (König et al., 2013). This extensive knowledge of innovation management will enable you to capitalize on internal innovations by outsourcing them. It supposes, strictly speaking, the commercialization of its innovations outside the core business through its intellectual property; In addition, this research deeply believes in the opportunity for SMEs to commercialize partner technological capital or what we define as the combination of efficient and successful relationship between AI technology and people in organizations, which leads to a source of competitive advantage. for a company (Makarius et al., 2020).

Donnelley (1964) developed a theoretical framework in which he affirmed that family businesses were highly capable of consolidating and capitalizing on multiple interpersonal relationships in the form of value; including the result of these applied in the industry and machines of various items. This allows us to consider the potential of SMEs by making their experience profitable by developing socio-technological capital. However, since this is a subject that has not been developed and addressed, we must consider it as a gap within the literature.

Framework proposal

This proposal establishes 4 dimensions to consider in order to achieve an efficient implementation of OI in family SMEs. These dimensions address important concepts and strategies; the same ones that have been substantiated as part of the theoretical review of this research.

The 4 dimensions of the proposed framework must be addressed sequentially by the aforementioned SMEs, so that they can develop the concepts and strategies proposed in each dimension. The acquisition of certain strategies is not exclusive to the dimension in which they have been raised; However, in view of this research, it has been considered that it would be appropriate for the strategies to be acquired or perfected in each dimension raised; in order to guarantee adequate performance in implementation through the proposed pyramid.

See Figure No. 1 Pyramid Diagram Dimensions for Open Innovation Implementation in SMEs.

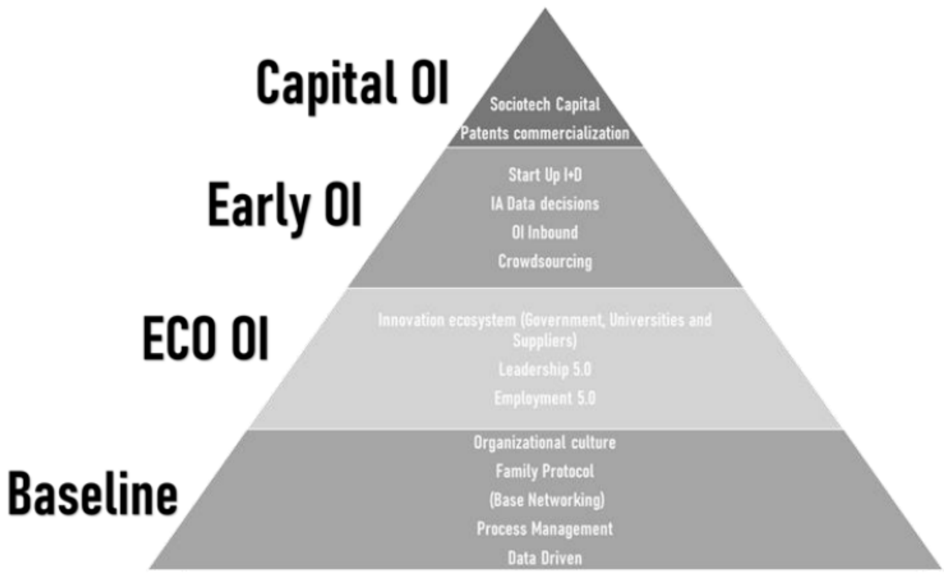

Figure 1 – Pyramid Diagram Dimensions for Open Innovation Implementation in SMEs
Source: Author.

Below is the description of each dimension:

Baseline Dimension: This dimension explores the paradigms, philosophies and strategies that the SME must have already assimilated to continue ascending the implementation pyramid. The correct adoption and improvement of the proposed concepts are aligned with guaranteeing the minimum degree of professionalism and business continuity required by SMEs that wish to implement open innovation within their management.

- *Organizational culture*: It is important to know and define the culture of the SME, with the main interest of establishing the degree of disposition of the management with respect to their commitment to the implementation of a management based on innovation. Family businesses, especially SMEs, have a particular culture with respect to non-family businesses; this culture is often enriched by the family culture itself. However, it is also the lack of the company's own cultural identity, in contrast to the family culture, which often prevents managing the changes required for the implementation of new management approaches.
- *Family Protocol*: Aimed at clearly, functionally and professionally establishing the framework to be followed for the management of the family business. Thus providing an execution and management body for the plans of the family business.
- *Base Networking:* SMEs must initiate a first approach to networking through unionization in various business associations of interest in their field; for example, Chambers of Commerce, Producer Associations, etc. These initial contact networks will allow the company to develop valuable internal and external relationship skills at a future level of multisectoral relationship (Innovation Ecosystems).
- *Process management*: Oriented towards the professionalization and self-knowledge of the SME about its business model, processes, procedures and tasks.

- *Data Driven*: The SME and its managers must have a commitment and a management culture based on data analysis. Assessing the collection and technical-methodological analysis of the data and its contribution to decision-making throughout the entire organization.

Eco Open Innovation Dimension: Refers to the first approach and interaction of SMEs in innovation ecosystems, preferably open innovation, through their inclusion and participation in innovation circles with multisectoral actors.

- *Innovation ecosystem*: Participation in multi-sector innovation networks. With links to the Government, Universities and innovation providers.
- *Leadership 5.0*: Adoption of a leadership philosophy for the entire business family nucleus under the 5.0 paradigm. It is vital for any company and especially SMEs, whose managers assume correct and efficient leadership models; however, this paradigm becomes much more relevant in a family SME due to the lines of succession. The transgenerational gap between the actors in the line of succession of a family business represents a great challenge for the management and continuity of the company over time; this is how a multigenerational adoption of leadership is sorely needed. In our implementation model, leadership 5.0 is deepened; since this paradigm represents the ideal management model for innovative development in a BANI environment.
- *Employment 5.0*: The organic structure of the SME must be reconceived, under a modern model oriented to the creation of networks. More agile, interconnected between departments and people, that promotes the creation of value in teams.

Early Open Innovation Dimension: This dimension explores the early interaction of SMEs with the development of open innovation. The company assumes a main role as an entity interested in developing and obtaining innovations. The first experiences of an SME in this dimension may be oriented especially towards OI inbound initiatives. The organization carries out R&D tasks with external efforts, as a strategy to reduce costs and maximize the possibility of success; These initiatives could be further developed through Start Up's or crowdsourcing. We also consider that one of the main interests of SMEs in this dimension will be the investment in artificial intelligence that complements or facilitates the analysis of Data for decision making.

Capital Open Innovation Dimension: At the top of the implementation model, the dimension oriented towards capitalization initiatives for SMEs under OI application is proposed. In other words, an OI outbound adoption model. In this dimension, the SME has developed and matured all the management strategies proposed in each of the previous dimensions; with this, its internal innovation management capacities are collaborative professionals. Similarly, it has successfully developed a highly productive relationship between its labor departments and assistive technology; Thus, it has managed to achieve a rare, valuable and difficult to imitate intangible: Socio-technological capital (Makarius et al., 2020). Both this resource and the innovations patented by the SME offer in this dimension an opportunity to capitalize on the IO by externalizing them in the market. Giving rise to new conveniences and profitability as a result of their commercialization and/or through the creation of new business divisions.

Conclusions

This paper has highlighted the importance of OI in family SMEs as a contemporary paradigm of survival and competitiveness in new uncertain environments and continuous change. Similarly, OI is presented as a tool that helps continuity and succession in family businesses, thus ensuring the sustainability of the entrepreneurial project.

Thus, a conceptual structure with 4 dimensions that allow the implementation of OI in said companies was proposed. These are: Baseline, OI Ecosystem, Early OI and Capital OI. Each dimension is designed to promote the development of capabilities and maturity of the SME, thus ensuring a successful implementation of OI and

As future work, it is intended to carry out a quantitative study to better define each of the proposed dimensions; as well as subsequently, the application of the model in Peruvian family SMEs. The intention is to validate the proposed structure in order to make it more robust.

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The role of industry 4.0 and open innovation practices in the renewal path of an industrial cluster

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Purpose

The digital transformation is profoundly modifying the current business models (Götz & Jankowska, 2017) and in inter-organizational arrangements, such as clusters (McPhilips, 2020). There is no clear definition of Industry 4.0 but rather a wide array of interdisciplinary technologies McPhillips (2020). According to Rüßmann et al. (2015), nine technology advances are the backbone of Industry 4.0: Big Data and Analytics; Autonomous Robots' Simulation; Horizontal and Vertical System Integration; The Industrial Internet of Things; Cybersecurity; Cloud; Additive Manufacturing 3D and Augmented Reality. As industry 4.0 is accelerating innovation by shortening product life cycles, firms need to speed up their innovation processes. However, firms cannot count only on their internal resources. Thus, they need to acquire external knowledge (Mubarak & Petraite, 2020). In this sense, industrial clusters and regional innovation ecosystems can act as enablers for companies to keep up with the pace of innovation processes through open innovation practices. Likewise, clusters can act as intermediaries of open innovation in the context of emergent economies (McPhillips, 2020), such as Latin American countries. This paper aims to analyze the renewal of an industrial cluster based on open innovation practices and Industry 4.0.

Literature Review

Industrial clusters in traditional sectors are struggling with the impact of digitalization imposed by the industry 4.0 phenomenon. In this regard, digitalization and its effect on regions and clusters constitute an emergent literature gap (Hervas-Oliver, Estelles-Miguel, Mallol Gasch & Boix-Palomero, 2019). Still, little is known about the geographic dimension of Industry 4.0 or the meso-level aspects of the fourth industrial revolution, with most extant literature focusing on firm-level problems (Gotz, 2020). Digitalization may lead to substantial changes in the organization and innovation at the industry and regional levels. Digitalization also demands new and modification of assets, such as new competencies and institutional changes (Isaksen, Trippl, Kyllingstad & Rypestol, 2020). In this sense, these different modes of modification, including re-use of existing assets, creating new assets, and destroying outdated assets, lead to various regional path development (Isaksen et al., 2020). We argue that open innovation mechanisms will support these modifications of assets at different levels to foster the renewal path of an industrial cluster.

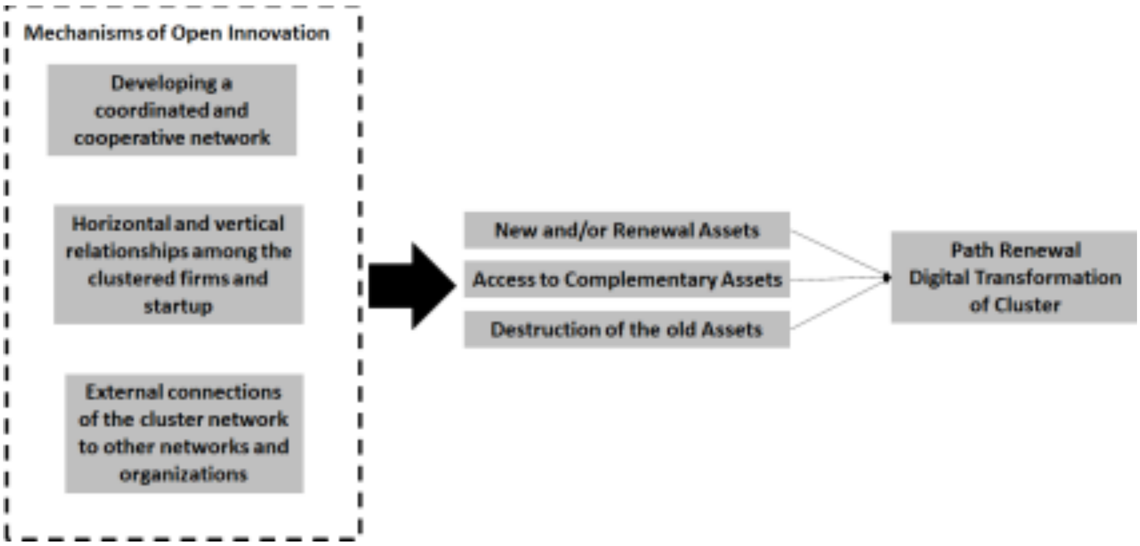
Methodological Procedures

We conducted qualitative research based on case study methodology (Yin, 2010) of the Automotive Metal-Mechanic Cluster (AMMC) of the Serra Gaúcha, south of Brazil. The data collection happened in the first semester of 2021, based on primary and secondary data. Brazil is the largest economy in Latin America, with the ninth-largest GDP in the world. Brazil is well-known for its oil, gas, mining, and agriculture-based economy and is increasingly shifting toward the age when the digital and the physical will intertwine. Some of Brazil's industries have come together to increase Brazil's adoption and position in preparation for the global embrace of Industry 4.0 (CNI, 2016).

Findings

In this case, a key driver to the renewal process was a network of leaders´ firms and the development of Institute Helice, initially formed by four leading Brazilian companies located in the same cluster in cooperation with a local university, a science and technological park, and a business accelerator. Therefore, analyzing the case through the lens of industry 4.0 and open innovation approach, we contribute to the extant literature by elucidating how an industrial cluster overcame its scarcity of resources and created a flow of innovation, bringing solutions of industry 4.0 for traditional companies through open innovation practices, such as (a) developing a coordinated and cooperative network; (b) horizontal and vertical relationships among the clustered firms and startups; (c) external connections of the cluster network to other networks and organizations. Figure 1 presents a framework based on the literature and our data.

Figure 1 – Open Innovation and Path Renewal of Clusters



Source: Based on Isaksen et al. (2020) and Pustovrh et al. (2020)

Implications

Recent studies have stressed the relevance of external sources of knowledge and technology for business innovation in the context of industry 4.0. In this regard, R&D collaborations ecosystems of startups can influence the digital innovation in Brazilian manufacturers (Rocha, Mamédio & Quandt, 2019). Therefore, we analyze the renewal of industrial clusters through industry 4.0 based on open innovation approach. In this way, we contribute to the extant literature by elucidating how an industrial cluster created a renewal path in industry 4.0 through open innovation practices. We also discuss this transition process to industry 4.0 in an emergent economy, such as Brazil.

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Approaching the collaboration of intraorganizational competition in a public bank

Abstract ID#157

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Purpose

Collaboration in competitive environments gained prominence in academia. Coopetition is the name of the strategy that unites collaboration and competition. Most of the literature is focused on the interorganizational level (Cygler and Sroka 2017). Recently, studies have been dedicated to analyzing co-opting relationships within organizations. However, few studies have investigated whether the strategy of associating internal competitiveness with increased internal collaboration through a coopetitive strategy could influence the organization's performance. In this line, the research opportunity in the banking segment was identified, which is recognized for its internal hypercompetitiveness, despite studies that consider internal competition harmful to knowledge sharing and innovation (Alavi and Leidner 1999; Brolos 2009). This article is focused on analysis the context of intraorganizational of a public bank. Its central objective is to understand whether the results of the organization can be influenced through intraorganizational coopetition. For that, a case study will be conducted with document data collection and semi-structured interviews with managers of agencies of different sizes and places of operation.

Literature Review

Coopetition is a strategic process and originates from the search for the balance of opportunities where all those involved win and lose. This action establishes a strategic interdependence between organizations, where individual interests are added up and depend on collective actions, generating value from collaboration (Cygler and Sroka 2017). Using collaborative force together with competition in the internal environment is an intraorganizational coopetitive strategy that seeks to achieve departmental objectives and promote value creation and capture (Bouncken et al. 2015). Supported by the adoption of this strategy, is the role of the drivers and motivators of the organization's actions, which stimulate, from collaboration and competition, a greater distribution of knowledge, technological advancement, and development of the organization's units. Studies such as Brolos (2009) have highlighted coopetition as an important to innovation, given its ability to preserve knowledge sharing and competitive stimulation, but research was focused on the interorganizational level. It was identified that collaboration between actors can occur in several ways: 1) resource sharing and administrative infrastructure; 2) social interaction between actors; 3) better communication and synergy; 4) knowledge sharing. However, for these flows to occur, some degree of confidence is required. Other background summing up the coopetition was also mapped: perceived benefits, strategic adequacy, partner reputation, participation in existing networks, trust in partners, collaborative guidance and previous coopetition experience (Czakon, Klimas, and Mariani 2020).

Methodological Procedures

The research will adopt the case study method, according to Yin (2012) analyzing a public financial institution located in Brazil. The case study will have data collection in two stages: 1) data collection through interviews to raise initial questions about collaboration and competition; and 2) documentary research to understand the results of the analysis units. Data analysis will take place through content analysis categorizing the findings by collaboration and competition nodes.

Findings

Data collection is in course but will be complete until delivery of the full version if the article will select for the event. However, a focus group was held with the aim of raising general questions and guiding the adaptation of the semi-structured interview protocol. The initial results are aligned with the literature. Were identified categories of antecedents, dynamics, results, and evidence of an informal structure of intraorganizational coopetition. The results of the research will contribute to the identification of analytical categories at the intraorganizational level in the banking segment, which is characterized by a hypercompetitive internal environment (Alavi and Leidner 1999). Based on the literature review already performed and the findings of the focus group, a framework was proposed to support the interview stage and guide documentary research. The research aims to analyze the elements that drive the results of banking institutions through intraorganizational coopetition, as well as antecedents, dynamics, and classification practices. The preliminary analysis shows that the sum of strategy, networking, and relationships between organizational actors, consolidated and structured in the organization's management model, provides a favorable environment for the alternation between collaboration and competition between the units. The proposition is to identify whether units that adopt coopetitive strategies, even informally, perform better results than those that adopt only competitive strategies.

Implications

The article contributes to the theory with the provision of a framework on coopetition in banks, classification of antecedents and evidence on the influence of coopetition strategies on the performance of organizations. To managers, the work can contribute by guiding the best practices of coopetition and warning about the importance of reducing the competitive environment in search of better results and favoring innovation. The research is limited to a single case, focused on a specific context, of a public bank. As for the suggestion of future studies, it is suggested to incorporate actions on the assumptions of institutional theory in the context of intraorganizational coopetition. Similarly, new studies may incorporate organizational culture issues into the findings of this research. It is also suggested to develop a scale adapted to coopetition in the internal environment in order to measure the impact of the strategy on the results.

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SPECIAL TOPICS ON MOT II

May 2nd: 3h10 pm – 5h pm

Chair

Rafael Crispim (University of São Paulo, Brazil)

Papers

The next wave of smart HCM solutions with emerging technologies apps

Ahmed Mohamed Abdelrahman Fayed

The social changes and stakeholders impacted by digitalization of business models: A systematic literature review

Celia Hanako Kano, Sandra Naomi Morioka, Marly Monteiro de Carvalho

Building Capabilities for Sustainable Innovation Ecosystems

Gita Surie

The next wave of smart HCM solutions with emerging technologies apps

Abstract ID#217 | Full Paper ID#433

Ahmed Mohamed Abdelrahman Fayed (Nile University, EG)

Abstract: Emerging technologies are impacting the way companies do business and with the acceleration, there is an urge to leverage Innovation to bring value, remain competitive, and stay or become ahead of the competition. Enterprises are looking up to emerging technologies such as Artificial Intelligence (AI), internet of things (IoT), and Blockchain to achieve more personalized & immersive experiences, build transparent and secure employee experience, reduce the cost of operations, get predictive insights and amplify human competencies to drivethe business forward. The focus of this paper is to discuss how emerging technologies apps areapplied to Human Capital Management (HCM) solutions to open opportunities and drive innovations. In particular, the benefits of the current applications of AI, IoT, and Blockchain technology in HCM solutions.

Keywords: Emerging Technology Apps, Smart HCM Solutions, Artificial intelligence (AI), Blockchain, Internet of Things (IoT)

Introduction

Work as we know it is changing so quickly, and post-pandemic companies are facing unprecedented challenges with the Workforce at the forefront. Beyond delivering a single source of information on your employees – past, present, and contingent, HR departments need to leverage technology to impact key moments that matter in the employee journey.

A study conducted by Accenture and the World Economic Forum found that eighty- seven percent of workers surveyed believe new technologies such as AI will improve their job experience and are prepared to devote their free time over the next few years to learn new skills to augment their present ones. For many companies, digital transformation is their most important priority, which means they are leveraging technology to modernize their organization. They need One Powerful HCM platform that can make work simpler, smarter, and more agile by visualizing HCM data patterns to simply discover the actionable insights to make informed decisions.

The main purpose of this paper is to provide some guidelines for companies intended to upgrade their HCM solutions to gain from smart HCM solutions with combinatorial effects of emerging technologies apps such as AI, Blockchain, and the IoT. The paper also tries to answer the question, “How can current apps of emerging technologies influence smart HCM solutions?”

Theoretical Background

HCM is undergoing a major transformation in many areas, fundamentally to improve employee outcomes. These areas include impacts from the COVID 19 pandemic, regulation & interoperability, and digital transformation. In order to support this continual change, Emerging technologies have continued to evolve HCM solutions to a newly proposed concept called Smart HCM which provides a unique end-to-end, scalable solution that includes a combination of purpose-built cloud applications, the latest emerging technologies like AI, IoT, and Blockchain.

There are a lot of use cases where Emerging technologies can bring real business value to the HCM team and the CHROs. Every HCM functional area can actively use new technologies in their work. This revolution is changing the customer and employee experiences, the way operational processes happen, and upending business models themselves.

The next section will explore the use of those emerging technologies and their apps in HCM solutions.

AI use in HCM Solutions

In simple terms: AI is closely related to the ability of computer systems to perform tasks that normally require human intelligence. It is not a specific technology, but rather a collection of technologies designed to mimic how a human learns, decides, and acts. AI uses tools such as Machine Learning, Big Data Analytics, Neural Nets, and other techniques to achieve the best result. AI enables the discovery of data patterns and correlations and provides actionable insights to improve performance.

AI generally works' intelligently, with the simple example of finding the best-fit candidates for a particular opening in the company. AI starts with Unsupervised Learning models to read the job requisition document and the candidates' resumes through Natural Language Processing technology. The candidates most closely matching the requirements are ranked in order of similarity. This is one area where a machine can outperform humans. The machine can read hundreds or thousands of resumes in a fraction of the time that a human can read them and with much greater accuracy. After AI completed Unsupervised Learning models, another Supervised Learning technique is deployed to re-rank the candidate list to allow the recruiter to weigh certain factors, such as experience or education, which might affect the re- ranking.

AI enables virtual digital assistants to eliminate the traditional navigation of HCM screens and systems. Business users can simply interact with digital assistants using natural language: 'What's my vacation balance? Show me my payslip?

IoT use in HCM Solutions

Internet of Things (IoT) is about connecting physical things (factories, assets, and fleet) to enterprise applications through the internet. IoT enables physical assets, and value chains as a whole, to be operated significantly more efficiently by reducing waste and minimizing energy use.

IoT is a worldwide trend and paradigm that's become one of the most research- attracting issues in recent years when thinking of IT technology and innovations. Billions of connected devices, from smart cars to smart meters, create massive amounts of data in today's environment. The Internet of Things is based on a worldwide network of interconnected devices (IoT).

Porter and Heppelmann (2014) claimed that the most important aspect of IoT is the "things" and what they can accomplish. They divided the capabilities into four areas, where each area builds on the capabilities of another area. These four areas are monitoring, control, optimization, and autonomy.

The usage of IoT technology apps within HCM solutions helps to track employees' real- time visibility into work environments. For example, the connected worker app monitors industrial workers for their safety. Check for environmental conditions and other safety hazards for industrial workers.

Blockchain use in HCM Solutions

Marc Andreesen called Blockchain "one of the most fundamental inventions in the history of computer science". Blockchain technology is defined as "the core system that underpins Bitcoin. Separately owned computer systems adhere to a cryptographic protocol to constantly verify updated records in an openly accessible database" (Casey & Wong, 2017). There is a digital ledger that records every transaction in the network (Swan, 2015). One block of transactions has been documented, at which point it is added to the general ledger. All blocks form a chain which is the reason that the technology has been given its name (White, 2017). A block could be made up of monetary transactions (Bitcoin) or smart contracts (Ethereum) (Swan, 2015).

Blockchain considers one of those emerging technologies forcing companies to rethink how transactions are established, recorded, secured, and made transparent for audit trails both the intra-company, but also intercompany (across company boundaries). Trust models between individuals, business entities, and business partners can be re-designed entirely and will have a profound impact on HCM solutions.

The usage of blockchain technology within human resources solutions helps to secure trust with every transaction being made. A timestamp is applied to each record in a transaction, and it is appended to the previous event. The blockchain offers human resource solutions advantages such as visibility, optimization, and demand by utilizing this technology. Blockchain records can only be accessed by those who have been permitted to do so. Records can be shared and secured simultaneously.

Tapscott (2017) presented the possibility of Blockchain usage in organizations' Human Resource activities such as recruiting new talents to the company's opening. Requirements such as university degrees and previous employment can be stored by institutions and companies in a Blockchain. Personal information about possible employment candidates is then made accessible to the hiring companies.

Methodological Procedures

A literature review has been performed to establish a basis for emerging technologies features and their adoption within manufacturing solutions. The literature review covered academic researches and corporate whitepapers, academic journals, and books to identify what research topics have already been conducted in this field. In addition to interviews with twelve HCM solutions experts based in the US, Dubai, and Egypt were used. The purpose was to gather qualitative information by asking the subject matter experts open-ended questions to get their elaborated and clarified opinions regarding emerging technologies features adoption on HCM solutions.

Finding

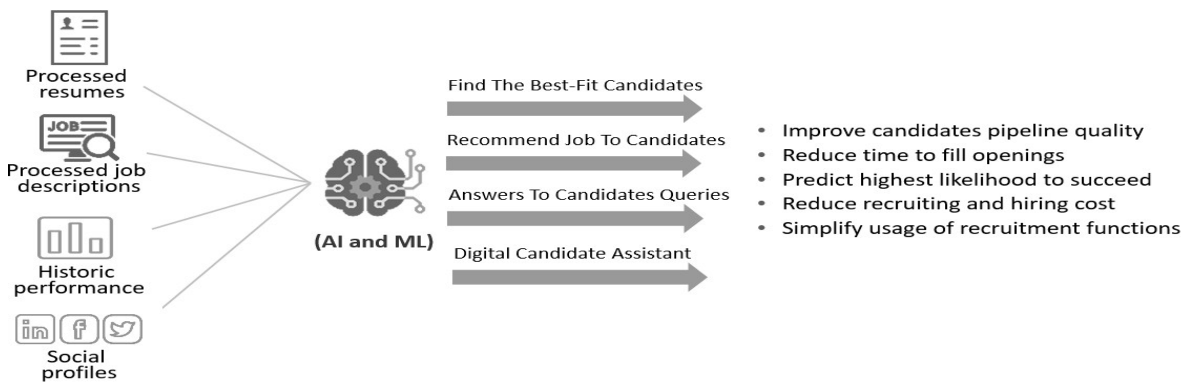
The feedback from the respondents and analysis of research results showed that AI Apps, IoT Apps, Blockchain Apps can add extremely important benefits to human resources solutions. The findings related to the influence of emerging technologies apps on HCM solutions areas are noted in the below further detail:

AI Apps Influence on HCM Solutions:

The respondents overwhelmingly believe that AI Apps influenced HCM solutions. The emergent themes from the data regarding the influence of current AI Apps in HCM solutions grouped responses around the following areas: A.1) recruiting and A.2) talent development.

AI Apps Influence on Recruiting

The emergent themes from the data regarding the influence of current AI Apps in the recruitment module grouped responses around the following areas: A.1.1) screening candidates, and A.1.2) identifying candidate experiences (See figure 1).



AI Apps Influence on Screening Candidates

Respondents indicated that AI capabilities enabled finding the best fit candidate and recommend job to candidates apps which leverage a combination of job, profile, hiring, and HR data to proactively assess a candidate's fit for a particular requisition, as compared to other candidates and employees. The AI algorithm also learns from organizational behavior to provide more relevant recommendations in the future. Respondents agreed that finding the best candidates reduced the time a recruiter or hiring manager needs to screen job applications, increased the pipeline of qualified candidates, and reduced time-to-hire for hard-to-fill jobs.

AI Apps Influence on Candidates' User-Experiences:

Respondents indicated that AI and natural-language–processing capabilities enabled candidate digital assistant App which improved the candidate user-experience by providing conversational assistance, making it easier than ever to get questions answered and tasks completed. The candidate's digital assistant enables the candidate to search for jobs and get answers to questions directly through channels such as text messages. These also automatically alert candidates for updates and actions needed on their channel of choice.

AI Apps Influence on Talent Development

The emergent themes from the data regarding the influence of current AI Apps in the recruitment module grouped responses around the following areas: A.2.1) Career Development, A.2.2) Learning, A.2.3) Employee User Experiences (See Figure 2).

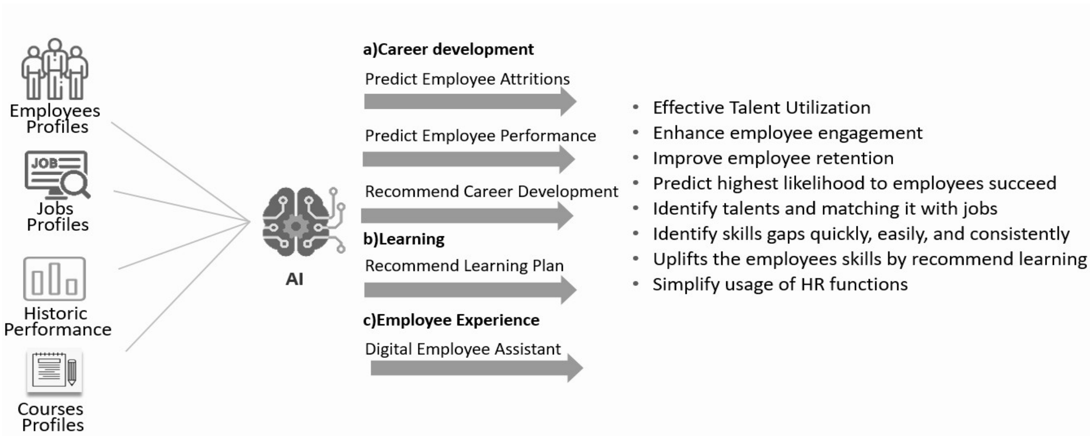


Figure 2. AI Apps Influence on Talent Development

AI Influence on Career Development

Respondents agreed that AI apps enabled HR specialists and managers to predict employees' attritions and performance to provide recommendations for their career development to jobs that better suit their capabilities and desires. They also indicated that AI capabilities provide a higher likelihood of filling existing jobs with internally qualified and interested personnel.

AI Influence on Learning

Respondents shared that AI apps enabled employees, HR specialists and managers to identify courses and other learnings tools beneficial to all. AI apps also help employees in finding better matching learning resources quickly and accurately in order to advance their careers.

AI Influence on employee user experience

Natural Language Processing (NLP) is an area of study concerned with how well computers can understand human language in order to process, analyze and extract meaning from large amounts of text data that is written in natural language.

Respondents indicated that AI and NLP capabilities enabled employee digital assistant App, which improved the employee user experience by providing conversational assistance, making it easier than ever to get questions answered and tasks completed. Employee digital assistant enabled employees to quickly and easily access information such as benefits, time off and contact information and get questions answered directly through channels like SMS or Messenger.

IoT Influence on Human Resources Solutions:

The emergent themes from the data regarding the influence of IoT in the HCM solutions grouped responses around the employees' location tracking area (See Figure 3).

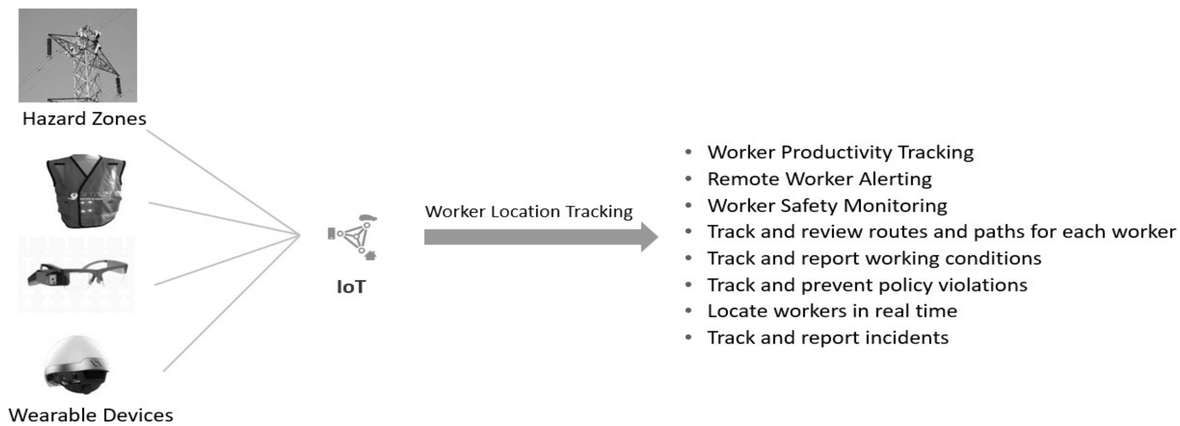


Figure 3. IoT Apps Influence on HCM Solutions

Respondents cited that IoT capabilities enabled connected worker App, which enhance worker safety through monitoring of workers and the environment. In real-time, the location of workers can be continuously monitored. In the event of an accident or emergency, the supervisor can broadcast a message to select or all workers, ensuring that the right workers receive accurate instructions based on location. It can support both auto-generated and user- definable rules, so that the health and safety of workers can be automated. For example, a rule can be written to detect if a worker has not moved in 10 minutes, indicating that he might have passed out.

Blockchain Influence on HCM Solutions:

The emergent themes from the data regarding the influence of blockchain in HCM solutions grouped responses around the employees' background checks and education verification (See Figure 4).

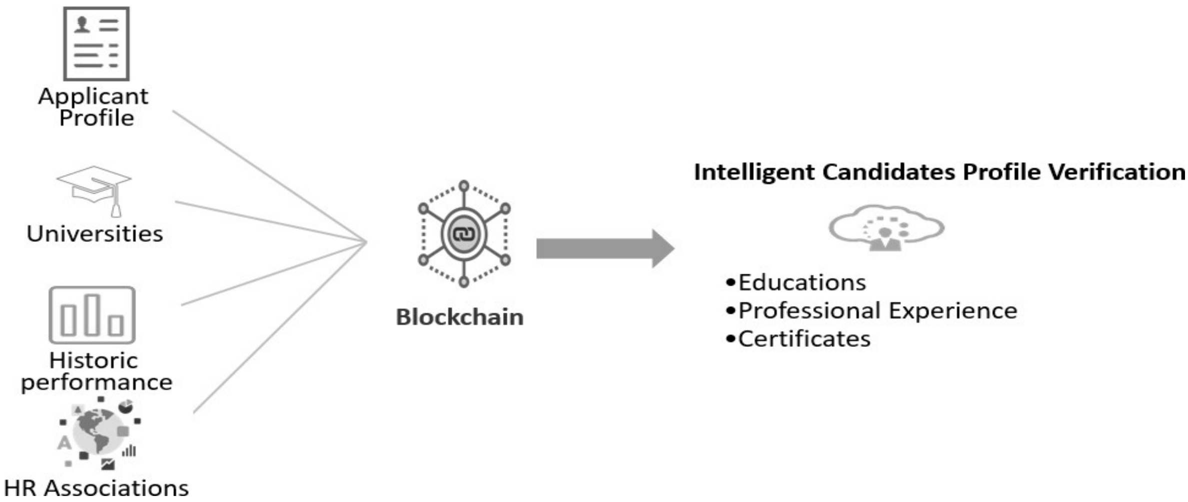


Figure 4. Blockchain Apps Influence on HCM Solutions

Respondents mentioned that Blockchain technology makes it possible to accelerate and automate the way employers verify information relating to the identity of their potential future employees and offer a better match between candidates and positions. They discussed the possibility to create Blockchain networks by HR Associations to have a comprehensive digital record of candidates' experiences and accomplishments. Any company recruiting candidates can use this network of HR Associates and validate any candidate data.

Conclusions

This research has displayed a great interest, excitement, and urgency in the field of emerging technologies apps used for smart HCM solutions. Emerging technologies apps can help HCM Solutions to drive different trust, audit, and business model changes to allow for more speed, increased business agility, and real liberation to drive value add and competitive differentiation. Whether it be insightful dashboards to help trusts work faster and smarter, or Adaptive Intelligence (AI) combining data with advanced machine learning and sophisticated decision science to help improve talent management, provide automated learning recommendations, complete workforce insights, and increased operational efficiency. The scalability, flexibility, agility, and cost-effectiveness that AI Apps, IoT Apps, and Blockchain Apps with the smart HCM solutions provide will ensure industrial human resources have a modern platform that is ready for the future whatever it might bring.

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The social changes and stakeholders impacted by digitalization of business models: A systematic literature review

Abstract ID#284

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Purpose

This paper aims to investigate social changes and how the digitalization of organizations impacts stakeholders and contributes to sustainable development. In order to investigate this, the paper seeks to answer the following research question: “what are the positive and negative social changes and stakeholders impacted by digitalization of traditional and established firms’ business models?”.

Literature Review

In 1987, United Nations made a call to discuss global challenges, publishing a report called “Our Common Future” and defining sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 40). Later, in the 1970s, the German government introduced “Industry 4.0” developing intelligent production, internet of things, cloud technology and big data (Oztemel & Gursev, 2020). Industry 4.0 modified business models and triggered social behavior changes (Kotarba, 2018). In industry, technological changes take place at different rates. In sectors such as energy and metallurgy, where the life cycle of devices counts in decades, changes are slower than in the sector of everyday goods and services (clothing, shoes, cars, household appliances, electronics) (Saniuk et al., 2020). For this reason, social behaviors will also change in different rates. Another relevant aspect is related to the measurement of social impacts that is not a trivial task because social impacts can be positive or negative, depending the value stakeholder give to them or even preestablished standards on the context (Godina et al., 2020). From the business view, digitization will bring positive impacts (for example, improvement in industrial productivity, development of new products, processes or new business models) but from employees view, it will bring negative impacts (for example, substitution of human workforce by machines) (Cezarino et al., 2019). To better understand social changes and how the digitalization of organizations impacts stakeholders, this paper maps the social changes, positives and negatives, that employees, suppliers and customers will have with the digitalization of traditional and established firms’ business models.

Methodological Procedures

The paper presents a systematic literature review on digitalization of traditional businesses. The sampling was performed in both Web of Science and Scopus databases. After the screening process, bibliometric and content analyses, using VOSviewer, map social changes and stakeholders impacted. We classified social change as having a positive or negative impact on stakeholders

Findings

This paper contributes to identifying twelve social changes impacting employees, suppliers, and customers related to the digitalization of traditional business models. We identified eight groups of employees-related social changes: (a) unemployment, (b) job creation, (c) better work positions, (d) labor relations and labor rights protection, (e) overload, strain, and distrust, (f) leadership enhanced by employee data, (g) IT tools supporting leadership, (h) educational and training programs. Besides, two suppliers-related social changes were clustered: (i) trustful, transparent and traceable relationships and (j) emergence of individual entrepreneurs. Furthermore, two customer-related social changes were identified: (k) customization, active participation, untact and unmanned service, and (l) fear with data protection and privacy rights. The content analysis showed that the most significant concerns are related to employees and their exposure to unemployment due to replacement by machines, the loss of rights due to changes in labor contract relations, and the overload and stress with the volume of data and new responsibilities workers will be exposed.

Implications

This paper anticipates business paradoxes to leaders becoming more conscious of sustainable development. For example, while digitization automates operational activities and reduces human intervention in decision-making, the presence of people becomes even more relevant as "human beings", in other words, professionals with more human soft skills to deal with employees who are more overloaded with technology and data analysis. The paper highlights that traditional businesses have the opportunity to be protagonists in the search for general social well-being with the digitalization of their business model. Considering the research method, this study was limited on the exclusion of articles and did not include articles to be read as usual in snowballing technique. In addition, the article was limited to evaluating sustainable development taking the social pillar as its focus and did not study the economic and environmental pillar, nor the relationship of the social pillar with these two other pillars. For this reason, the assessment of sustainable development was limited to taking the assessment of social welfare enhancement as a sufficient factor for the sustainable development of a country. A deeper analysis of what social welfare is and its relationship to sustainable development could be done in the future. In addition, it is important to highlight that the content analysis focused on the digitization of social businesses of traditional and established firms. In the future, the analysis can be extended to understand the social impacts of digital native startup or new digital opportunities by existing digital companies.

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Building capabilities for sustainable innovation ecosystems
Abstract ID#370

Surie Gita (Adelphi University)

Purpose of the paper

This paper examines the capabilities required for building sustainable innovation ecosystems as digital technologies (e.g. social media, virtual communication infrastructure including Internet-of-things for hyper-connectivity; 3D printing, cloud services, big data analytics and artificial intelligence) transform and disrupt industries. It examines the question: (1) What capabilities are required to create sustainable innovation ecosystems and how can they be developed?

Related work

The paper draws on the following relevant literature streams: (1) national innovation systems (Lundvall, 2016; 2010; 2007; Nelson, 1993) and industrial ecosystems (Iansiti and Richards, 2006) that emphasize interfirm exchanges and coordination for ecosystem resilience; (2) institutional and entrepreneurial capabilities (North, 1991; Audretsch et al. 2019; Baumol et al., 2007; Schumpeter, 1934; Kirzner, 1973). Entrepreneurship is required for commercializing inventions as invention alone is insufficient. Even in industrialized economies, it is acknowledged that government plays an important role in facilitating the establishment of entrepreneurial firms. Therefore, institutional support is necessary for promoting entrepreneurship.; (3) sustainability and the diffusion of sustainability related concepts (UN, 2015; Pearce and Atkinson, 1993a; 1993b); (4) digitalization and Industry 4.0 (Kagerman et al., 2013; Frank et al., 2019) which involves smart manufacturing and integration of the factory with the entire product life cycle and supply chain activities. Industry 4.0 relies on digital technologies such as the Internet-of Things (IOT), artificial intelligence to improve decision making and save costs (OECD, 2019), cloud services, big data and analytics to gather, store and analyze data in real time for decision making in various applications (Wang et al., 2015; Frank et al., 2019).

Integrating the broader disciplines of science, engineering and management is necessary strategize, develop and implement technology and create sustainable socio-technical ecosystems that are beneficial over time. Ecosystems literature informs us that interactions and coordination across organizations is critical for ecosystem resilience. Resilience is defined as the ability of a system to absorb changes and still persist, while stability is the ability of a system to return to an equilibrium state (Holling, 1973). Resilience refers to the ability of the system to retain essentially the same function, structure, identity and feedbacks" and is a dynamic concept (Walker et al., 2004) thus indicating that the system stays in the same "basin of attraction" (Zhu and Ruth, 2013).

Literature on sustainability highlights that the built environment based on innovation cannot completely replace the natural environment (Pearce, D.W. and Atkinson, G., (1993a; 1993b); Heal, 2011). Hence sustainability concepts such asthe adoption of clean energy, circular economy and waste-to-energy in manufacturing need to be widely embraced in industry (McDonough and Braungart, 2010). Likewise, literature on entrepreneurship and entrepreneurial capabilities highlights that these capabilities are critical for niche development, as niches are protected spaces where radical innovations can develop without being selected out by the pressures of the prevailing regime (Markard et al., 2012; Geels and Schot, 2007), and, thus, contribute to ecosystem resilience (Iansiti and Richards, 2006).

Recently, the rapid advance of digital technologies enables transformation from physical to cyber physical systems and accelerates the creation of linkages across individuals, companies and nations. Thus, new technologies and capabilities pertaining to digitalization along with knowledge of sustainability, entrepreneurship capabilities and institutional capabilities that enable inter-firm exchanges can contribute to the development of new niches and industrial innovation ecosystems that are sustainable and resilient.

Design/Methodology/Approach

The paper focuses on the following capabilities necessary for developing sustainable innovation ecosystems: (1) entrepreneurial capabilities that diffuse innovations, thereby enabling niche creation and ecosystem sustainability and resilience. (2) institutional capabilities for promoting linkages and creating pathways for diffusing innovations; (3) capabilities pertaining to sustainability and (4) capabilities pertaining to new digital technologies.

The paper provides a multi-level framework spanning industry, national and global levels and outlines how innovation ecosystems can be made sustainable through the capabilities described above.

Case examples of innovation ecosystems are provided to support the framework.

Findings

The paper suggests that there may be differences across innovation ecosystems depending on differences in capabilities – entrepreneurial, institutional, sustainability and digitalization. For example, lack of entrepreneurial capabilities may impede the growth and sustainability of innovation ecosystems. Likewise, lack of institutional capabilities may inhibit the diffusion of innovations. Similarly, a dearth of capabilities pertaining to sustainability may have a detrimental effect on the future of the national innovation ecosystem. Correspondingly, insufficient capabilities with regard to digital technologies may make it difficult for national innovation ecosystems to be at the forefront of innovation. As ecosystem resilience arises from building linkages and diversity; adopting these concepts can facilitate the transformation of industrial ecosystems into digital ecosystems.

Research limitations/implications

A limitation of the paper is that the development of capabilities for sustainable innovation ecosystems is examined through case examples.

Practical implications

Insights on how to build capabilities for creating sustainable innovation ecosystems can help MoT experts and policy makers to proactively build institutions and capabilities required for developing sustainable innovation ecosystems.

Originality/value of the paper

The paper contributes to the MoT literature by applying theories from different streams of literature to develop a framework for how to build sustainable innovation ecosystems that are at the technological frontier. It highlights how MoT experts can help policy makers to use digital technologies in combination with other capabilities to bring about innovation and transformation for national and global innovation ecosystems.

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INNOVATION ECOSYSTEMS II

May 2nd: 3h10 pm – 5h pm

Chair

Olivier Coussi (University of Poitiers, France)

Papers

Evolution of governance mechanisms and the use of trust and contracts to achor FDI and build an ecosystem

Oliver Coussi, Kadigia Faccin, Evelyne Lande, Alsones Balestrin

Governance of innovation ecosystems: analysis of the pact for innovation in Santa Catarina, Brazil

Micheline Gaia Hoffmann, Elisa Pereira Murad, Dannyel da Cunha Lemos, Josivania Silva Farias, Beatriz Lancellotti Sanches

Innovation ecosystems: An analysis of scientific production

Ricardo Santos Fenner, Paulo Vanderlei Cassanego Jr, Mygre Lopes da Silva

Proposing a new capability for ecosystem management: The technological interdependence management capability

Fabio Emanuel Farago, Felipe Mendes Borini, Leonardo Augusto de Vasconcelos Gomes, Ximena Alejandra Flechas Chaparro, Ana Lucia Figueiredo Facin, Lucas Emmanuel Nascimento Silva

Information and communication technology governance model for a smart university

Fernanda Rachel Osorio Espinoza, Pedro Palominos Belmar, Javier Donoso Oyarzún

Evolution of governance mechanisms and the use of trust and contracts to anchor FDI and build an ecosystem

Abstract ID#106

Oliver Coussi, Evelyne Lande (University of Poitiers); Alsones Balestrin, Kadígia Faccin (University of Vale do Rio dos Sinos)

This contribution aimed to explain how governance mechanisms evolve as an ecosystem is formed to anchor foreign direct investment (FDI). To examine this issue, we used a unique case study with a processual data approach considering the analytical grid of actor-network theory to assess the different stages of ecosystem development. The study results showed a change in terms of governance that is highly formalized through explicit contracts that clearly define the economic purpose of cooperation and lead to more horizontal and asymmetric governance over time. Governance therefore becomes more balanced (it tends to take a vertical form otherwise) even though the number of actors has increased, which is a major finding of this research. The originality of this study lies in its finding that balanced governance is not the prerogative of an ecosystem with few actors; it is the result of the ability of various stakeholders, particularly nonbusiness stakeholders, to gain legitimacy by using business vocabulary while being faithful to their public values.

Many studies have been done on network building during and after international market entry. All the behavioural internationalization models, for example, the Uppsala Model (J. Johanson & Vahlne, 2009), the Network Model (Jan Johanson & Mattsson, 2015) , and International New Venture Model (Oviatt & McDougall, 1994; Zahra, 2005) use a network analysis. A market such as Brazil offers marketers many opportunities despite specific characteristics of the Brazilian economy that are quite negative in terms of logistics, corruption and bureaucracy (Gouvea, Kapelianis, & Montoya, 2018). These difficulties can be overcome if there is an alignment between territorial strategies such as ecosystems and business strategies (Guerrero & Martínez- Chávez, 2020). In terms of impact on welfare and knowledge infrastructure through the governance of the host country (Lehnert, Benmamoun, & Zhao, 2013), to our knowledge, no research has focused on the role of FDI as a pretext for coordinating actors in the territorial dimension of business ecosystem dynamics. Despite the different approaches of the ecosystem concept, there is poor understanding of how the ecosystem environment is established and evolves and of the processes by which it develops over time. Thus, governance, which has rarely been rarely studied, can help to understand this evolution is governance.

Governance indicates how a group of organizations is structured and organized as well as its regulatory and decision-making mechanisms (Wegner & Verschoore, 2021). Collaborative processes require the acceptance of the rules of the game by the participants and include some legal conditions, even if these are adhered to only informally (Binz-Scharf, Lazer, & Mergel, 2012).

In this scenario, the following research question emerges: **how have governance mechanisms evolved in an entrepreneurial ecosystem to attract and anchor FDI?**

To answer this question, a study of the literature on business ecosystems and governance mechanisms within cooperative ventures is conducted to establish an analytical and conceptual framework. Then, the methodology based on the implementation of the actor-network theory (Callon, 1986) as a methodological framework is presented and justified, followed by the results of the case study that allows to understand the resolution of several controversies to have a stabilization of the network of actors involved in the management process for the localization and anchoring of a FDI project in the south of Brazil.

As results we show that the FDI project management process studied here followed a whirlwind evolution, each stage of which was marked by the resolution of a new controversy that allowed the project to evolve, anchor itself in the territory and thus expand its network. The three translation loops intertwined throughout the project management process to achieve a stabilized final situation. In accordance with the postulates of the sociology of translation, this nonlinear and whirlwind process led actors to adopt new behaviors. In particular, they developed personalized support and follow-up with foreign investors by identifying needs for adopting the most relevant resource-related solution.

Moreover, actors created new ways of operating through collaborative work among the company manager, city technicians, the university project manager (on behalf of the university's governance) and governmental institutions. This variety of actors was the source of the strength of this ecosystem and included business actors as well as nonprofit actors. This proliferation of actors and their interrelation was also at the origin of new knowledge through the creation of a research laboratory within the university and a technology transfer center dedicated to semiconductor technologies and the research and development being conducted there. These governance mechanisms led to a social context conducive to the implementation of innovative solutions for the anchoring of the FDI project in the territory and its appropriation by all stakeholders in the territory.

This study shows that several governance mechanisms can be put in place, ranging from oversight-based governance mechanisms to trust-based governance mechanisms between partners (Gulati, 1995). Governance mechanisms based on trust are based on explicit contracts binding the parties (and can also be mobilized within the framework of governance mechanisms based on control) and on implicit and subjective contracts or agreements that reinforce complicity and trust between the partners (Marion, Eddleston, Friar, & Deeds, 2015). Finally, the literature also highlights the major role of the trust guardian (Child, 2001), particularly for financial transactions, or the focal entity within the network (Jacobides, Cennamo, & Gawer, 2018) in aligning interests within the network. However, more fundamentally, trust is based on attitudes and a common history developed over time as the relationship continues (Lui & Ngo, 2004) and can be referred to as goodwill trust (intangible assets developed internally within the network); alternatively, it can be based on competence, the ability of network members to meet commitments because of their resources and their reputation (Das & Teng, 2001).

The business ecosystem studied here shows that in practice, networks rely on a combination of governance mechanisms based on control or trust to bring the interests of the parties together.

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Governance of innovation ecosystems: analysis of the pact for innovation in Santa Catarina, Brazil

Abstract ID#249 | Full paper ID#402

Micheline Gaia Hoffman, Elisa Pereira Murad, Dannyela da Cunha Lemos, Beatriz Lancellotti Sanches (Santa Catarina State University); Josivania Silva Farias (University of Brasília)

Abstract: This study analyzed the governance characteristics of the Pact for Innovation in Santa Catarina, a program created to foster the development of the existing ecosystem in the state and connections between the actors. The case study was carried out through semi-structured interviews, document search, and a questionnaire. The analysis model originated from a systematic literature review that generated theoretical-analytical categories. For analyzing qualitative data, we conducted a thematic analysis with the support of ATLAS.ti software. For quantitative data, we used descriptive statistics. We identified that the Pact governance includes a diversity of actors that operate in specific working groups through exchange and sharing relationships guided by coordination mechanisms; despite the existence of a central leadership, this approach gives room to actors' leading roles, in a decentralized way, with little formality. Even so, the results suggest that the movement's sustainability requires increased mobilization of new orchestrators. The paper contributes to the literature and IE managers, considering the knowledge gap on governance in this type of context.
Keywords: Governance; Innovation Ecosystems; Pact for Innovation; Santa Catarina; Brazil.

Introduction

Inspired by the business ecosystems approach (Moore, 1993), the concept of innovation ecosystems (IEs) is still recent and a growing topic of study (Cobben, Ooms, Roijakkers & Radziwon, 2022; Granstrand & Holgersson, 2020; Foguesatto et al., 2021; Stahl, 2022). Its meaning relates to an evolving set of actors, activities, and artifacts, as well as complementary and substitute institutions and relationships relevant to the innovative performance of an actor or a population of actors (Granstrand & Holgersson, 2020).

Given the diversity of actors, an IE demands the coordination of interactions through an alignment structure that enables the performance of specific and complementary roles (Thomas & Autio, 2020). Innovation ecosystems can develop organically or through deliberate intervention (Santos, Zen, & Bittencourt, 2021), which occurs through the action of an individual, organization, or group, which plays the role of orchestrator (Chen et al., 2021). Then, different IE configurations require specific coordination strategies for mobilizing actors, aligning interests, and developing a common agenda (Santos et al., 2021).

Therefore, a governance effort becomes necessary (Wegner & Verschoore, 2021). The concept of governance is related to the act of ruling interorganizational relations through norms created together, to regulate the collective action (Ostrom, 1990). Through governance, it is possible to favor directionality, control, and coordination between individuals and organizations, focusing on collective goals and interests (Lynn, Heinrich, & Hill, 2000). In the IE literature, there is an emphasis on the presence of an orchestrator, a role that is not necessarily assigned to a focal company, and which has different characteristics, depending on each ecosystem's context (Cobben et al., 2022). Hence, it highlights the importance of rules and participation mechanisms, involving actors' engagement (Gomes, Santos & Facin, 2022)

Although governance is a focus of study in IE literature (Cobben et al., 2022), it is still a poorly addressed topic (Spena, Tregua & Bifulco, 2017), thus lacking more studies. Understanding governance and its forms in different innovation ecosystems is a latent research path in the IE field (Foguesatto et al., 2021).

In the state of Santa Catarina, Brazil, the Pact for Innovation program was created in 2017 to foster greater convergence of resources to the state's innovation ecosystem (Santa Catarina, 2017). Assuming that a strong ecosystem is hyperconnected, increasing its capacity for articulation and collaboration was necessary. To this end, it covers a diversity of actors, including the government, the business sector, support foundations, universities, associations, research institutes, incubators, technological innovation centers, and technology parks. Forty-one organizations involved in the program have agreed on 240 actions focused on common objectives. Therefore, it involves diverse actors, actions, and interests, making a good governance structure essential and urgent.

Given this scenario and the need for further theoretical deepening on governance characteristics in different IEs, this study analyzed the governance attributes of the Pact for Innovation in Santa Catarina.

In the next section, we present a synthesis of the literature review which led to the theoretical-analytical categories for studying the governance of innovation ecosystems, which, in turn, made up the research analysis model. Next, we present the methodological procedures, results, and final remarks.

Governance of Innovation Ecosystems

Innovation ecosystems (IE) comprise the relationship between interdependent and interconnected actors focused on value creation (Adner, 2017; Auria et al., 2016; Gomes et al., 2016), which articulate value joint proposals (Gomes et al., 2016; Konnola et al., 2021) for seeking collective benefits (Konnola et al., 2021).

This is a field of study that has gained visibility (Granstrand & Holgersson, 2020), so that the number of papers that address the relationship between actors oriented to value creation through EI has increased (Stahl, 2022). The concept originated in the business ecosystem approach, described by Moore (1993). Among the variety of industries that business ecosystems involve, a company is not just a participant in a sector, but rather a part of an ecosystem.

The specificities of the IE concept promote advances in the literature by allowing to understand the complexity of existing relationships between interdependent actors (Adner, 2017; Auria et al., 2016; Dedehayir, Makinen, & Ortt, 2022; Gomes, Santos & Facin, 2022; Stahl, 2022), and the dynamics of innovative contexts (Auria et al., 2016), also differing itself from the approaches of innovation systems and networks. In innovation systems, the focus is on the different contexts (political, economic, and cultural) in a perspective of geographical coverage (regional, national, etc.), involving activities done by various actors in a system. Innovation networks, on the other hand, address the firm or industry perspective, leveraging resources and technologies to translate knowledge and collaboration into innovation (Auria et al., 2016; Spena, Tregua & Bifulco, 2017). Thus, IE differs from these concepts, whose specificities are discussed in Auria et al. (2016), by shedding light on value creation, providing a new look to shape the collective dimension of this process (Gomes et al., 2016).

In face of the complexity of relations, of multiple views and interests among actors, it becomes imperative to coordinate their interactions through an alignment framework (Thomas & Autio, 2020), which makes governance necessary. IE governance is about developing actions and practices oriented to actors' alignment given their objectives and goals.

From a systematic literature review conducted in SciELO, Scopus, and Web of Science databases, we identified, in a previous paper (Hoffmann et al., 2023), attributes of IE governance that we assumed as theoretical-analytical categories for this study, which are: common objective and value cocreation; actors and roles; goals and evaluation; coordination mechanisms; the relationship between actors; and governance approach.

Common objectives and efforts for **value cocreation**, which define an ecosystem's direction and purpose (Konnola et al., 2021), guide IE governance. Hence, interests are aligned for the implementation of the IE strategy (Roig, Wang & Sánchez, 2020), emphasizing value cocreation (Autio, 2021; Cappellano & Makkonen, 2020; Chen et al., 2021; Duarte et al., 2021; Grobbelaar, 2018; Leceta & Konnola, 2019).

There are different **actors and roles** in this process, highlighting the presence of companies, universities, public authorities, civil society organizations, entrepreneurs, investors, startups, coworking, incubators, and accelerators (Duarte et al., 2021; Cobben et al., 2022). Each can play multiple roles and participate in different projects (Duarte et al., 2021), and new functions may emerge (Leceta & Konnola, 2019).

The government, for example, has an important role in developing public policies that favor the ecosystem, acting as a facilitator and funder (Camboim; Zawislak & Pufal, 2019; Cappellano & Makkonen, 2020; Gifford, McKelvey & Saemundsson, 2021; Leten et al., 2013; Liu et al., 2020). The private sector contributes by cocreating knowledge and technologies through exchanges with other actors (Duarte et al., 2021; Leten et al., 2013; Roig; Wang & Sánchez, 2020). Universities exchange knowledge and learning through research (Grobbelaar, 2018), and civil society organizations propose solutions and ideas for improving social and environmental problems (Chen et al., 2021).

By articulating a joint value proposition (Duarte et al., 2021; Konnola et al., 2021), actors develop **goals** that must be monitored and assessed through an **evaluation** system that requires indicators and metrics, given the established strategic objectives (Chen et al., 2021; Leceta & Konnola, 2019).

To align the actors around IE purpose and objectives, management practices (Leceta & Konnola, 2019) and **coordination mechanisms**, both formal and informal, are required (Arena, Azzoni & Piantoni, 2021), stimulating participation, information exchange, and collaborative problem solving (Duarte et al., 2021). To this end, events, meetings, and conferences are held (Chen et al., 2021; Leceta & Konnola, 2019), in addition to agreements, such as contracts (Wegner & Verschoore, 2021). Therefore, actions are coordinated to ensure directionality in the ecosystem (Konnola et al., 2021).

Hence, for collective action to occur, it is necessary to strengthen the **relationship between actors**, stimulating collaboration, partnerships, and integration activities (Gifford et al., 2021) based on the exchange and sharing of knowledge and information (Cappellano & Makkonen, 2020), as well as reinforcing trust between the parties.

In this context, a **governance approach** develops, which can have an orchestrator with different characteristics and roles (Dhanaraj & Parkhe, 2006; Cobben et al., 2022), and power is shared among stakeholders (Cappellano & Makkonen, 2020). The governance approach can vary from a formal and strict control to a less hierarchical form and decentralized management that favors the participation of different actors (Camboim et al., 2019). As the governance approach varies according to IE context and its stage of maturity (Santos et al., 2021), there may be a combination of both types of approach (Camboim et al., 2019; Gifford et al., 2021).

Methodological Procedures

The choice of the Santa Catarina Pact for Innovation as object of study was due, on the one hand, to the expressivity achieved by the program, which, in three years, mobilized 41 organizations to agree on the execution of 240 actions for the development of the State's innovation ecosystem; on the other hand, to the demobilization that occurred afterwards, during the COVID-19 pandemic. Considering the focus of the program on converging efforts and the increase of the collaborative capacity in the ecosystem, we chose to study it under the governance perspective.

The innovation ecosystem of Santa Catarina is recognized both nationally and internationally, due to aspects such as the significant number and degree of qualification of entrepreneurs, the presence of an institutional arrangement focused on the promotion of ST&I, and of cooperation networks (SDS, 2017). The State is one of the pioneers regarding the business incubation movement in Brazil (Azevedo & Teixeira, 2018), and its cities were evaluated as the most entrepreneurial in the country, according to the general ranking of the Entrepreneurial Cities Index (ICE) 2023. The capital, Florianópolis, was ranked first for the human capital factor and the innovation driver, considered as the Innovation Capital (ENAP, 2023).

To analyze the governance characteristics of the Pact for Innovation, we carried out a qualitative and interpretative case study, through a data collection process that triangulated semi-structured interviews, document search, and questionnaires, from February to November 2022. We interviewed 12 key players of the program (Table 1), chosen by their representation of the existing diversity in the ecosystem.

Table 1
Interviewees' codes

Code	Institution
E1	State Secretariat of Sustainable Economic Development - SDE
E2	State Secretariat of Sustainable Economic Development - SDE
E3	Euvaldo Lodi Institute- IEL/FIESC
E4	Santa Catarina Technology Association - ACATE
E5	VIA Group/ Federal University of Santa Catarina - UFSC
E6	State University of Santa Catarina - UDESC
E7	Euvaldo Lodi Institute- IEL/FIESC
E8	State Secretariat of Sustainable Economic Development - SDE
E9	National Service for Commercial Learning - SENAC SC
E10	National Institute of Industrial Property - INPI
E11	Brazilian Bar Association - OAB SC
E12	State Secretariat of Sustainable Economic Development - SDE

The interview script was designed from a theoretical-analytical model based on Hoffmann et al. (2023), referring to the following categories: common objectives and value cocreation; actors and roles; goals and evaluation; coordination mechanisms; the relationship between actors; and governance approach. We also collected minutes of all meetings held within the program, regulations, cooperation terms, spreadsheets of agreed actions, photos, videos, and documents produced on the Pact.

The questionnaire had 17 categorized closed questions, mutually exclusive (yes/no), and other multiple-choice questions, distributed in three blocks of closed questions. The first one focused on characterizing the organization, with questions related to its type (company, university, government, civil society organization, or others), sector of activity (education; arts and entertainment; agriculture; fish farming and hunting; financial; construction; information technology; telecommunications; manufacturing; mining and quarrying; professional/technical services; public administration/government/defense; real estate; retail; transportation and warehousing; automotive; healthcare; lodging; utility services; and others), location and range of operation (municipal, state, national, or international). The second block, oriented to identifying the implementation stage (ongoing, concluded, paralyzed, or canceled), among other information on the agreed actions under the responsibility of the organization (results achieved; number of people involved; amount invested; partnership; types of partners; partner organizations; origin of the action - if it was created before or after the Pact; if paralyzed or canceled, the reason).

As for the last block, it had two multiple-choice questions, asking respondents to indicate issues that, in their perception, were the Pact's strengths and achievements (strong central leadership; capacity for actors' self-organization; diversity of actors; presence of leading actors; counterparts; actors' commitment; resource sharing; physical/geographical proximity between the actors; collaborative processes; quality of the communication process; effectiveness of the formal processes of coordination and control; shared values and vision; existence of indicators; and others), and additional issues considered as challenges for its consolidation (strengthening of a central leadership; higher counterpart from the actors; greater commitment of the actors to their role; greater openness and trust for sharing resources; greater physical/geographical proximity between the actors; deepening collaborative processes; improving communication; improving formal coordination processes; development of shared vision and values; development of indicators).

We focused the application of questionnaires on the managers of the agreed actions. We sent 41 forms to the managers of the 240 agreed actions (N=240). Of these, 25 were answered, corresponding to 167 actions (n=167). The reason for such differences is that the same organization can coordinate more than one action.

For data systematization purposes, we separated the respondents in four main groups of actors: Associations and incubator networks, technological innovation centers, and technology parks (RED); organizations representing companies, associations, and professionals (EMP); government (GOV); and science and technology institutions (ICT). The set of the 25 responding organizations was composed of 9 entities from the ICT group, who answered about 73 agreed actions, eight from the GOV group, responsible for 45 agreed actions, five from the EMP group, who answered about 26 actions, and finally three from the RED group, who responded on 23 agreed actions.

The range of these organizations is mainly statewide, since 15 of the 25 respondents operate at this level. There is some representation of organizations that operate at the national level (7), five of which belong to the ICT group. Municipal (1) and international (2) organizations are less represented in the research sample. Regarding the sector of activity, there was a predominance of organizations that operate in the field of education (7), followed by those that operate in public administration/government/defense (5), while the others were scattered among the other sectors.

The data collection strategies adopted, as well as the participants selected, allowed carrying out data triangulation in the analysis process. That is, different sources were used and different collection methods were combined, aiming to consolidate conclusions regarding the investigated phenomenon (Zappellini & Feuerschutte, 2015): the characteristics of the governance of the Santa Catarina Pact for Innovation.

We used the thematic analysis technique for data analysis from these categories defined in advance. Using the ATLAS.ti software, codes were applied and analysis schemes were generated as images that show the number of citations per category. The number of times each code was applied is represented by the letter G (grounded). The images also contain the value of D (density), which refers to the number of connections between the one code and others. As in this work these relations were not generated, the D value is zero. To process quantitative data obtained from the questionnaire, we used simple descriptive statistics, extracting absolute and relative frequencies.

Results

This section shows the results achieved for each of the categories that made up the theoretical-analytical model of the research, following the proposition of triangulating data sources. The next section presents an integral discussion of the findings, considering their relationship with the problem that motivated the study.

Common Objectives and Value Co-creation

In this category, the elements most mentioned by respondents were the existence of a shared vision, the motivation for creating the Pact, the alignment of the value proposition, and the challenges to directionality faced in the movement. Figure 1 shows the number of citations that refer to these elements.

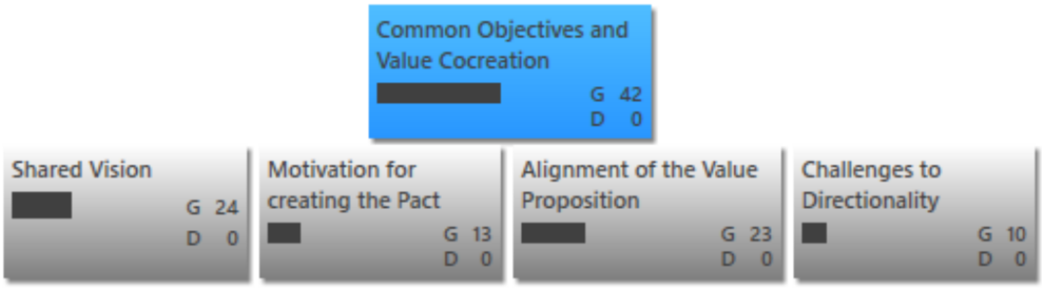

Figure 1 - Common Objectives and Value Co-creation

Regarding the **shared vision** among the actors who worked directly in the Pact for Innovation, understanding that its main objective is to strengthen the innovation ecosystem in the state was unanimous. There is a shared wish to expand the recognition of Santa Catarina's leadership in innovation (E1; E4; E5; E6; E8; E12) nationally and internationally (E7). The existence of shared values and vision is the second issue most mentioned among the Pact's strengths, with 13 citations, just behind actors' diversity, which received 22 from the 25 respondents.

We identified, both in the interviews and document search, that the program's central objective is the integration of innovation-oriented agendas and the promotion of actors' capacity to work in an articulated and collaborative way, focused on concrete actions. Hence, we highlight the existence of a common objective (Konnola et al., 2021) and a shared vision among the participants (Duarte et al., 2021). However, the quantitative empirical evidence showed that deepening collaborative processes in the ecosystem is still a challenge to address in the future. Mentioned by 10 out of 25 managers that answered the questionnaire, it is the most cited challenge.

As for the **motivation for creating the Pact**, several actors referred to the duplicity and overlapping of efforts and initiatives, which led to the dispersion of resources and weakening the existing potential in the State (E1; E2; E4; E6; E8; E10). The Pact for Innovation emerged to promote directionality.

In addition, the results confirmed that the context of the Pact's creation had a strong interface with building Innovation Centers in different regions of Santa Catarina. Therefore, the objectives and vision that permeate this movement are intrinsically related to the network of innovation centers in the state.

When asked to explain what was sought, that is, the Pact's **value proposition** and the collective concept of innovation, some actors mentioned objectives associated with research, development, and technological innovation (E1; E2; E8; E9). Others, the attraction and qualification of talents and the creation of new technology-intensive businesses (E2; E5; E9; E11). There is also the vision that the Pact went beyond fostering innovation capacity in the business sector, as it wanted to promote all kinds of innovation in all spheres, including public management and civil society organizations, through social innovations (E1; E2; E4; E5; E7; E8; E11). From a broader perspective, the Pact's focus was creating policies and programs for innovation (E1; E10). Hence, it revealed the common goal of promoting collaborations and joining efforts for the state's development and leading role based on innovation capacity and more diverse and emerging objectives, which arose gradually and varied according to the nature and origin of each actor. Thus, we observe that social responsibility and social impact (Cobben et al., 2022) are the objectives most recently incorporated into IEs.

The most prominent results obtained with the actions taken, identified by the analysis of quantitative data, show this diversity of initiatives, aligned with Pact's objective. The main results, and the percentage of actions linked to them, were: qualification on innovation and entrepreneurship (46.70% of the actions in the sample); expansion of partnerships for innovation in the state (45.50% of actions); extending the acquisition of new knowledge and technologies (41.31% of actions); attraction and talent training for the state (33.53% of actions); and companies more able to anticipate technologies and create new markets (32.33% of actions).

Given this diversity and dynamism to achieve concrete measures, the Pact's strategy was to unfold this set of more abstract objectives into actions and goals, focusing on ensuring directionality, which refers to "the purpose of the system and its normative direction" (Konnola et al., 2021).

At this point, we identified **challenges to directionality** faced in the process, such as diffuse objectives, difficulties in breaking down objectives into actions, and managers' turnover. The purpose was to make the state a reference in innovation, but according to interviewee 3 (E3), the objective was not broken down into actions aligned between the institutions. The change of organizational managers also contributes to weakening the knowledge on the objectives and guidelines of the Pact (E4), resulting in challenges to keep its directionality.

Actors and Roles

The analysis of the category 'actors and roles' involved in the Pact allows us to highlight the following elements from interviewees' standpoint: types of actors, with emphasis on diversity; actors' engagement in the movement; and actors' roles and their contributions. Figure 2 shows these findings, where the most prominent element is the diversity of actors participating in the movement.

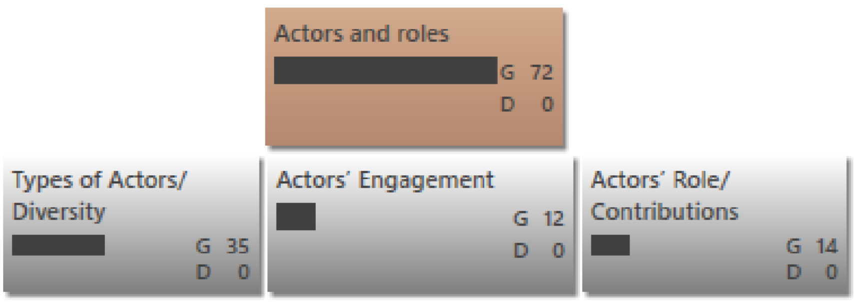

Figure 2 - Actors and roles

The Pact involves actors that promote or support science, technology, innovation, entrepreneurship, and education in Santa Catarina. The agreed actions involve companies, business and professional associations, government, universities, research institutes, technical and professional education institutions, higher education institutions, foundations that support science and technology institutes, incubator associations and networks, technological innovation centers, and technology parks. This composition is marked by **diversity**, according to the literature on the different types of actors that make up an IE, which allows for performing different and complementary roles (Duarte et al., 2021; Cobben et al., 2022). The results from the quantitative data also highlight actors' diversity mobilized by the Pact. It was mentioned by 22 out of the 25 respondents as one of the achievements/strengths of the program, ranking first in the number of citations.

Interviewees recognize SDE as an orchestrating element of the movement in its initial phase, developing the architecture and mechanisms for coordinating the ecosystem, focused on value creation (Autio, 2021). This secretariat's initiative was to make initial contact with institutions that exercised leadership in the ecosystem to mobilize them to articulate a collective value proposition. Therefore, SDE plays the role of orchestrating existing resources and knowledge in the IE (Grobbelaar, 2018).

To join the movement, the criterion established for **engagement** was that the organization should have a state, national, or international coverage, excluding municipal operations. Because of the growing interest in joining the Pact, an instrument was created to attract new members through adhesion terms. During this process, initiatives emerged throughout the State aiming to become Local/Regional Pacts for Innovation (E1; E2; E8; E9; E12). They could join the movement if they met the acceptance conditions for unlisted entities. This analysis was made by a management group, as we discuss in detail later.

Joining the Pact implied that each organization assumed contributions, the so-called "agreed actions". Document search showed that these actions were defined based on the identification of priority areas and structuring projects and were organized in four axes: Knowledge and Talents (Axis 1), Capital and Investment Attraction (Axis 2), Infrastructure (Axis 3), and Networks and Collaboration (Axis 4). Thus, as summarized by E10, the movement's agenda was established from the contribution of each institution to IE development, considering the specifics and possibilities of each stakeholder (Duarte et al., 2021; Cobben et al., 2022), as well as the interdependence between the actors (Gifford et al., 2021). To this end, several alliances were created, strengthening the collaboration between the institutions (Cobben & Roijakkers, 2018).

The analysis from the triangulation of quantitative data, interviews, and documents on the agreed actions shows the prevalence of those already ongoing within organizations, even before and regardless of the Pact. According with quantitative data, the 167 actions are distributed in the following way: 64.67% already existed before Pact creation, and 34.13% were created out of it (two forms received no answers). Therefore, we identified a small number of new actions created to contribute to the structuring projects. This issue was criticized by some interviewees (E1; E3; E8), who felt the need for efforts to develop new initiatives.

Interviewees also revealed some aspects related to actors' participation. Within the working groups (WGs), some institutions were more active than others (E1; E2), and there was a diversity of actors within some axes, while others were more concentrated in specific types of actors (E4). Amidst this diversity, the university had a leading role, as well as the government (E2; E4; E5; E6), which was also identified through quantitative data. This enabled noticing the predominance of finished actions by ICT actors (41 actions, corresponding to 56.16% of those completed, according to the sample), as well as the government (20 actions, corresponding to 27.39% of those completed). In addition, we also observed that the largest ranges of invested values were concentrated in actions under the responsibility of these two groups, totaling 26 actions with investments above R$ 1 million. Such findings align with

Grobbelaar (2018), about the university playing an important role in regional development, and with Liu et al. (2020), who see the government as a facilitator of alliances in IEs. Under another perspective, quantitative data also suggest that insufficient commitment from actors could be one of the reasons for interrupting the uncompleted actions, when 17 out of 25 actors responsible for canceled or interrupted actions mention insufficient partnerships and external articulations.

Goals and Evaluation

With shared vision and objectives, good governance in an IE involves unfolding objectives into concrete goals and establishing mechanisms for monitoring and evaluating their progress (Chen et al., 2021; Leceta & Konnola, 2019). Data analysis in the "goals and evaluation" category resulted in the following elements: measurement methodology adopted in the Pact, time horizon, follow-up and monitoring, indicators and metrics, and measurement of outcomes and continuity of actions.

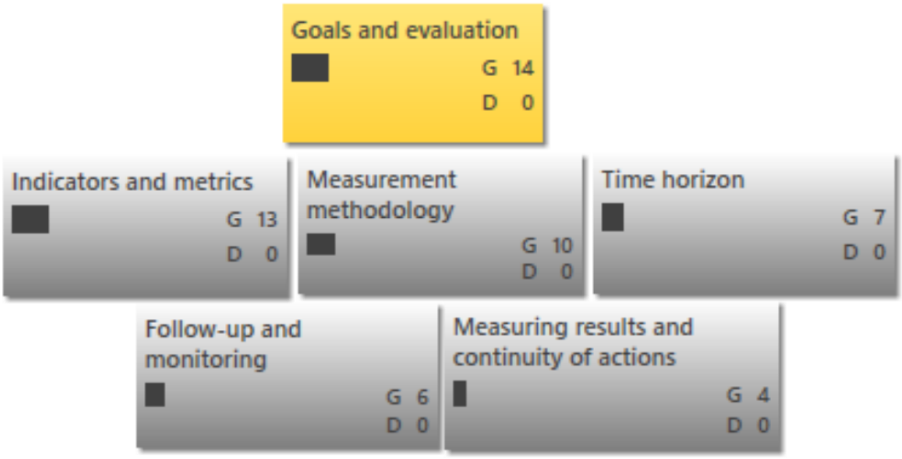

Figure 3 – Goals and evaluation

While interviewees understand the need for evaluation and monitoring indicators, they said this aspect was not discussed and matured, despite some attempts. Interviewees E2, E7, and E8 mentioned monitoring actions by a tool that updated the implementation status. In this sense, Cobben et al. (2022) strengthen the importance of adopting metrics for monitoring performance and comparative analysis of different ecosystems.

As shown in Figure 3, the element **"indicators and metrics"** stood out in data analysis, being appointed as a challenge related to the difficulty of making measurements. In this regard, interviewees highlight the OKR [Objectives and Key Results] **methodology** (E2; E5; E6; E8; E9). With the support of a facilitator, meetings were held in each working group, focused on the actions that were assigned to it, and, through a participatory approach (Grobbelaar, 2018), they created indicators and deadlines for achieving actions, showing concern with the definition of a **time horizon**. This allowed us to move towards more specific guidelines for **follow-up and monitoring** the movement's progress (Chen et al., 2021; Leceta & Konnola, 2019).

These findings from the interviews are consistent with quantitative data. The development of indicators and feasible goals is the fifth most mentioned challenge of the Pact among respondents, along with the presence of leading actors and the development of actors' self-organization capacity, cited by 6 of the 25. On the other hand, and consistent with this finding, in the question that addressed Pact's strengths, the existence of indicators and feasible targets was among the five alternatives with the lowest number of citations.

Still, we noted that prioritizing actions, defining the incorporation or not of actions already in progress by the agreed entities, ensuring the connection of indicators and goals with macro-objectives, linking goals to deadlines, and establishing monitoring remain as governance challenges for the Pact.

Coordination Mechanisms

To keep the directionality and alignment of the actors in an IE, it is necessary to use coordination mechanisms (Konnola et al., 2021). Data analysis highlighted the following in this category: control, monitoring, and communication instruments used; formality; and directionality.

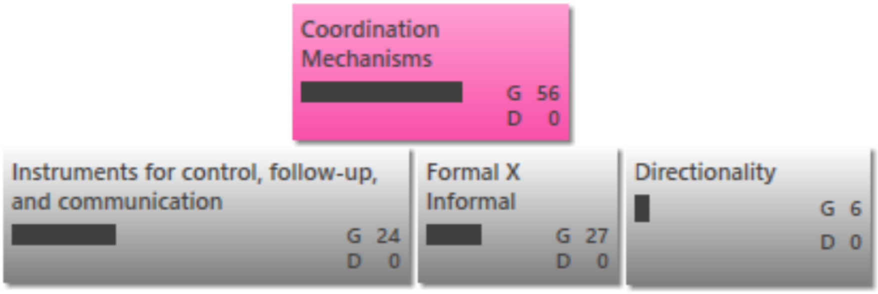

Figure 4 – Coordination Mechanisms

Meetings were identified as the main **coordination mechanisms** in the Pact, such as assemblies, general meetings, WG meetings, and events. Thus, several appointments were facilitated (Chen et al., 2021; Leceta & Konnola, 2019), so meetings encouraged the involvement and mobilization of the actors, keeping the group active.

The assemblies had the participation of at least one representative per institution and were an important mechanism for actors' updating. On the other hand, WG meetings brought the actors closer due to the small number of people involved, according to interviewees E1, E2, and E6. Since they were small groups, people had more autonomy and freedom of action (E1; E2; E6). In general, the appointments enabled by the joint effort of the agreed organizations strengthened communication and dialogue between the actors (Liu et al., 2020; Roig, Wang & Sánchez, 2020).

As instruments of **control, follow-up, and communication** used by the groups, we highlight those that helped following up the agreed actions, such as a platform provided by the Federation of Industries of the State of Santa Catarina - FIESC, and a control spreadsheet designed and operated by the SDE team (E6; E8; E9; E10). The communication efforts should be improved, according to quantitative data, since their enhancement was the second issue most cited among Pact's future challenges, with eight citations. The communication efforts undertaken seem to remain as an element to be improved according to the quantitative data, to the extent that its improvement is the fourth most cited point among the future challenges of the Pact, with 8 citations.

Regarding the **formality** of the coordination mechanisms used, we noticed, in the stage of Pact creation, the choice for more formal mechanisms, like the signature of the agreed actions and the creation of rules (E1; E5; E6; E7). However, the movement took on a voluntary characteristic since there were no explicit controls regarding organizations' participation. At the same time, informal mechanisms such as meetings facilitate interactions, establish links, provide freedom, and encourage participation (Duarte et al., 2021). Interviewees 8, 9, and 11 associate the absence of formal control mechanisms and the prevalence of volunteer work with difficulties in feeding data and loss of engagement over time. Grobbelaar (2018) mentions that both formal and informal engagement processes depend on the development of appropriate capacities in actors, and, ultimately, these will allow constructive and productive collaborations.

Despite the prevailing informality, the figure of the coordinator appears in the results, responsible for seeking adjustment between the different axes. WG coordinators were in charge of thematic meetings and tried to stimulate the participation of members, being also responsible for managing action plans. There was also a concern with the alignment between the Pact's coordinator and WG coordinators, in addition to standardizing communication to the media.

Relationship between the Actors

Relationships between the actors, especially in collaborative arrangements, are part of the very nature of IEs (Leten et al., 2013; Cobben & Roijakkers, 2018). In this category, the following aspects stood out: connections, collaboration, trust, and learning, as shown in Figure 5.

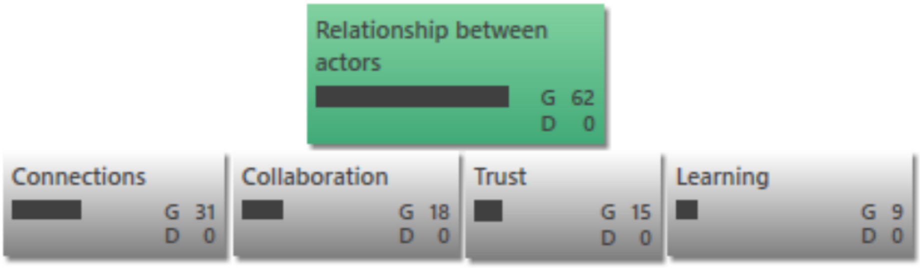

Figure 5 – Relationship between actors

The **connections** between actors within the Pact are considered an important element and are part of the program's assumptions. They resulted from the actors' union of efforts, generating ideas and opportunities that otherwise would not be possible to achieve (E6) from interactions and connectivity (Konnola et al., 2021). In addition, Santa Catarina is a state with a solid infrastructure for qualifying people, with a group of highly skilled professionals (E2), and the Pact is the opportunity to leverage these resources, especially through connections, integrating the actors involved in the ecosystem (Gifford et al., 2021).

The program opened doors for many institutions (E2), with partnership building and expanding perspectives for achieving innovative actions. It created a space for free circulation and discussion of ideas that culminated in defining objectives. Likewise, the environment allowed networking among those who represented the institutions (E3; E6; E8; E10; E11; E12).

To ensure homogeneous participation, joint production and **collaboration** were valued and expressed in discussions that led to creating the statute and building OKRs, for example (E4; E7; E9). The profiles of the participating actors and their different personalities and experiences provided heterogeneity to the process and contributed to building a collective culture towards a common purpose (E4; E9). We also observed a strengthening of the sense of belonging since participants identified themselves with the Pact vision (E1; E7).

Document search, the interviews and the questionnaire showed that the Pact contributed to identifying and beginning new partnerships in the ecosystem. On the other hand, the questionnaires revealed that, of the 73 completed actions, 34 were done with partnerships and 39 without them, and of the 57 ongoing actions, 49 have partnerships and only eight do not. Therefore, increasing the capacity for collaboration is still a challenge, considering that the main reason for the program's creation was precisely the establishment of connections. This is made explicit in the quantitative data, since deepening collaborative processes is among the three challenges with the highest number of citations. Hence, data triangulation suggests that while the ability to collaborate in the ecosystem is one of the achievements of the Santa Catarina Pact for Innovation, it is still an ongoing process.

Still in this category, we highlight the establishment of **trust** relationships, which is essential in initiatives of this kind, where collaboration between the actors is appreciated. The history of people's relationships and knowledge before the Pact also made a difference, facilitating the approach and the working format (E3; E7; E8), in line with the literature (Cobben & Roijakkers, 2018; Cobben et al., 2022). Interviewees E1 and E8 revealed personal connections from interactions within the program, which, in turn, leverage new actions beyond the Pact in an overflow effect.

The possibility of learning together (E1; E7) and sharing knowledge (E4) was also important in this process, strengthening **learning**. The synergies and interdisciplinary knowledge stand out as gains (Gifford et al., 2021). However, regarding opening and resource exchange, some participants mentioned the difficulty of sharing financial resources and information because some actors do not make data from their organizations available (E2; E8; E9).

Governance Approach

Regarding the approach developed by the Pact and understanding its characteristics, the following stood out in the analysis: structure, management, the process of creating the Pact, and decision-making.

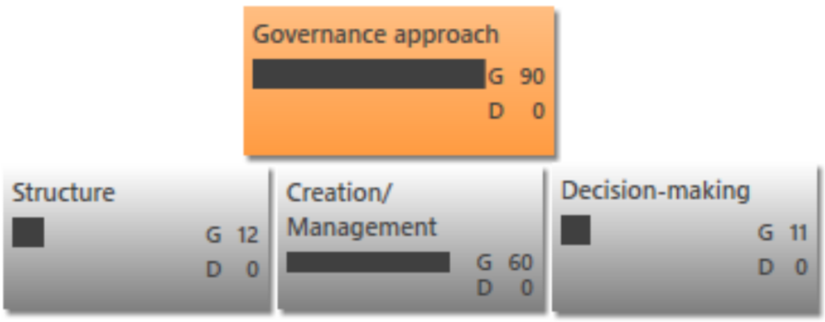

Figure 6 – Governance approach

SDE was a key actor in the process, being responsible for uniting the institutions, being at the forefront of the movement and directing it, organizing meetings, encouraging the connection between actors, and monitoring WG coordinators (E6). New entities were integrated into the Pact, which grew and expanded organically (E11), with decentralized management, open to the participation of different actors (Camboim et al., 2019).

In other words, although SDE was initially in charge of the Pact, it did not hold power and centrality. On the contrary, it favored the leading role of different institutions, providing them with leadership in emerging situations (E11). The assumption was that the Pact was not the property of any specific actor.

In this sense, we identified a deliberate effort to promote the involvement of all actors in the meetings to debate ideas (E7; E11). There was a strong engagement of the active organizations in the movement (E4, E10, E11), although it was voluntary (E9). On the other hand, quantitative data reveal the lack of resources as the most cited reason for interrupting agreed actions, along with insufficient partnerships and external articulations. Both were mentioned by 17 of the 25 respondents, ranking ahead of the 10 citations that refer to the impact of the COVID-19 pandemic on continuity of actions. In addition, the questionnaire also highlights actors' greater commitment as the challenge with the highest number of citations, 10 out of 25.

According to the documents examined, the Pact has a **structure** based on a managing committee and four working groups oriented to the following topics: Knowledge and Talent (Axis 1); Capital and Investment Attraction (Axis 2); Infrastructure (Axis 3); and Networks and Collaboration (Axis 4). The axes were broken down into strategic projects to meet the main demands for strengthening the ecosystem. From the need's assessment, entities sought to commit themselves to publicly agreed actions and became monitored by an open access tool.

As for the program **management**, there was a general coordinator, a secretary, a coordinator, and a vice-coordinator for each WG. The coordinator is responsible for provoking and making the movement happen without effectively being the process controller (E11). At the General Assembly, each participating entity was represented by its chief officer, who designated people to participate in the axes (E4).

Therefore, the Pact had a participatory, democratic (E5; E7; E10; E11), and horizontal management (E8), being a decentralized movement (E5) that stimulates freedom, autonomy (E7), and discussion of ideas (E5). According to interviewee 11, there was little rigidity and formality, making it dynamic.

In this context, **decision-making** was done jointly, at the axes, and the strategic ones at the Annual Meetings (E4, E5, E8), with the participation of institutions' leaders (E1). In the beginning, decisions were in the hands of the government/SDE, but after establishing governance (E6) they became collective, with dialogue and ideology building (E10). Hence, we notice the perspective of Pact's cocreation (Camboim et al., 2019; Duarte et al., 2021).

Although document search and the interviews show an alleged bottom-up governance approach, quantitative data and the interviews revealed the importance of a strong and present central leadership for the program's continuity (E2; E5; E6; E7; E11; E12), suggesting the importance of a top-down approach (Arena et al., 2021). Interviewees' references to the impact of managers' rotation in participating organizations on the program, indicate the difficulty of the ecosystem to mobilize new orchestrators. Going further, we highlight 'strengthening a central leadership' as the challenge with the highest number of citations, 13 out of 25, and only two citations for the existence of a strong leadership as a Pact's strength.

Regarding the set of research findings, Table 2 presents some interviewees' statements that represent each of the analysis categories.

Table 2
Categories and interviewees' quotes

Category	Quote
Common objectives and value cocreation	• "To leverage innovation in the State, to really change the State of Santa Catarina into the most innovative State in Latin America until 2030" (E6). • "It is putting a conductor so that the instruments play under that baton, and not being a dissonant polyphony. So, that is the vision" (E4). • "Hence, we had, in general, innovation in all its aspects inside there, to really make the state achieve a level of maturity in each one of innovation aspects, and we could reach this goal of transforming Santa Catarina into a more innovative state" (E6).
Actors and roles	• "In the beginning, it was a movement that SDE organized and talked with each actor; then, everybody wanted to be part of it" (E6).
Goals and evaluation	• "It was difficult to measure these goals or translate them into something effective within the Pact. But we mapped the OKRs and which indicators could help us in monitoring these actions" (E6).
Coordination mechanisms	• "Therefore, the axes, the general coordination, and the General Assembly, they were very important to keep the link with the agreed institutions, the vision, the values" (E4).
Relationship between actors	• "Then, among us, it created an even stronger link; we got together and saw this will, "this business is spectacular, it will be part of the history of Santa Catarina. I want to be part of this history". So, the feeling of belonging was strengthened" (E7). • "In general, people were very open, especially at work, everyone so dedicated. What people did not provide was money, and data opening. I see that the government is more practical in this initiative than the private sector" (E2).
Governance approach	• "We strongly insisted: this movement does not have ownership. It doesn't belong to the state government, it belongs to the state of Santa Catarina" (E7).

Note. Categories defined based on Hoffmann *et al.* (2023)

Final Remarks

This study analyzed governance characteristics in an IE, the Pact for Innovation in Santa Catarina, Brazil. Based on theoretical-analytical categories for understanding the characteristics of ecosystem governance defined by Hoffmann et al. (2023), the article showed empirical evidence collected through document search, interviews, and a questionnaire with Pact actors.

The results showed the existence of common objectives in the program, emphasizing the recognition of Santa Catarina as an innovative state. On the other hand, emerging objectives arose gradually as the actors joined the program. Such objectives are also related to the nature of participating entities and regional priorities. The Secretariat of Sustainable Economic Development's role in the initial mobilization of the players was evident.

The number and diversity of actors that joined the Pact while enriching the program create challenges for coordination. Although SDE assumed the role of orchestrator in the process, defining strategies to foster interaction and collaboration between the entities and using formal and informal coordination mechanisms, we noticed that the program's success depended on keeping a decentralized approach. Despite this, the capacity to mobilize new orchestrators was identified as a challenge to the adaptability and sustainability of the Pact. Other challenges were the prioritization and alignment of agreed actions towards common objectives, the connection of indicators and goals with macro objectives, and operating a monitoring and evaluation process. At the bottom appears the complexity associated with strengthening links of trust, connection, and collaboration capacity between the actors.

We expect that this paper can fill some gaps in the literature, which lacks studies focused on governance characteristics in IEs, by bringing empirical evidence related to the state ecosystem through the governance analysis of the Pact for Innovation in Santa Catarina. The proposed theoretical-analytical model can also contribute to the literature, being a benchmark for future research.

The identification of theoretical-analytical categories for understanding the characteristics of governance in ecosystems can also have managerial implications. The production of empirical evidence from the study on the Pact for Innovation and other IEs can contribute to managers and policymakers working in the field to implement actions and practices favorable to value creation in the ecosystem by promoting alignment and collaboration between actors. Especially for the Santa Catarina Pact for Innovation managers, the results can contribute to decision-making oriented to program resumption, after the demobilization starting in 2020.

On the other hand, defining categories in advance may limit identifying the new ones. While methodological procedures sought to ensure care was taken in identifying emerging categories, this can be mentioned as a study limitation. Future studies could include other Pact actors and data collection techniques, expanding triangulation. Studies focused on the governance challenges identified here and comparative research with other IEs, could also contribute to advancing the topic.

Acknowledgments

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Innovation ecosystems: an analysis of scientific production

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Abstract

Goal: To systematize discussion regarding the actors of the innovation ecosystem and their interaction.
Design/methodology/approach: The research presents a Systematic Literature Review (SLR). The databases accessed were *Web of Science* and *Scopus*. The publications refer to the years from 2018 to 2022. The data analysis techniques were bibliometric analysis and content analysis.
Results: By means of the framework developed, it was verified that the actors of the innovation ecosystem are classified in seven groups: ideation, investors, research and development (R&D).
Originality: The present research aimed at contributing to the studies of the innovation ecosystem and its actors, once it analyzed their functions and interactions. By means of the SLR, it was possible to develop a framework with seven actor groups.
Keywords: Innovation-Ecosystem, Innovation-Ecosystem-Actors, Systematic-Literature-Review.

Introduction

The concept of the innovation ecosystem has its origins in the field of Biology, describing a system with interactions among living organisms inside its physical environment (CAVALLO et al., 2019). Ecosystems emphasize the strategic relevance of a company's business environment, helping businesses reach a sustainable competitive advantage (ZHANG; WATSON, 2020).

Innovation ecosystems can be defined as a group of independent actors which combine capacities and specialized and complementary resources to one another, which aim at co- creating and adding value to their final users, providing earnings received in their processes (WALRAVE et al., 2018). On the other hand, for Granstrand and Holgersson (2020), the innovation ecosystem is a group of actors which evolve simultaneously with their activities and artifacts. Innovation ecosystems form a cooperation environment around their innovation activities and their actors are in co-evolution, organized in co-innovation processes and, consequently, resulting in the co-creation and delivery of new value through innovation (KLIMAS; CZAKON, 2022).

Starting in 2000, the term "ecosystem" has become focus of interest by the academy, from policy makers and organizations management (AARIKKA-STENROOS; RITALA, 2017; ADNER, 2017; JACOBIDES et al., 2018). The literature signals the innovation ecosystem as a growing research theme (DŸBROWSKA et al., 2019; GRANDSTRAND; HOLGERSSON, 2020; KLIMAS; CZA KON, 2022). The main features of an innovation ecosystem are to provide new forms of generating knowledge and the development of new partnerships for the creation and value capture (NAMBISAN; ZAHRA; LUO, 2019).

In an environment in which organizations are increasingly specialized, an organization alone does not hold internal resources for the development and implementation of innovation (ADNER; KAPOOR, 2010; TALMAR et al., 2018). That said, companies need contributions from different stakeholders, internal or external, to elaborate a value proposal for the whole ecosystem (TALMAR et al., 2018). Thus, the innovation ecosystem can be understood as a network of interconnected and interrelated actors (GOMES et al., 2016).

There is a large number of studies regarding innovation ecosystems, such as Abootorabi et al. (2020) investigated an entrepreneur ecosystem, by means of the academic spin-offs approach. Adner and Lieberman (2021) researched a business ecosystem and its actors as complementary. However, it can be verified that there is a scarcity of studies that investigate innovation ecosystem actors and their interaction, with the goal of generating knowledge to develop the ecosystem. In this context, the present study aims at answering the following question: Based on the literature, who are the actors in innovation ecosystems and how do they interact among themselves?

Thus, the present research is justified in order to contribute to future studies regarding the actors of the innovation ecosystem and how they interact with one another. Among the studies analyzed, a scarcity of studies and researches carried out as Systematic Literature Review was verified. This fact is relevant because it identifies that there are gaps to be researched in order to motivate studies in this area. As a practical contribution, the analysis of the types of actors and their roles and interaction can provide bases for the construction of public policies for the development of ecosystems, besides providing feedback for the management of organizations.

Regarding systematic literature reviews, there is a study that addresses the structure of an innovation ecosystem and its foundations for future research, using the Web of Science database and employing content analysis and bibliometric analysis methods. The results of the content analysis showed that the main classifications related to the structure of the innovation ecosystem are associated with the phases and life cycle of the ecosystem, and are classified according to the level of the innovation ecosystem and its layered structure. The results of this study also show that studies are focused on a small group of actors (BERMEJO; MOREIRA; SOUZA, 2019).

The present article is structured in four sections, including this introduction. The second section addresses addresses the methodological procedures applied in the Systematic Literature Review. In the three section, the main results found, regarding the innovation ecosystem, are presented: the main actors and how they interact among themselves. In the final section, the main considerations are presented, as well as the study discussions and its conclusions.

Methodological Procedures

The present study is characterized as a Systematic Literature Review (SLR) and includes bibliometric analysis (OKUBO, 1997) and content analysis (DOWNE-WAMBOLDT, 1992). The bibliometric and the content analyses combined allow the identification of tendencies, themes, areas with major discussion and gaps existent in the literature (GOMES et al., 2018).

In the next section, the search procedures are presented, with description of the sample and procedures of the bibliometric analysis and the content analysis.

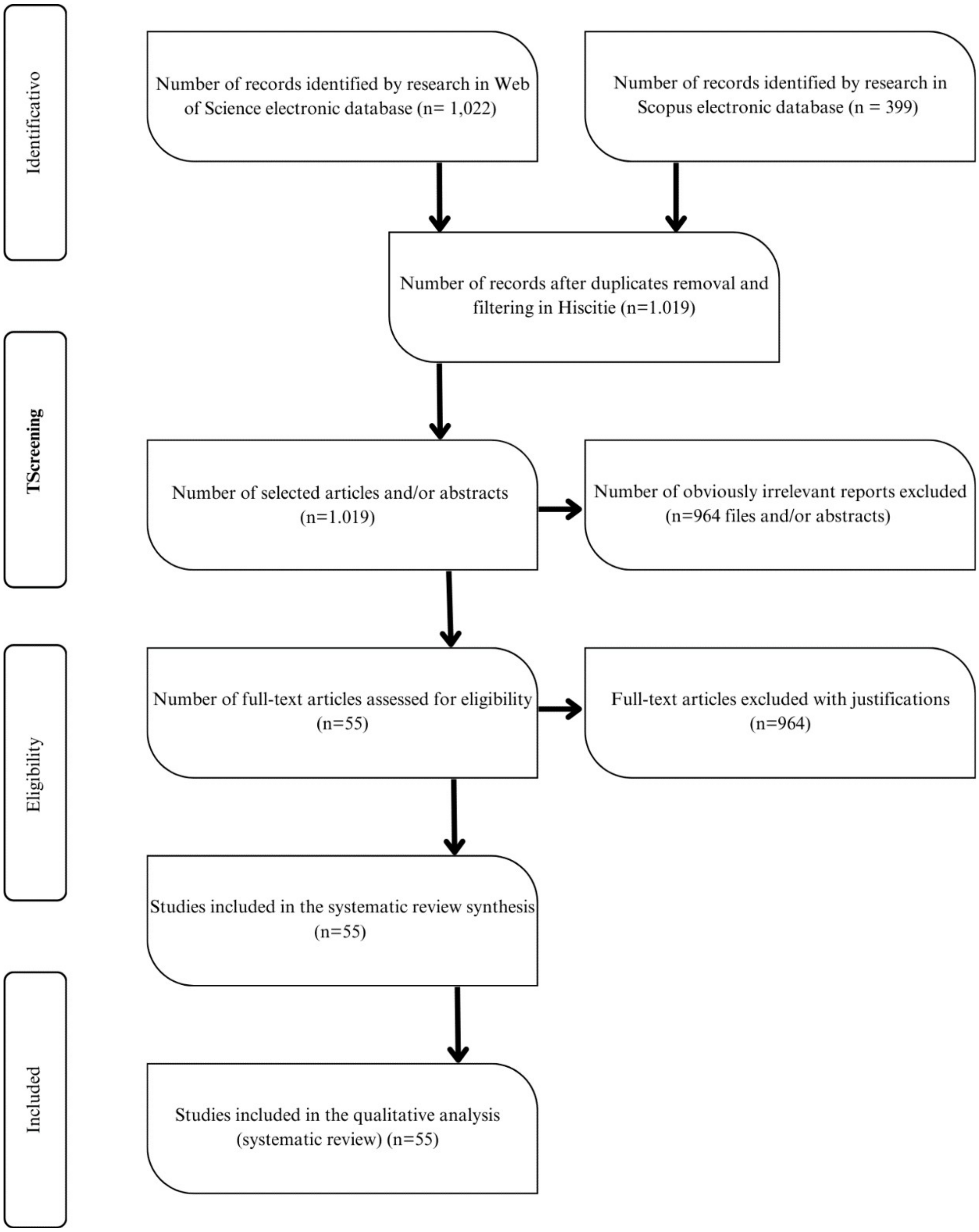
Search procedures

Description of the sample

The papers analyzed were extracted from two databases: Web of Science and Scopus. The research in the databases was carried out on March, 27th, 2022. For selection of the papers, the strings "ecosystem" and "innovation" were used. The search in the database Web of Science resulted in 1,022 papers. From this initial sample, the filter "papers" to "types of documents", the language selected was English, the period and date were the last five years, being selected papers from 2018 to 2022. The categories selected were "management", which resulted in 682 papers, and "business", which resulted in 610 papers, totalizing 1,022 papers.

The same strings "ecosystem" and "innovation" were used in the database Scopus. Using "papers" as the type of document, the language selected was English and the categories applied were "business management and accounting"; the period was the last five years, being from 2018 to 2022 with paper publications. The search resulted in 399 papers. By unifying the results obtained in the databases Web of Science and Scops, a total of 1,421 papers were collected. After the triage, with the aim of excluding repeated papers, the exportation of the papers to the software Histcite was performed. The result obtained after the unification was 1,019 papers. Next, Figure 1 is presented, which depicts the Prisma flow diagram, based on the theory of Pollock and Berge (2018).

Figure 1 - Prisma flow diagram



Source: Elaborated by the authors based on the theory of Pollock and Berne (2018).

After reading all the abstracts, the verification of the title and keywords, 964 papers were excluded, resulting in a sample of 55 published papers. Below, the criteria of inclusion and exclusion of papers are presented in Table 1 (ATKINSON et al., 2015).

Table 1 - Criteria of inclusion and exclusion of papers for the study

Inclusion Criterion	**Exclusion Criterion**
Full text available	Only abstract or part of paper is available
Title focused on the innovation ecosystem theme	Presentation of context only regarding ecosystem or only regarding innovation
Objective of paper focused on study of actors of innovation ecosystem	Absence of objective focused on the study of actors in ecosystem innovation
Presentation of the abstract focused on the theme of innovation ecosystem and its actors	Innovation ecosystems are cited, but discussed superficially
Keywords: innovation ecosystem	Presentation of other types of ecosystems not related to the objective of the study

Source: Elaborated by the authors.

As an example of a paper that obeyed the criteria to be included in the research, the study developed under the perspectives of the network of multi-stakeholders in the Cali Baja region, can be mentioned, a binational and emerging innovation ecosystem. In the study, by analyzing the abstract, features in accordance with the research objective were noticed, that is, the paper presents in its abstract a perspective of the multi-actors and the mapping of parts interessed, as well as the identification of the main actors in the binational innovation ecosystem of Cali Baja (NÚÑEZ P.M.S., SERRANO-SANTOYO A., 2020).

Among the numerous papers that were excluded for not obeying the criteria, the paper "Descompactando a construção do ecossistema de inovação: evolução, lacunas e tendências" from GOMES et al (2018) was excluded for not being related to the objective of this study.

Bibliometric Analysis Procedures

In accordance with the data demonstrated during the performance of the study, a number of results among the 55 papers of the sample were found by carrying out a bibliometric analysis. The tool and software VOSviewer was used to carry out and analyze the network of keyword and co-citations, with the objective of performing and observing citations in the papers. This way, it is possible to identify similarities and, thus, the analysis of these networks revealed the themes and interests common to the research groups (VAN ECK; WALTMANN, 2010).

Content Analysis Procedures

The content analysis was based on the method proposed by Bardin (2016), which presents and contemplates three phases, namely, the pre-analysis phase, the materials exploration phase and the treatment of results, interferences and interpretation phase.

According to the pre-analysis phase, the same was carried out in the form of reading and can be called the first contact with the documents, and together with the development of the indicators capable of guiding the interpretation and formal preparation of the analyzed material. The composition and definition of the indicators took place the following way: type of ecosystem, actors that compose the ecosystem, research tendencies and gaps in innovation ecosystems.

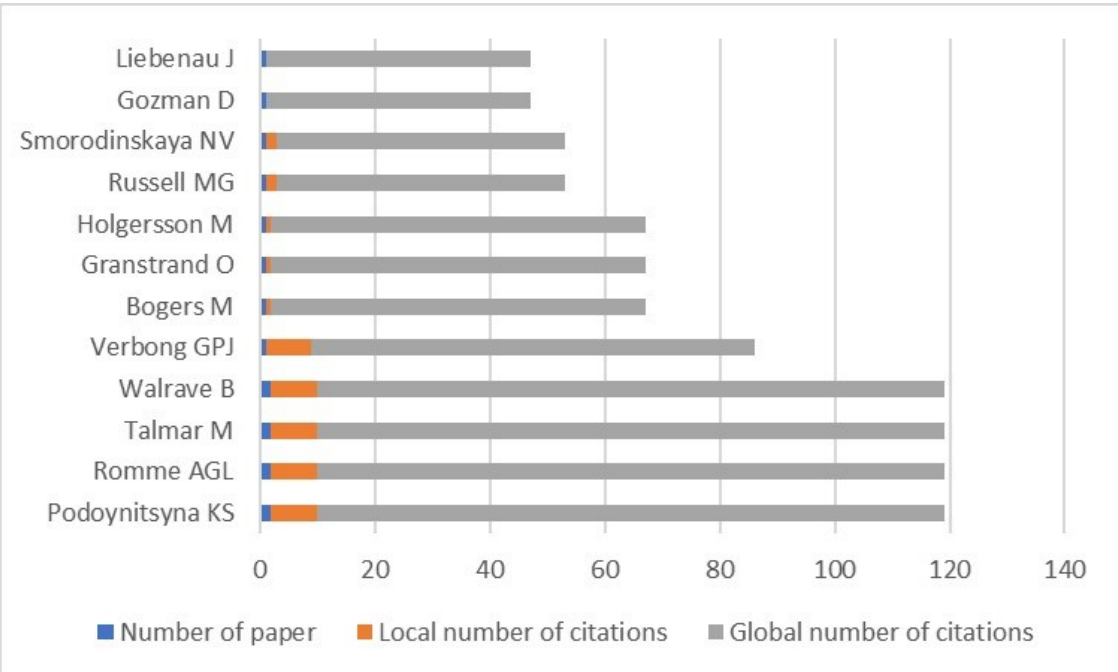
The materials exploration phase was carried out in the form of reading all the papers selected, with identification and definition of the indicators and development of a framework. Therefore, the treatment and results collection phase, the interference and interpretations, was conducted according to the following section, which presents the results and discussions regarding the theme proposed.

Results

Descriptive Statistics

Based on the results obtained by the bibliometric analysis, after triage of the papers according to theme and research objective, 55 papers were selected. The selected papers present 167 authors, were published in 37 journals, have 3,287 citations and references, and present 252 keywords. After triage, the survey of the research elite was performed, that is, from the 167 authors directly involved in the study, 12 authors are considered the research elite. According to the criteria established by Price (1976), the concept of Research Elite is the number of authors responsible for the papers that compose the research corpus. Based on this datum, Figure 2 presents the number of citations, authors and number of papers.

Figure 2 - Composition of authorship of journals and subjects

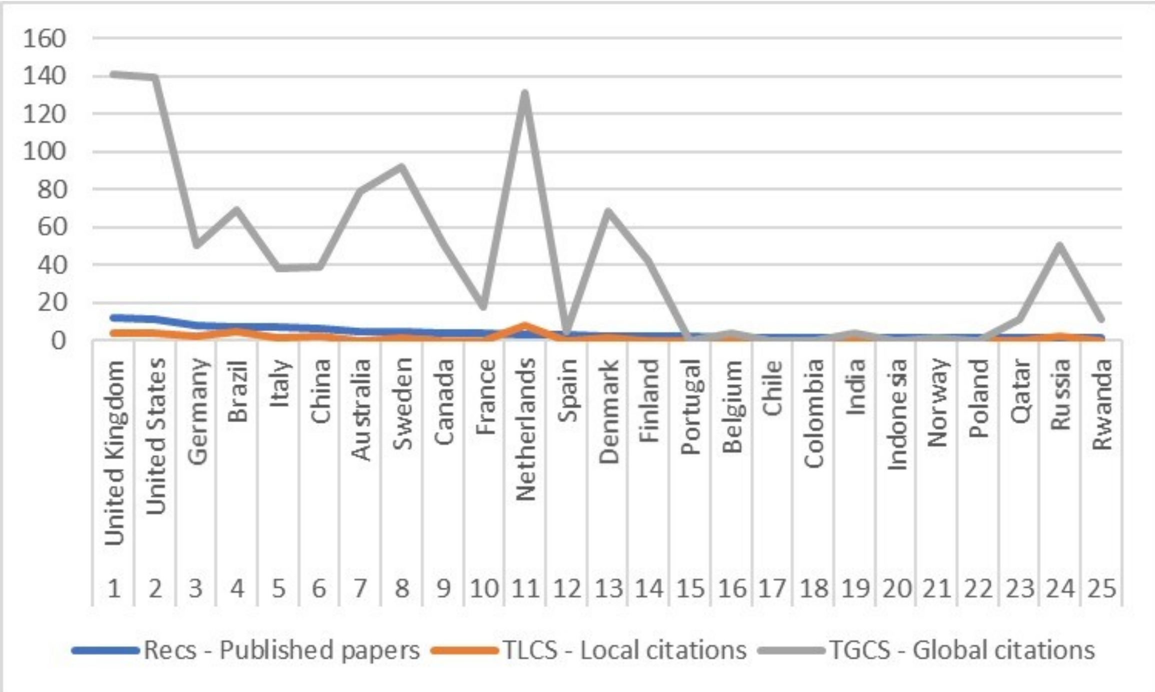


Source: Elaborated by the authors - *Software Histcite* (2022).

Figure 2 points Podoynitsyna K.S., Romme A.G.L., Talmar M., and Walrave B. as the authors that publish the most (2), present the highest number of local citations (8), and also the same number of global citations (109). The authors appear in 12 papers, which represents 21,82% of the textual corpus.

Through the Histcite software (2022), it is also possible to analyze the publications by country, by the number of local citations, and by the number of global citations and occurrences (TGCS). Figure 3 allows the visualization of such results.

Figure 3 - Number of publications by country, local and global citation



Source: Elaborated by the authors - *Software Histcite* (2022).

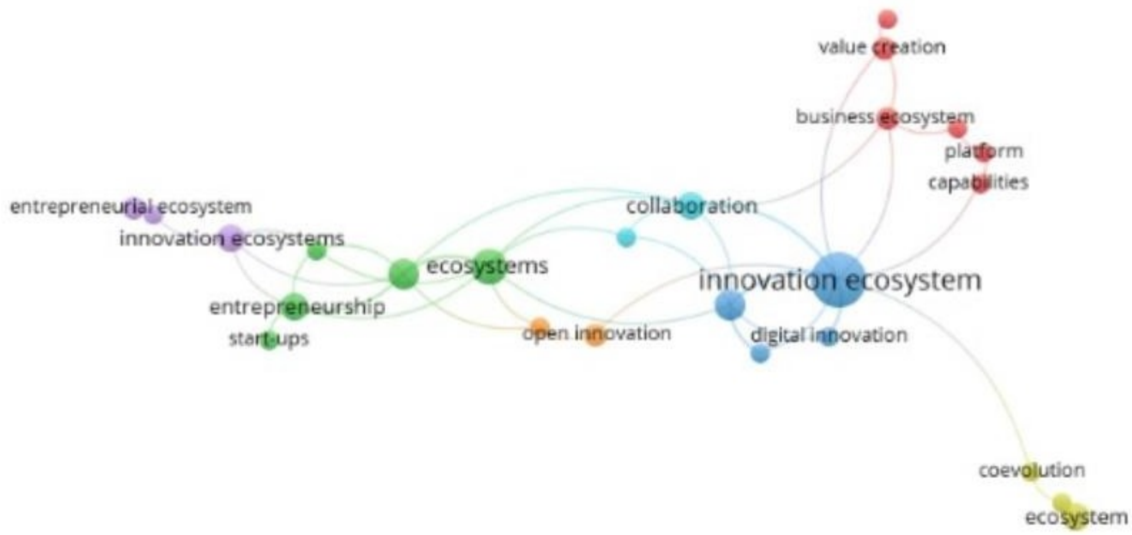
Figure 3 presents the results based on the number of published papers by country, as well as the results of the local citations and global citations. In the first position, there is the United Kingdom with the result of 12 papers published in the last 5 years, in the second position, the United States of America, which presents the result of 11 papers published, and, next, Germany with 8 papers published in the period. The fact that Brazil is in the fourth position can be highlighted, presenting 7 papers published in the period of carrying out the research.

Bibliometric Analysis

Network of Keywords

The network of keywords was used for the identification of the innovation ecosystem concepts and of the actors that are part of this ecosystem. Next, in Figure 4, the results obtained regarding the co-occurrences and the keywords of the cited authors in the papers selected in the research sample are presented.

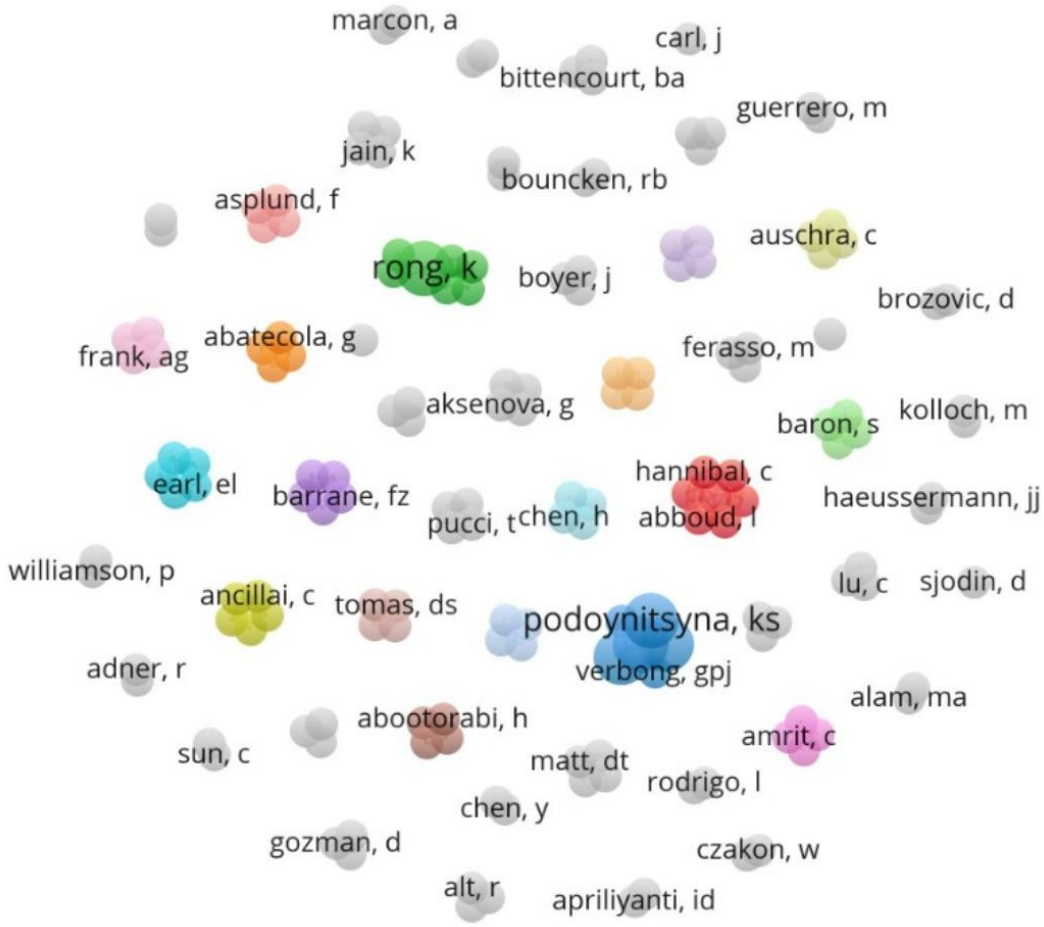
Figure 4 - Co-occurrence of the author' keywords



Source: Elaborated by the authors - *VOSwiever* (2022).

In Figure 4, it is observed the cloud formulated based on the co-occurrence of the textual corpus' authors' keywords, elaborated using the VOSwiever software. The result presents the number of 8 clusters, of which cluster 1 has 6 items that present the keywords: "business ecosystem", "capabilities", "grounded theory", "platform", "service ecosystem", and "value creation". Figure 3 allows the identification of occurrences between words and their results, demonstrating indications and connections among the main words and networks constructed among them. The total of keywords was 236 words, considering the number of occurrences of 2 words, resulting in 27 items. Next, Figure 5 demonstrates the analysis, considering all the authors.

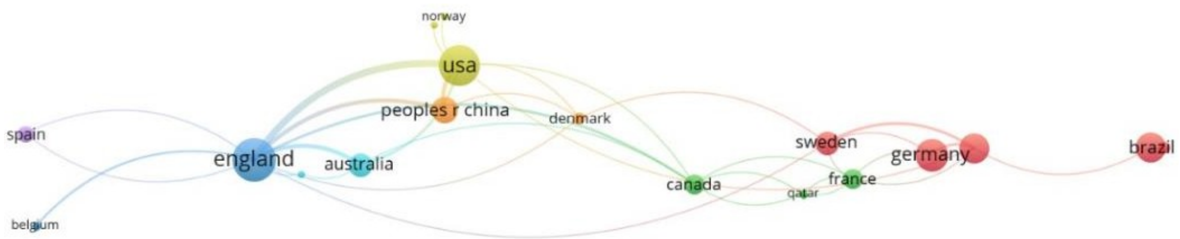
Figure 5 - Global Network of Authors and Coauthorhip



Source: Elaborated by the authors - *Software VOSwiever* (2022).

Figure 5 demonstrates an analysis of all the authors, considering one document per author, the result demonstrates a fragmented network, because the knots are not interconnected, the authors are writing isolatedly by some geographic factor, or by approaches to different themes. This result confirms the disparity of approaches of research on the innovation ecosystem theme. By reading the abstracts and deepening in the reading of the selected papers, several approaches were noticed, that is, some authors focus on the entrepreneurial ecosystem, others on the business ecosystem, on the services ecosystems, on the platforms ecosystems, on the new technologies and 4.0 industry, on startups and corporate clusters, among others. Figure 6 presents the network of coauthorship by country.

Figure 6 - Network of Coauthorship and Countries

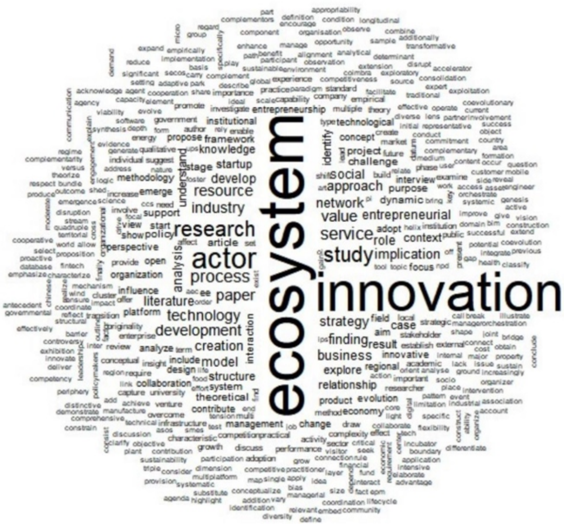


Source: Elaborated by the authors - *Software VOSwiever* (2022).

According to Figure 6, it is verified that there is an association between the authors from one country with other countries. It is noticed that the presented results demonstrate an association between the United States of America with Noruega, England, China, Denmark, Australia, Canada, and Italy. England, in turn, associates with Spain, Belgium, India, Australia, China, the United States of America, Denmark, Canada, and Sweden. Brazil presents an association with Italy.

Next, it is presented the result of the research carried out in Iramuteq software, based on the occurrences found in the papers selected for the research.

Figure 7 - Occurrences Description Iramuteq Summary



Source: Elaborated by the authors - *Software* Iramuteq (2022)

Figure 7 presents the result obtained in the research on the number of occurrences based on the abstracts of the 55 papers selected for the research. The research presented as result: text number 55, segmented texts number 303, occurrences number 10,917, forms number 2,131, and hapax number 1,103 which equates to 51.76% of the forms and 10.10% of the occurrences. Figure 7 shows that the words "innovation" and "ecosystem" have a higher number of occurrences, followed by the occurrence of "actor". Thus, it is evident that themes related to the innovation ecosystem and its actors are gaining prominence in the research being conducted, which contributes to the theoretical foundation of the present study.

Table 2 presents the journals that published papers related to the research, the number of published papers, and the number of citations, based on the research carried out in Iramuteq software.

Table 2 - Journals description, number of papers and citations

Journal	Number of papers	Number of citations
Technological Forecasting And Social Change	10	210
Technology Innovation Management Review	03	18
Long Range Planning	02	97
Technology Analysis & Strategic Management	02	19
Review Of Managerial Science	02	09
Journal Of Business Research	02	08
Industry And Innovation	02	06
Ieee Transactions On Engineering Management	02	04
Entrepreneurship Research Journal	02	01
Journal Of Management Information Systems	01	46
Journal Of Service Research	01	36
Entrepreneurship And Regional Development	01	26
Business & Society	01	22
International Entrepreneurship And Management Journal	01	21
International Journal Of Innovation Science	01	14
Construction Management And Economics	01	13
Benchmarking-An International Journal	01	11
Management Decision	01	10
Chinese Management Studies	01	07
Strategy Science	01	06
Mp Journal	01	05
International Journal Of Managing Projects In Business	01	05
Journal Of Management Development	01	04
Schmalenbach Business Review	01	04
Systems Research And Behavioral Science	01	04
International Journal Of Energy Sector Management	01	02
International Journal Of Innovation	01	02
Journal Of Business Economics And Management	01	01
Journal Of Business Venturing	01	01
Industrial Marketing Management	01	00
International Journal Of Innovation And Technology Management	01	00
International Journal Of Nonprofit And Voluntary Sector Marketing	01	00
Journal Of Entrepreneurship In Emerging Economies	01	00
Journal Of Manufacturing Technology Management	01	00
Journal Of Science And Technology Policy Management	01	00
Risus-Journal On Innovation And Sustainability	01	00
Thunderbird International Business Review	01	00

Source: Elaborated by the authors - *Software* Iramuteq (2022).

Table 2 presents the results obtained from the journals' research, cited papers, and the number of citations per paper. The journal with the highest number of cited papers is the Technological Forecasting And Social Change journal, which has 10 published papers in its journals and presents a total of 210 citations. With 3 published papers and 18 citations, there is the Technology Innovation Management Review Journal, seven journals present 2 published papers, and a citation amount that varies from 1 citation up to 97 citations.

According to the result of the research, the Long Range Planning journal is presented, with 2 published papers and 97 citations, the Technology Analysis & Strategic Management journal with 2 published papers and 19 citations, the Review Of Managerial Science journal presents 2 published papers and 9 citations, with the same number of published papers there is also the Journal of Business Research with 8 citations, the Industry and Innovation journal with 6 citations and the journals Ieee Transactions on Engineering Management and Entrepreneurship Research Journal with a total of 4 and

1 citations respectively. Table 2 presents the number of 28 journals with one published paper and citations that vary from 0 to 46 citations, while 8 journals present one published paper and no citations.

Table 3 – Number of journals per area, published papers and citations

Area	Number of Published Papers	Number of Citations
Technology, Innovation	23	273
Entrepreneurship, management, strategic	19	146
Marketing, business, planning, service	15	193

Source: Elaborated by the authors (2022).

In table 3 the research result allows us to relate the journals in three different areas, that is, the journals of technology and innovation areas are presented, which show as a result a total of 23 published papers and 273 citations. Another group is the journals from entrepreneurship, management, and strategic areas, which present a total of 19 published papers and 146 citations. Finally, the group of journals from marketing, business, planning, and services areas, with 15 published papers and 193 citations. The result allows us to notice that the innovation ecosystem theme is growing because it presents a big number of published papers, as well as citations on the theme in several research areas.

Content Analysis

Innovation Ecosystem

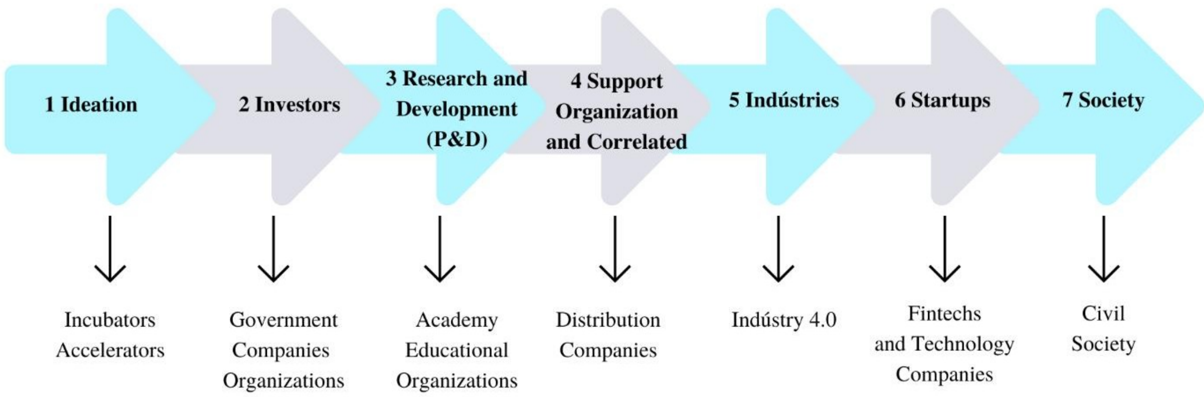
This section presents the discussion on the innovation ecosystem, the types of the innovation ecosystem, and the actors that compose it. The 55 selected papers are studied in a more detailed way and deeply analyzed.

The papers explored and presented several approaches, for instance, it is highlighted the paper that explores the strategies for entrepreneurship and innovation ecosystem formation, with emphasis on the conceptual structure of the Portuguese cases. The research explores the entrepreneurial ecosystem and the studied actors were the social actors and the technological parks, the highlighted result is the potential of the study carried out under public orientation of the low population density, focusing on the entrepreneurial and innovation ecosystem formation (ALVARES D.F., et al, 2020). Another paper aimed at identifying the role of the innovation of the multi-actor services, explored the services ecosystem, presented partner and multi-actor actors, and presented as a result the development of a set of 17 functions that present resources and competencies of the actors that are needed to the development of the smart services systems (ANKE J.; POEPPELBUSS J.; ALT R., 2019).

There is also a study that explores the issue of confidence construction in several concerned parties' collaboration for the development of new products in the era of digital transformation, exploring the business ecosystem focusing on the actors of the industries and organizations (BARRANE Z.F.; NDUBISI O.N., 2020). The entrepreneurial ecosystem is approached in a study that explores the accelerators as an infrastructure of startups for business clusters, besides, it explores the types of ecosystems, highlighting here the platform ecosystem, of software and innovation (BLIEMELA M.; DE KLERKC S.; MILES P.M., 2019).

The Systematic Literature Review (SRL) indicates the development of a framework to assist in the search for subsidies and resources to carry out this research. The framework is used to assist in the construction of propositions for the present study. In structuring the framework, all 55 selected articles were read and based on this reading, screening was carried out to identify which articles described the role of actors involved in an innovation ecosystem. These can be seen in Figure 7.

Figure 7 – Innovation ecosystem stakeholder groups model



Source: Elaborated by the authors (2022).

The propositions were formulated through the grouping of the actors mentioned in the study on innovation ecosystems, so, the identification of seven groups can be cited as a result, as described below:

Group 1, called ideation, is composed of incubators and accelerators. The incubators contribute to the performance of academic spinoffs (ASOs). According to Ferreira et al. (2017), spinoffs are used to shape the formation of new ventures or companies. Academic spinoffs provide management support and advice related to how to develop and manage the new organization through consulting, training, guidance, and exchange of experiences (RASMUSSEN; WRIGHT, 2015; SOETANTO; JACK, 2016). Accelerators, on the other hand, are a "factory for startups", that is, they are considered an intensive capital investment that allows their operator to receive raw materials to transform them into startups (MILLER; BOUND, 2011).

Group 2 is called the investors group, made up of government, companies, and organizations. An innovation ecosystem can encompass several actors, including the development actor, which are made up of governments, banks, virtual capitalists, angel investors and companies that provide financing mechanisms for the phases that make up the construction of the ecosystem. Examples include angel investors who play an important role in helping small, fast-growing companies and venture capitalists who are investors who provide capital for start-up ventures or support small companies that want to expand and do not have access to the stock market. (TEIXEIRA; TRZECIAK; VARVAKIS, 2017).

Research and Development (R&D), make up group 3, formed by the academy and educational organizations. According to Teixeira et al. (2016), knowledge actors are composed of educational and/or R&D institutions, being responsible for training qualified people, promoting entrepreneurship and the creation of future companies. This actor also includes students and researchers.

Support organizations and correlates correspond to group 4 and they are made up of those organizations that sell raw materials or distribute products and services in the innovation ecosystem. The role of this group is to connect organizations, facilitate the transfer of ideas and other resources to help them commercialize at scale, that is, innovation ecosystems correspond to a group of interdependent and heterogeneous actors, such as suppliers, distributors, competitors (MOORE, 1993; TEECE, 2007).

Group 5 is called industries. Industries, such as industry 4.0, are considered a broad phenomenon that requires a diverse group of actors, including companies, government, regulators, universities, and research centers (GOMES et al., 2018; BENITEZ et al., 2020). Infant industries are considered an important phenomenon because they contribute technologically and economically to society. The development of a nascent industry is a social process in which customers' needs and their behaviors are reformulated, but also relationships in the production and transaction sector and government institutions (NEE; OPPER, 2012; VAN DE VEN; HARGRAVE, 2004).

The startups are referred to as group 6. They play an important role in introducing technologies to the market, mainly because many are responsible for the innovations that they develop and that they lead to economic growth (COLOMBELLI; QUATRARO, 2019; FUKUGAWA, 2018). Technological startups have significantly contributed to job creation and economic development at the regional and national levels, generating revolutionary innovations that sometimes end up disrupting the preexisting market (AL-MUBARAKI; BUSTER, 2017; DAKSA et al., 2018).

Group 7 is called society. The civil society can be perceived as a user of innovation, acting as a driver in the innovation processes (CARAYANNIS; CAMPBELL, 2009). They can also be composed of individuals, associations of Non-Governmental Organizations (NGOs) that create society, demands, and needs, which can profoundly affect business and impact innovation in development, can also act as customers. In this context, users are at the center of the model and start to encourage the development of innovation that is relevant to them (ARNKIL et al., 2010; CARAYANNIS; RAKHMATULLIN, 2014).

Next, Table 4 presents the groups of actors and their respective actors.

Table 4 - Groups of actors and their respective actors.

Actors group	Actors	Authors
Ideation	Incubators, accelerators	Ferreira *et al.* (2017) Rasmussen; Wright, (2015) Soetanto; Jack, (2016) Miller; Bound, (2011)
Investors	Government, companies, andorganizations	Teixeira; Trzeciak; Varvakis,(2017)
Research and Development (R&D)	Academy and educational organizations	Teixeira *et al.* (2016)
Support Organizations and Related Entities	Distributing companies	Moore, (1993) Teece, 2007
Industries	Industry 4.0	Gomes *et al.*, (2018)Benitez *et al.*, (2020) Nee; Opper, (2012) Van De Ven; Hargrave, (2004)
Startups	*Startups*	Colombelli;Quatraro, (2019) Fukugawa, (2018) Ries (2011) Al-Mubaraki; Buster, (2017) Daks *et al.*, (2018)
Society	Civil society	Carayannis; Campbell, (2009) Arnkil *et al.*, (2010) Carayannis; Rakhmatullin,(2014)

Source: Elaborated by the authors (2022).

Table 4 provides a summary of the actor groups, the actors that constitute each group, and the authorship of the authors who address each actor in the systematic literature review presented. The discussion of the present is elaborated below. Next, in chapter 4, the discussions related to this research are presented.

Discussion

The present study contributed with a Systematic Review of Literature and among the selected articles was found the result of 55 articles studied, with 167 authors, with publications in 37 journals, with 3,287 citations and references and presentation of 252 keywords, its research elite, of the 167 authors involved in the study, the number of 12 authors was considered. Among the articles published by countries, the United Kingdom stands out with the highest number of articles, with 12 articles in the last five years, followed by the United States of America, which has 11 published articles, in third place is Germany with 8 articles published. Brazil stands out in fourth place with 07 articles published during the research period.

Regarding the keywords of the textual corpus authors, 8 clusters are presented as a result, totalizing the keywords as 236 words, considering 2 the number of occurrences of words, resulting in 27 items. Regarding the analysis of the authors, a fragmented network is presented, as the nodes are not interconnected, the authors are writing in isolation due to some geographic factor or approaches to different themes, a result that confirms the disparity of approaches on the theme of innovation ecosystems. There is an association between authors from a country with other countries, for example, the United States of America has an association with Norway, England, Denmark, Australia, Canada, and Italy. England has associations with Spain, Belgium, India, Australia, China, United States, Denmark, and Sweden.

With this study it was also possible to contribute to the development of a framework that resulted in seven groups of actors in the innovation ecosystem, through the groups of actors it was verified the functions of each actor and evaluate what the actors can do within the innovation ecosystem and analyze how may be their interaction within the innovation ecosystem, forming a cooperative environment around innovation activities, enabling actors to be in co-evolution and being in the process of co-innovation and, automatically, resulting in the co-creation and delivery of value through of innovation (KLIMAS; CZAKON, 2022).

There are two contexts in which actors and entrepreneurs can relate, that is, the institutional context, which is composed of governments, universities, incubators, accelerators, and science parks that support the development and growth of organizations through direct funding or training activities. Another context is the social one, the one in which entrepreneurs can receive support from industrial actors, such as customers, other suppliers, business angels, enabling them to have access to resources, such as venture capital, talented workers, resources for marketing and production capacity (AUTIO et al. 2014; SPIGEL, 2017).

Conclusions

The purpose of this study was to systematize the discussion about the actors of the innovation ecosystem, as well as to analyze how is their interaction. A systematic review of the literature was applied, and the methodology used included bibliometric analysis and content analysis. The descriptive statistics of the bibliometric analysis on the innovation ecosystem indicated and identified similarities between the published articles, going on to reveal common themes and interests between the research groups of this research in the search for results and achievement of its purpose.

Through the result of the SRL, it was possible to create a framework of the main actors and identify seven groups of actors in order to contribute to the development of the article and achievement of the proposed objective. It was possible to classify the actors into seven distinct groups, in group 1, called the ideation group, there are incubators and accelerators, for group 2 investments, the Government, companies and organizations are presented. Group 3, called Research and Development (R&D), which is made up of academies and educational organizations, group 4 or group of support and related organizations, are the distribution companies. Group 5, on the other hand, is constituted as the group of Industries, which as its name already tells us is the group of industries 4.0, group 6 is the group of startups, composed of fintechs and technology companies and finally, there is group 7 which is society composed of civil society.

Thus, the present study presents a comprehensive literature review on innovation ecosystems and this research presented a framework with its main actor groups in order to classify them into groups and identify them to analyze what these actors do exactly and how they interact with one another. Therefore, the conceptual advances of this review may become increasingly relevant to the field of studies in general.

There are some limitations for the present study, they are mainly related to the strings, that is, it is suggested that in addition to the strings studied, the string “actors of the innovation ecosystem”, “functions of actors in the innovation ecosystem” and “interaction of actors i the innovation ecosystem” should be used.. Another limitation of the study is the method itself, which analyzes only one case and does not allow for comparison with other innovation ecosystems in the state of Rio Grande do Sul. Considering analyzing how the interaction between the actors of the innovation ecosystem is, for future work they can explore and seek to study more deeply how the actors of the ecosystem relate to each other and how they perform their functions within the innovation ecosystem, it is suggested the analysis of the activities carried out by the actors and how they are performed within the ecosystem to which they belong. Future researchers could analyze how the interaction among actors affects or contributes to the development of the innovation ecosystem.

This research contributes to the innovation ecosystem theory by exploring the ecosystem and the actors that make up the ecosystem, as well as discussing the impact that innovation ecosystems can have on local and regional economic development. The research results show that there are few investigations that directly address the interaction between the actors of the innovation ecosystem**.**

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Proposing a new capability for ecosystem management: The technological interdependence management capability

Abstract ID#248

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Purpose

The literature often cites technological interdependence as a definitive feature of ecosystems. However, despite its relevance being widely recognized, it is still unclear how focal firms can develop technological interdependence for ecosystem management (EM). While the current literature implicitly places this feature as if it emerges automatically inside ecosystems, we propose that it need to be developed by focal firm through an EM capability. We argue that when focal firms decide to engage in EM, they need to develop a new capability to be able to develop and manage the technological interdependence in the ecosystem. Given this, our main objective is to unveil how focal firms develop technological interdependence for EM.

Literature Review

The literature provides a broad understanding of different types of capabilities for different functions. However, little is known about capabilities that are specific for EM (Hannah and Eisenhardt, 2018; Hou et al., 2020). There is a growing line of research that evidence the relevance of dynamic capabilities for EM (Bogers et al., 2019; Faridian & Neubaum, 2021). However, another group of schoolars affirms that theres must exist new and specific capabilities for the context of ecosystems (Hannah & Eisenhardt, 2018; Hou et al., 2020; Kay, Leih & Teece, 2018; Gomes et al., 2022). However, there is a research gap as there is still a lack of knowledge on capabilities specific for EM as the literature still does not explain the emergence of the most central feature of EM, which is interdependence (Jacobides et al., 2018; Gomes et al., 2022). Interdependence can be defined as a set of interactions that arise in multilateral configurations dependent on each other (Adner, 2017; Jacobides et al., 2018), and can shape ecosystem value co-creation and co-evolution (Hou et al., 2020; Jacobides et al., 2018).

Methodological Procedures

Given the objective of this research was to understand a theme that is still little explored in the literature, we considered suited to employ an exploratory and qualitative research. The research strategy was a multiple case study (Eisenhardt, 1989), in favor of immersion and a deep understanding phenomenon. We conducted a multiple case study covering ten ecosystems. We collected data through 47 in-depth open interviews, to have greater freedom to explore how these firms manage their ecosystems. The methodology we used for data analysis combined multiple cases comparison (Eisenhardt, 1989) with coding analysis (Gioia et al., 2013).

Findings

This study proposes a new EM capability: the technological interdependence management capability, consisting of 1) technological modularity; 2) co-development; and 3) binding mechanisms. This capability is described with its own definition and set of activities employed by the focal firm to develop this feature for EM. Our findings contribute to the capabilities-based view by showing a new type of capability specific for ecosystem management. For the ecosystem's literature, we contribute by presenting an understanding of how focal firms articulate the most central feature of ecosystems into a new capability. We also present the implications for practice and the ecosystem management capabilities framework for focal firms.

Implications

Our main contribution is to the capabilities-based view by presenting a capabilities debate that considers not just value creation for the individual firm, but for the ecosystem. We did this by characterizing a new capability specific for EM, and we defined and discussed the main activities that composes it. The second main contribution we make is for the ecosystem's literature, by presenting an understanding of how focal firms articulate the most central feature of ecosystems into a new capability. This contribution is relevant, as the literature implicitly treats this feature as if they were a phenomenon that emerges spontaneously or automatically within ecosystems. While there are articles dealing with these elements (Adner, 2017; Nambisan, Zahra & Luo, 2019; Pitelis & Teece, 2018; Jacobides et al., 2018), these authors fail to empirically articulate their development and understand of interdependence in the light of a capability. These contributions change the ecosystem discussion since now its most central feature, which is interdependence, can no longer be seen as spontaneous, as the literature implicitly describes them. On the contrary, there is a new capability and from now on, we argue that interdependence need to be seen as an ecosystem feature that can be developed and managed by the focal firms.

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Purpose

The literature often cites technological interdependence as a definitive feature of ecosystems. However, despite its relevance being widely recognized, it is still unclear how focal firms can develop technological interdependence for ecosystem management (EM). While the current literature implicitly places this feature as if it emerges automatically inside ecosystems, we propose that it need to be developed by focal firm through an EM capability. We argue that when focal firms decide to engage in EM, they need to develop a new capability to be able to develop and manage the technological interdependence in the ecosystem. Given this, our main objective is to unveil how focal firms develop technological interdependence for EM.

Literature Review

The literature provides a broad understanding of different types of capabilities for different functions. However, little is known about capabilities that are specific for EM (Hannah and Eisenhardt, 2018; Hou et al., 2020). There is a growing line of research that evidence the relevance of dynamic capabilities for EM (Bogers et al., 2019; Faridian & Neubaum, 2021). However, another group of schoolars affirms that theres must exist new and specific capabilities for the context of ecosystems (Hannah & Eisenhardt, 2018; Hou et al., 2020; Kay, Leih & Teece, 2018; Gomes et al., 2022). However, there is a research gap as there is still a lack of knowledge on capabilities specific for EM as the literature still does not explain the emergence of the most central feature of EM, which is interdependence (Jacobides et al., 2018; Gomes et al., 2022). Interdependence can be defined as a set of interactions that arise in multilateral configurations dependent on each other (Adner, 2017; Jacobides et al., 2018), and can shape ecosystem value co-creation and co-evolution (Hou et al., 2020; Jacobides et al., 2018).

Methodological Procedures

Given the objective of this research was to understand a theme that is still little explored in the literature, we considered suited to employ an exploratory and qualitative research. The research strategy was a multiple case study (Eisenhardt, 1989), in favor of immersion and a deep understanding phenomenon. We conducted a multiple case study covering ten ecosystems. We collected data through 47 in-depth open interviews, to have greater freedom to explore how these firms manage their ecosystems. The methodology we used for data analysis combined multiple cases comparison (Eisenhardt, 1989) with coding analysis (Gioia et al., 2013).

Findings

This study proposes a new EM capability: the technological interdependence management capability, consisting of 1) technological modularity; 2) co-development; and 3) binding mechanisms. This capability is described with its own definition and set of activities employed by the focal firm to develop this feature for EM. Our findings contribute to the capabilities-based view by showing a new type of capability specific for ecosystem management. For the ecosystem’s literature, we contribute by presenting an understanding of how focal firms articulate the most central feature of ecosystems into a new capability. We also present the implications for practice and the ecosystem management capabilities framework for focal firms.

Implications

Our main contribution is to the capabilities-based view by presenting a capabilities debate that considers not just value creation for the individual firm, but for the ecosystem. We did this by characterizing a new capability specific for EM, and we defined and discussed the main activities that composes it. The second main contribution we make is for the ecosystem's literature, by presenting an understanding of how focal firms articulate the most central feature of ecosystems into a new capability. This contribution is relevant, as the literature implicitly treats this feature as if they were a phenomenon that emerges spontaneously or automatically within ecosystems. While there are articles dealing with these elements (Adner, 2017; Nambisan, Zahra & Luo, 2019; Pitelis & Teece, 2018; Jacobides et al., 2018), these authors fail to empirically articulate their development and understand of interdependence in the light of a capability. These contributions change the ecosystem discussion since now its most central feature, which is interdependence, can no longer be seen as spontaneous, as the literature implicitly describes them. On the contrary, there is a new capability and from now on, we argue that interdependence need to be seen as an ecosystem feature that can be developed and managed by the focal firms.

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Information and communication technology governance model for a smart university

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Abstract: Cities that aim to become "smart" currently face a series of challenges in improving the quality of life for their populations using information and communication technologies (ICTs) in a cost-effective manner. This situation is similar to that of universities striving to evolve into "smart universities," but on a smaller scale. This research emphasizes the importance of using ICTs to achieve the evolution into a smart university, leading to the question: What model of ICT governance would be most appropriate for smart universities? However, throughout the literature, models of ICT governance in smart universities have yet to be discussed. Therefore, this research aims to "Design and propose a governance model for information and communication technologies (ICT) for smart universities".

Keywords: Smart City, Smart University, ICT Governance, Governance Model

Introduction

Smart cities arise from the need to optimize resources (infrastructure, water, and energy, among others) through the use of technologies (Maestre, 2015). This is why they are of great relevance for the implementation of public policies around the world, especially considering the exponential population growth of urban centers (Maestre, 2015), where currently 55% of the world's population lives (World Bank, 2020). However, a smart city's approach or path can vary greatly depending on policies, objectives, funding, and the context in which they are located.

Smart governance can be seen as the ability to apply digital technologies and intelligent activities to process information and make decisions (Pereira et al., 2018). A similar understanding is held by Chourabi (2012) and Meijer & Rodriguez (2015), who mentions that smart governance is based on ICTs to improve the exchange of information between government agencies and stakeholders, including citizens (Pereira et al., 2017), and serve as support for the activities or objectives of the city government. Other vital elements Meijer & Rodriguez (2015) mentioned are collaboration and participation, coordination, and management. The expected outcome of smart governance is a sustainable urban development that integrates all values, both environmental, social, and economic (Tomor et al., 2019).

Thus, ICT governance becomes fundamental for organizations to achieve their strategic objectives through evaluating, supervising, and directing different initiatives (Reis et al., 2020). Furthermore, ICT governance in smart cities is relevant and necessary for adequately managing resources and achieving a sustainable digital transformation of smart cities (Reis et al., 2021). However, research related to this type of governance for smart cities still needs more research (Reis et al., 2020).

Similarly to cities, there is a need to improve the quality of life in university environments. Therefore, if we apply these dimensions to the university community, we can obtain the vision of a smart campus or university. Unlike the smart city, the smart university is in a more controlled environment, where political, economic, and development decisions are local and do not depend as much on external factors (Parra-Valencia et al., 2017).

Higher education increasingly depends on information technologies, as these allow them to form digital systems, acquire, process, analyze and transmit information quickly, bringing a variety of intelligent solutions (Parra-Valencia et al., 2017). However, it is imperative to establish the governance of information and communication technologies (ICTs), which leads us to define in broad terms who will be responsible for making decisions and how the decision-making process will be. In this sense, it is vital that stakeholders are committed to taking on new challenges and that an organizational and process transformation is understood as necessary to carry out intelligent operations and services (Abdulrasool & Turnbull, 2020).

With regard to research on ICT governance models in smart cities, we can find the case developed in Munich, Germany (Scholl & AlAwadhi, 2016), where the proposed model was carried out for years to culminate in its final model called "3 houses - 1 ICT". This case is the closest related to this study. Although several ICT governance models are implemented in private institutions, these differ significantly from the expected objectives of the model. The models developed for universities are primarily in Spain, where the main driver has been the Spanish University Rectors Conference (CRUE), which has been working on the role of ICT in universities since 2006.

On the other hand, frameworks such as COBIT, ITIL, or ISO 38500 support achieving good security or financial management practices. However, ICT governance models in smart universities still need to be addressed throughout the literature. In this context, the question arises: What ICT governance model would be most appropriate for smart universities? This allows describing the purpose of the research as "Design and proposes an ICT governance model for smart universities".

An exploratory research methodology is used to carry out this work, along with a literature review and the selection of ICT governance models that will be used as a basis. In this way, the study can be divided into three phases. First, the problem is posed, and the key concepts of ICT governance and smart university are developed. Then, in the second phase, a literature review is carried out on the two concepts mentioned above. Finally, those articles that contribute to ICT governance models are selected, which will be used to propose an ICT governance model in smart universities. The objective is to develop an ICT governance model for smart universities by analyzing the models proposed for smart cities, universities, and private organizations. The expected result is to delimit the fundamental pillars of the ICT governance model for smart universities. The importance of the proposed model lies in need to have governance models that guide the development of Smart Universities and Campuses, given the need for more research on ICT governance in smart universities.

Theoretical Background

Smart City

The term smart city was born at the end of the 1990s, and since then, a definition for this concept has been sought. Currently, it is still a relatively new research topic and has been expanding around the globe, mainly in Europe and Asia, and more recently in America, becoming the new city paradigm.

Most authors agree on one thing (Cocchia, 2014; Capdevila & Zarlenga, 2015; Maestre, 2015; Quesada-García & Pulido, 2012) and that is that the smart city model must be able to improve the quality of life and solve the problems of the city, such as population growth, environmental pollution, efficient use of energy and natural resources, using information and communication technologies to achieve it. Similarly, we can understand the smart city as an open concept in its definition, which tries to respond to the demands of society (Quesada García et al., 2012). Therefore, the concept can follow varied paths depending on each city's specific policies, objectives, funding, and scope according to its particular context (Maestre, 2015).

To understand when a city is considered smart, Caragliu et al. (2009) posit that "when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructures drive sustainable economic growth and high quality of life, with smart management of natural resources, through participatory governance" it can be considered smart.

Similarly, Maestre (2015) understands the smart city as a territory characterized by the intensive use of ICTs, promoting collaboration, innovation, and efficiency to improve citizens' quality of life. If we transfer this definition to the university environment, the concept of a smart university is born, which maintains the same objective of improving the community's quality of life by using ICTs.

Regarding ICTs, several authors agree that they are an essential element within smart cities, emphasizing that they are a characteristic element and key to the design and implementation of smart city projects and initiatives. Although at the beginning of the literature, the smart city discourse focused too much on ICTs, it has been evolving and encompassing more concepts and delivering a complete vision. For example, Giffinger et al. (2007) propose the six pillars of smart cities, which are: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living.

Although ICTs have the power to address the governance challenges of cities and thus improve the quality of life of their inhabitants, the successful use of ICTs is much more than a mere investment in hardware and software. In this sense, a smart city is a city that seeks to address public problems through ICT-based solutions based on multiple actors in partnership (Maestre, 2015). This is how the incorporation of ICTs in cities becomes a real challenge, as it requires a governance model that effectively allows for the progressive transformation of the city. A governance model that effectively allows the progressive transformation of cities into smart cities (Broadbent & Weill, 1997).

Smart University

The smart university concept has been researched in the last 20 years (obtaining its peak of articles in 2021), so it is still an evolving topic developed mainly in Europe. The smart university should be an organization capable of taking advantage of technologies to improve the quality of life of its community, and in this several authors agree (Rico-Bautista et al., 2020; Abdulrasool & Turnbull, 2020; Parra-Valencia et al., 2017; Nuzzaci & La Vecchia, 2012; Luckyardi et al., 2022; Rico-Bautista et al., 2021; Mbombo & Cavus, 2021). The main areas for improvement include learning, management, health, safety, and environment (Abdulrasool & Turnbull, 2020; Rico-Bautista et al., 2021).

ICTs provide support to higher education institutions. However, they must focus on more than their physical implementation, such as hardware but also require organizational and process transformations due to the complexity with which they evolve (Rico-Bautista et al., 2020).

Smart universities use different tools to improve the education quality of life of students and the community in general so that they can learn, be informed, and keep in touch with the outside world in the same way (Rico-Bautista et al., 2020). Some of these tools are the Internet of Things, which with the help of sensors distributed in the territory, can generate useful information for the institution (Parra-Valencia et al., 2017; Luckyardi et al., 2022; Mbombo & Cavus, 2021), and big data, which supports the management of the data obtained and its analysis (Rico-Bautista et al., 2020). With the help of these and other technological tools, the competitiveness and productivity of the higher education institution can be improved, impacting the lives of its community positively.

It can be understood that using information and communication technologies is fundamental for the growth and development of smart universities (da Silva et al., 2021). Higher education institutions that adopt this model should efficiently use resources and apply smart solutions and services for the community (Luckyardi et al., 2022).

ICT Governance

ICT governance broadly comprises the decision-makers and their process. Thus, ICT governance becomes fundamental for smart cities to achieve their strategic objectives, properly manage their resources and achieve a sustainable digital transformation (Reis et al., 2021).

For Reis et al. (2020), ICT governance refers to the investment and effective use of ICT to guide the organization to meet its strategic objectives. Therefore, it should be the basis for decision-making structures, processes, and relational mechanisms for the direction and control of ICT operations (Reis et al., 2021).

In general, ICT governance is composed of structures (roles and responsibilities) and processes (ICT best practices), such as COBIT and ITIL, and active participation and collaboration. These components must interact to deliver effective results (Reis et al., 2021). It encompasses the description of policies, structures, and process management that are related to IT functions. It is a system that should direct and control the use of ICTs in the present and the long term, thus supporting and monitoring the fulfillment of strategic and operational plans (Fernandez & Llorens, 2009; Prasad et al., 2011).

ICT governance must be aligned with one or more organizational objectives. It should also contribute to the performance and efficiency of the organization, such as, for example, cost reduction and better use of the IT infrastructure. It encompasses everything related to leadership, structures, and processes to ensure that ICT is aligned with organizational strategy and objectives. ICT governance is defined as specifying what is governed, who governs, and how it is governed (Reis et al., 2020).

Bibliographic discussion

The common elements that could be observed in the six selected articles were strategy and services, all of which agree that these elements are fundamental to ICT governance. The strategy, on the one hand, must be proposed by the organization in order to be able to orient itself and set a course. On the other hand, services become an intrinsic part of ICT governance, encompassing hardware and software implementation. This dimension supports the organization's activities by ensuring proper short- and long-term functioning.

Regarding control, the only article that does not mention it is the one developed by Scholl & AlAwadhi (2016). However, only this article has a case study. Scholl & AlAwadhi (2016) analyze the case of Munich, Germany, where the ICT governance model "3 houses - 1 ICT" was developed and implemented over new years (2006-2015). The control dimension serves as a support to develop performance evaluations in the other dimensions and, in this way, identify the strengths and weaknesses of the organization and then develop a plan according to the results.

However, two articles consider five of the six dimensions. On the one hand, the work developed by UNAM (2018) considers the strategy, services, processes, human component, and control but leaves aside the objectives dimension. On the other hand, the work developed by Fernandez & Llorens (2009) differs from all other studies as it takes into consideration the objectives dimension, this is because, in the university context, the authors emphasize the university's objectives that should serve as a reference for ICT processes.

It is concluded that these six dimensions are essential for the ICT governance model in smart universities to improve management and performance, covering the most critical points that need constant development and control.

Table 1 - Comparison of dimensions addressed by authors.

		Dimensions					
Article	Context	Strategy	Servicios	Processes	Human Component	Control	Objectives
Scholl & AlAwadhi (2016)	Smart City	X	X	X			
Abdulrasool & Turnbull (2020)	University	X	X	X		X	
Reis et al, (2020)	Smart City	X	X	X		X	
Prasad et al, (2011)	Private organization	X	X	X		X	
UNAM (2018)	University	X	X	X	X	X	
Fernández & Llorens (2009)	University	X	X		X	X	X

Note: This table shows the dimensions addressed by each author.

Methodological Procedures

The methodology used to conduct the study consists of 3 phases. In the first phase, the problem related to ICT governance in smart universities must be understood, and for this, the concepts of ICT governance and smart university are explained.

Since there is no systematic knowledge about ICT governance in smart universities, it was decided to apply an exploratory research methodology. The second phase, a literature review of ICT governance in smart universities, was carried out. To develop the literature review, two searches were made, one related to smart cities and the other to smart universities, due to the scarce information on smart universities and ICT governance. The searches were conducted on November 1, 2022, in four different database engines: Springer Link, Web of Science, IEE Explorer, and Scopus. The keywords used were grouped, resulting in the following search strings:

TITLE-ABS-KEY ((smartcities OR "smart city") AND ("governance model" OR "management model") AND (governance OR "smart governance") AND (ict OR "information and communication technology"))

TITLE-ABS-KEY (("Smart Campus" OR "Smart University") AND ("smart governance" OR "Governance") AND (ict OR "information and communication technologies" OR "information technologies"))

Table 2 - Results of the search in database engines

Database Engines	Articles retrieved (smart city)	Articles retrieved (smart university)
Springer link	2	0
Web of Science	4	12
IEE Explorer	2	1
Scopus	15	8
Total	23	21

Note: This table shows the results of a search in four databases conducted in November 2022.

The third phase consisted of selecting articles that would be used as a guide to propose an ICT governance model for smart universities. To propose the model for this study, six articles were used as a reference point, two of which are developed in a smart city context, three in universities, and one in private organizations. These were chosen to have different perspectives and find their points of agreement and disagreement. The abstract and the introduction section were read, especially the article's objective, corroborating that these articles proposed an ICT governance model that could contribute to the purpose of the research.

Results

The proposed ICT governance model for smart universities encompasses decisions about the hardware, software, and communication systems needed to acquire data and analyze it to predict trends. In addition, it considers the human factor and control methods to evaluate the performance of the model's components. It is a centralized model consisting of three levels. At the first level are positioned the ICT governance objectives that must be aligned with the strategic plan of the smart university and, in addition, must be related to its main areas, i.e., strategy, services, processes, and people. The following is a portfolio of objectives designed based on the ICT governance reference model for universities (Fernández & Llorens, 2009) and the COBIT5 roadmap for smart cities (Reis et al., 2020).

1. Align the university strategy and the ICT strategy.
2. Identify the principles and requirements of the smart university.
3. Have policies and procedures in place to manage ICT.
4. Establish services capable of meeting the objectives of the smart university.
5. Define a baseline for smart university processes.
6. Establish an IT structure flexible enough to accommodate future changes.
7. Have staff with the skills and competencies required for the smart university.
8. Ensure the proper functioning of all processes to achieve the objectives.

The second level presents the four pillars of ICT governance. It should be noted that each of these pillars has its own uniqueness and relevance, which implies that they are independent in their actions. Therefore, some institutions may seek to strengthen certain pillars more than others, which implies that not all pillars are considered equally. This perspective suggests that some pillars may receive greater attention or investment by certain institutions, resulting in an unequal allocation of resources and efforts to strengthen them.

It is essential to emphasize that this assertion is based on the premise that each pillar has its own autonomy and that institutions may have preferences or priorities in terms of strengthening. Some institutions may seek to strengthen certain pillars based on their specific objectives or interests, which may influence allocating resources and efforts to strengthen them. The proposed pillars are as follows:

Strategy: As mentioned in the research, ICT governance is crucial for achieving strategic objectives in organizations. A dedicated pillar for strategy is essential, as proposed in models by Abdulrasool & Turnbull (2020) and Scholl & AlAwadhi (2016). Considering current and future needs, this pillar should guide and plan ICT initiatives at the institutional level and within university entities. It should define ICT security and control concepts, manage ICT assets, project portfolios, and staff competencies. The ICT governance strategy should also standardize business processes and systems according to ITIL/COBIT or ISO guidelines (Abdulrasool & Turnbull, 2020).

UNAM (2018) establishes an Information and Communication Technologies (ICT) strategy to meet institutional goals, including short, medium, and long-term planning of ICT initiatives at both institutional and university unit levels. Plans, programs, and projects are aligned to prioritize the university's mission of being an active part of an interconnected society and a knowledge revolution reference.

UNAM (2018) suggests three steps to follow: first, establishing guidelines for ICT planning considering current and future capabilities, and promoting planning at both institutional and university unit levels, based on institutional needs, objectives, and priorities. Second, providing essential resources, including guidelines, tools, and best practices, to optimize the planning and prioritization of ICT-related programs and projects, and finally, evaluating results obtained from ICT projects to determine if planned objectives were met.

ICT services: ICT services are indispensable for any organization and support many university activities such as teaching and university management (Fernández & Llorens, 2011). These must be of quality and meet the current and future needs of the university community (UNAM, 2018). In addition, they provide ICT services regarding the planning, construction, implementation, and operation of university-wide ICT and ICT infrastructures (Scholl& AlAwadhi, 2016).

For Fernandez & Llorens (2009), in the context of this pillar, the provision of the required services is addressed, including from conventional operations to training, security, and continuity aspects. In order to optimally provide the services, the appropriate support processes are established. In addition, data processing utilizing application systems, often categorized as application controls, is contemplated.

This pillar seeks to provide high-quality Information and Communication Technology (ICT) services that meet the university community's needs. For this purpose, the relevant entities and agencies will establish guidelines for its implementation. In this sense, it seeks to establish an agreement to define the guidelines for interaction with the university community with the objective of promoting an adequate use of ICT services, always considering academic and institutional interests (UNAM, 2018).

Among the recommendations mentioned by UNAM (2018) for ICT services is the development of policies and standards to manage the life cycle of university ICT services, whose main objective will be to make informed, timely, and justified decisions based on the specific nature and scenario of each of the services. In addition, tools and guidelines should be developed so that university entities and agencies can implement formal practices in the supply of ICT services, considering factors such as decision-making, response times, quality, information security, and availability. Finally, it should be verified that ICT services maintain good performance, support university processes, meet the university community's needs, generate value and satisfy user expectations.

ICT processes: These are specific to each university (Fernández & Llorens, 2009) and cover technology architecture and project implementation. It is proposed that the pillar contemplates smart university ICT governance requirements, such as managing the architecture, operations, requirements, solution identification, capacity, and availability of smart services. For Fernandez and Llorens (2011), the ICT processes pillar includes the administration and execution of such processes. Some examples of decisions to be made concerning these are identifying the activities required to perform ICT tasks, defining standard process flows (such as procurement, service level management, and incident management), and developing procedures describing how to perform ICT tasks. Fernandez and Llorens (2011) recommend using the following standards related to IT systems and processes: ISO/IEC 15504, ISO/IEC 20000, ISO/IEC 24762, and ISO/IEC 27000 (Fernandez & Llorens, 2011), among others. The definition included in this standard is of great importance due to its ability to be applied in any organization.

ICT Talent: The human component is fundamental within organizations, its intellectual contribution is an essential part to achieve the objectives of the organization (Majad, 2016; Fernandez & Llorens, 2011), since they perform functions related to the direction, management, and operation of ICT (Fernandez & Llorens, 2009). The human component must have the necessary competencies and skills to cope with their functions (Fernandez & Llorens, 2011).

Fernandez and Llorens (2011) stress that the policies and procedures established in IT must be respectful of this component, taking into account all the needs and issues related to the people involved in the business processes, such as individual competence, training, group work, communication, etc. Furthermore, incentives, rewards, and other mechanisms that maximize the human factor should be implemented to encourage proper value realization.

In this sense, UNAM (2018) mentions that the university should recognize human capital as its leading resource and, consequently, adopt an approach to foster the professional development of ICT staff. This initiative aims to improve ICT professionals' competitiveness, innovation, and research capacity, providing them with the necessary tools and knowledge to address current and future technological challenges. Furthermore, the university is aware of the importance of keeping ICT staff updated and aligned with recent technological trends to ensure the production of innovative and effective solutions. Therefore, the recommendations made by UNAM (2018) consist of establishing the relevant standards and provisions that govern this process. In addition, the necessary mechanisms should be defined to provide comprehensive training to ICT personnel, including acquiring skills and abilities that support the achievement of strategic, tactical, and operational processes of the university's entities and dependencies. Finally, the results of these initiatives are evaluated to verify that the planned objectives have been achieved.

The proposed ICT governance model for smart universities is based on promoting the four pillars identified. However, it is recognized that each institution can make relevant distinctions according to its particular strategy and approach. It is important to note that these four pillars are fundamental to effective ICT governance in a smart university. While institutions may tailor their approach according to their specific needs, it is considered essential that all four pillars are present as the basis for sound and coherent ICT governance.

The third level is Control, and this dimension must be transversal to all the pillars where metrics and indicators must be designed and applied (Reis et al., 2020). These metrics should be evaluated by an authority that can act on the results. The measures to be taken should include intangible and qualitative factors such as feedback from faculties and other constituents, exception reports when governance issues arise, internal and external audit reports, and strategic IT progression against the plan (Abdulrasool & Turnbull, 2020).

Figure 1 - ICT governance model for a smart university.

Note: This figure represents the ICT governance model for smart university.
Source: Own elaboration.

Discussion

An ICT governance model for smart universities plays an irreplaceable role within the organization in managing and controlling the use of ICTs. Let us make a comparison with other existing models. The one described in this paper takes as primary reference 2 ICT governance models, the "three houses - 1 ICT" developed in Munich, Germany (Scholl & AlAwadhi, 2016), and the model of the National Autonomous University of Mexico (UNAM, 2018). These models were used as the primary reference since both have been applied in their respective contexts, smart cities and university. Moreover, both models agreed that strategy and service delivery are indispensable for ICT governance. Thus, the proposed model comes in the first instance from a model of ICT governance for smart cities, and the university perspective is added to it.

The proposed model consists of three levels: at the first level are the strategic objectives, and at the second level are the four main pillars that serve as support and support to achieve the objectives that focus on strategy, services, processes, and human capital. It is emphasized that the ICT governance objectives must be aligned with the strategic plan of the smart university. Furthermore, the "ICT Talent" pillar covers the human component, which is the primary driver of achieving the strategic objectives. Therefore, their professional development should be promoted to increase their competitiveness and innovation skills. Furthermore, finally, the third level "control," should be transversal to all the pillars to be constantly monitored, and the model's performance can be evaluated. In relation to the four proposed pillars, it is crucial to bear in mind that their unequal treatment does not imply that one is superior or inferior to another in absolute terms but may be due to different approaches or strategies of the institutions involved. Furthermore, each pillar may have its own importance and contribution to the system as a whole, and strengthening one does not necessarily imply weakness or neglect of the others.

Conclusions

It is crucial that smart universities can provide their community with the necessary tools to develop their activities in the best possible way through technological development and data collection. Consequently, it is essential to establish an appropriate ICT governance model for the organization that will guide it to achieve its strategic objectives and manage its resources correctly. Thus, the contribution of this work is defined as the proposal of an ICT governance model for smart universities, which takes into consideration 6 fundamental dimensions divided into three levels, these dimensions are: objectives, strategy, ICT services, ICT processes, and ICT talent. Furthermore, these dimensions have been proposed according to different models developed in smart cities, universities, and organizations. In this way, the research has taken the "smart" concept and brought it to the university context. Therefore, the value of this work is highlighted as it contributes to the scarce research related to ICT governance models for smart universities.

Regarding the research's limitations, the need for previous studies related to ICT governance models for smart universities is mentioned. Likewise, the database search was limited to four, and the research results were finally strictly conceptual.

Along the same lines as this study, a methodological proposal will be developed to implement the model proposed in this research. In addition, a survey will be applied to professionals related to the university's ICT governance to measure the model's effectiveness.

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INNOVATION CAPABILITIES III

May 2nd: 3h10 pm – 5h pm

Chair

Mario Sergio Salerno (University of São Paulo, Brazil)

Papers

Innovation capabilities in Agtech

Ariane Avila, Ricardo Machado, Rafaela Trizotto, Paulo Zawislak

The consequences of digital transformation on the transactional capability of micro and small retail businesses

Maicon Martins, Samuel Bonato, Carlai Netto, Jorge Tello-Gamarra, Gilnei Moura

Integration overcoming competition: Managing exploration-exploitation interface in a biopharma organization

Lethícia Mallet Vivas, Mario Sergio Salerno,

Innovation capacity evaluation of companies and public administrations: What is the difference?

Manon Enjolras, Vincent Boly, Laure Morel, Laurent Dupont

Innovation function resourcing: Balancing external and internal sources

João Vitor Nunes Leal, Mario Sergio Salerno

Innovation Capabilities in Agtechs

Abstract ID#322

Ariane Avila (UniRitter) Ricardo Machado, Rafaela Trizotto, Paulo Zawislak (Federal University of Rio Grande do Sul)

Purpose

Innovation is redefining agribusiness by improving the pace of technical change along its value chains. Due to the advances in technology and digital convergence, startups are playing a central role in this scenario due to their innovative behavior. Startups have the ability to develop technologies when compared to traditional firms. Startups are emerging technology-based firms, which have in technological innovation the foundations of their competitive strategy (Dullius, & Schaeffer, 2016; Cunha Filho, Reis, & Zilber, 2018). Especially in agribusiness, a sector that in general includes traditional and low-tech firms, startups are challenging value chains by behaving completely differently. In this sense, how innovation capabilities behave in agribusiness startups? Thus, this paper aims to analyze innovation capabilities in agribusiness startups.

Literature Review

Innovation capabilities have been approached from the technological to the dynamic perspective and can be defined as the firm's ability to perform an innovation (Zawislak, Cherubini Alves, Tello-Gamarra, Barbieux, & Reichert, 2012). In fact, innovation capabilities offer the understatement of how firms develop technologies and how they are put into market. Based on that, innovation is redefining agribusiness by improving the pace of technical change along its value chains.

Startups focused on agribusiness, the so-called agtechs, can be classified as firms that are concerned in technological development in chemical, biological, administrative and mechanical processes (Dutia, 2014; Manne & Stout, 2017). These advances bring greater income to agricultural economic activities and reduce production costs and the complexity of agricultural activity (Ramos & Pedroso, 2021).

Most studies in agtechs aim to explain their behavior under different approaches. The first one is concerned about technologies (von Veltheim & Heise, 2020; Silvello, Alves & Alcarde, 2021). The second one is concerned about the market issues (Hudson & Wood, 2017; Cavallo,Ghezzi, & Guzmán, 2019). However, to understand innovative behavior, it is necessary an approach that bound together technology and market as taught by evolutionary literature (Nelson et al., 2018).

Methodological Procedures

Using Zawislak et al (2012) we performed a multiple-case study considering five agtechs. Both within-case and cross-case analyses were applied. The case study allows us to analyze qualitatively the intrinsic perceived attributes of the innovations and to put them into context.

Findings

The results showed that the initial idea of the product is related to the proximity of the founders of startups with agribusiness or with the purpose of reducing socio-environmental impacts. In this context, the business objective is to add value to what is already produced in the countryside by proposing new technologies such as automation, traceability of information, and ecological packaging. Therefore, for the development capability, the knowledge and intellectual capital of the founders are the main factors that lead to innovation. In terms of transaction capability, the relationship of proximity and loyalty with rural producers has been a critical success factor, as these suppliers follow the evolution of the business. Respondents report the need to participate in competitions and incubation and acceleration programs to claim financial support, given that initial resources are scarce. As for the operational capability, the modality of outsourcing part or all of the production process appears to be an ally of agribusiness startups: just as Steinbruch et al. (2021) explain, outsourcing is an attractive alternative for early-stage startups, which have little experience, knowledge and scarce resources. Management capability was less solid than the capabilities studied. Despite the interviewees reporting a high degree of autonomy in the areas, the number of employees is relatively low, often the staff counts only on the founding partners of the business. For them, the main management tool used is agile methods, in view of quality. In general, it is possible to verify what was proposed in the studies by Dullius and Schaeffer (2016): startups begin their activities with technical or business knowledge and acquire new capabilities with maturity. With the start of the commercialization of the product, startups increase production and need to manage the entire process.

Implications

Results are not generalized due to the research method employed. However, this provides opportunity for further agtechs studies in this area and also studies using alternate methods, such as quantitative, in-depth analysis of these factors and their relationships, which may confirm results or produce different results.

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The consequences of digital transformation on the transactional capability of micro and small retail businesses

Abstract ID#346

Maicon Martins, Samuel Bonato, Jorge Tello-Gamarra (Federal University of Rio Grande), Carlai Netto (Federal University of Rio Grande do Sul), Gilnei Moura (Federal University of Santa Maria)

Purpose

Paying attention to digital transformation is no longer optional for business survival (Parviainen et al., 2017). It is a combination of effects generated through various digital innovations, giving rise to new actors, structures, practices, values and beliefs that change, threaten, replace or complement existing rules within organizations. When faced with this dynamic and highly competitive scenario, companies adapt and promote changes according to customer needs, aiming to maintain a good relationship - having, then, the potential to promote changes with regard to the companies' transactional capability.

Thus, the research question is "what changes in the transactional capability of companies occurred as a result of the digital transformation process?". In this sense, the objective of this study is to analyze the consequences of digital transformation on the transactional capability of micro and small food retailers. The choice for this type of company is justified by, during the period of the pandemic, companies in this sector were able to continue operating, despite the health restrictions imposed by the authorities. These restrictions eventually made businesses have to adapt to new ways of transacting. Micro and small companies were also chosen, considering that these are the ones that are most exposed to possible disruptions to existing standards, as they generally have less investment power and less responsiveness to change.

Literature Review

Digital transformation can be conceptualized as a process that seeks to catapult the performance of companies, bringing about improvements through combinations of technology, information, communication and connectivity (Vial, 2019). Due to the great impact that this transformation has been causing in business environments, not being aware of this new moment can be crucial in the dispute in highly competitive markets. These impacts can lead to operational and process improvements or the search for new business opportunities. For Berman (2012), there are three actions that lead to digital transformation: the focus on the value proposition for the customer; the transformation of the operating model; and the combination of these two strategies in order to transform the value proposition for the customer.

Focusing on retail it can be considered that the digital transformation process occurs in 6 stages (Alekseevna, Yakovlevna & Vasilievich, 2017), which are useful for identifying the state of the firm in relation to the digital transformations. For Alekseevna, Yakovlevna and Vasilievich (2017), as the first act of digital transformation in retail, there is the so-called initial situation, when the retailer and consumer relationship occurs only via direct interaction between agents, physically inside the establishment. At stage zero, some implementations begin to appear, such as electronic accounting programs, electronic management of products stocked in the store and receipts. When advancing to the first stage, there is the emergence of online tools, which aim to automate the main processes of the retailer. These tools may or may not integrate the company's internal control system. Therefore, in the second stage, the emergence of online stores occurs, in which the processes of choosing and selling products occur entirely via the web (app or website). In the third stage, there is the possibility of customizing offers for each customer through the networks, in addition to building a greater relationship within them. In the fourth stage, more advanced digital transformation processes take place, such as product exposure in various sales channels, as currently occurs through marketplaces.

For Tello-Gamarra and Zawislak (2013), the company must maintain a structure capable of aligning its offer with consumer needs, minimizing transaction costs for raw materials and finished products. Therefore, the company will only be successful in the market after the transaction. More specifically, the concept of transactional capability emerges as a repertoire of skills, ties, processes, experiences, knowledge and routines that the company uses to minimize its transaction costs (Tello-Gamarra & Zawislak, 2013). Through this concept, it is possible to observe that the transactional capability is essential for the functioning of the companies, due to the whole repertoire of characteristics that it carries and because of the ability to structure the best form of interaction between the firm, suppliers and customers.

Methodological Procedures

In order to achieve the proposed objective, we chose to use a qualitative approach, through semi-structured interviews. In all, 8 interviews were conducted, with an average duration of 30 minutes each. The sample is composed of 8 companies, among which they have been in existence for between 6 months and 25 years, in different stages of digital transformation. Regarding the data analysis, they occurred in order to compare the dimensions of analysis of the transactional capability between companies that were in different (or the same) stages of digital retail transformation.

Findings

Among the findings, it was possible to verify that the digital transformation has an influence on the transactional capability of micro and small companies in the food retail sector. As the level of digitization changes, the transactional capability also changes. In the dimensions of distribution channels, contract, pricing, commercial changes, and customer relationship, it was observed that the transactional capability was largely altered by digital transformation, whether through new systems or other aspects discussed in the previous section. On the other hand, in the negotiation dimension, it was possible to perceive that despite the digital transformation changing this process, the main act of the negotiation aspect was harmed, as much of the bargaining power that retailers had was reduced by adhering to rigid systems. and with less margins for negotiation.

In addition, it was possible to see that newly opened firms adhere and advance in digital transformation in a more homogeneous way, while those that have been in the market for a longer time find it more difficult to adapt and explore digital tools.

Implications

Regarding to the theoretical implications, it is possible to highlight the use of the transactional capability approach in a sector that had not yet been explored. As far as practical contributions are concerned, the fact that digitalization is not just an option, but a necessary transition to be made, is highlighted, either by demand from suppliers or customers. This need is even more evident for businesses that started more recently, which are already emerging in the new digital environment. However, those who already have a ballast in the market manage to survive, even if they do not take advantage of all the resources that digital transformation can provide to retail.

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Integration overcoming competition: managing exploration exploitation interface in a biopharma organization

Abstract ID#353| Full Paper ID#499

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Abstract: Exploration and exploitation draw upon a firm's limited stock of resources, which create management tensions to overcome. This competition for scarce resources requires trade offs. Although there is consensus on the need for this balance, the literature has not yet clearly explored how it can be achieved. The research purpose was to unfold critical events that influenced or lead (enabling or constraining) exploration-exploitation integration and its consequences in strategic innovation performance. The research chose to address an in-depth longitudinal study based on an inductive and interpretive analysis in a biopharma organization which has both nature of activities – exploitation (mainstream), represented by incremental and core operations and exploration (newstream), represented by technological development of high-tech brand-new biologics. Our findings indicated two main levels of discussion. At the organizational (macro) level there's a "coexistence dimension", associated with borrowing and sharing in resource-constrained contexts between innovation and ongoing operations; and at project (meso) level there's a "translational dimension", which addresses the transition challenges in innovation transfer from newstream to mainstream. We proposed a conceptual framework to represent critical factors within and between both dimensions that could potentially help to overcome the exploration-exploitation interface dilemma.

Keywords: Exploration-exploitation interface, integration mechanisms, transition modes, innovation transfer

Introduction

The innovation environment in the biopharmaceutical field poses constant challenges worldwide. In recent decades, even large pharmaceutical companies have been trying to adapt to a new dynamic associated with low productivity in innovation process (Fitzgerald, 2010; Sousa et al., 2011). The pressure on the pharmaceutical industry is twofold, both to improve the rate of successful innovative projects and to acquire greater efficiency throughout the R&D cycle (Aagaard & Gertsen, 2011).

Efforts to explore and develop endogenous innovations, however, are commonly supported by ongoing operations and incremental innovation processes that make the financial sustainability of organizations feasible in the short term (Govindarajan & Trimble, 2010).

The pressure and bureaucracy usually imposed on projects with a mainstream feature limit and eventually "kill" the creativity and dynamics necessary for newstream. In this regard, Rice et al. (2001) reiterate the need to establish appropriate business models and process management in a separate organizational unit, which integrates part of the strategic portfolio and is part of the corporate strategy. O'Connor (2008), in her turn, stand up for the implementation of a radical, regular and systematic innovation function, which formalizes a team, resources, coordination mechanisms and its own budget, generating visibility and organizational legitimacy.

In the same pathway, narrowing this thought to project portfolio management perspective, Brasil et al. (2021) argue that radical or strategic innovation can only flourish in organizations when portfolio management is constituted to deal ambidextrously with incremental and radical innovation projects.

This concept comes from an idea well established in studies of organizational theory that studied by the organizational ambidexterity literature (Duncan, 1976; O'Reilly & Tuschman, 2008; Raisch et al., 2009). In complex, rapid and high-technology based organizations, the ambidextrous capability is known as the competence to sustain a firm's long term success by exploiting its current capabilities while simultaneously exploring fundamentally new competencies capable to create competitive advantage (O'Reilly & Tuschman, 2008).

However, as Ireland and Webb (2009, p.472) settled, "exploration and exploitation draw upon a firm's limited stock of resources" which create management tensions to overcome. This competition for scarce resources requires trade-offs (March, 1991; Hansen, Wicki, & Schaltegger, 2019). And even if there's structural separation in different organizational units or departments, recent studies rely on the need of integration in order to adequately pursue exploration and exploitation simultaneously (Gassmann, Widenmayer, & Zeschky, 2012; Jansen et al., 2009), with particular focus on the process by which these activities are integrated (O'Reilly & Tushmann, 2007).

Although there is no doubt about the merits of this balance, the literature on organizational ambidextrous behavior has little agreement on how organizations reach and sustain exploration-exploitation equilibrium (Adler et al., 2009; Salerno et al., 2021). Additionally, Brix (2019, p.337) points out that balance "does not necessarily imply that an equal number of exploration and exploitation activities have to be carried out" and, as a complex phenomenon, eventual responses to this dilemma are pretty much context-dependent.

The research purpose was to unfold critical factors that influenced or lead (enabling or constraining) exploration-exploitation integration and its consequences in strategic innovation performance in a biopharma context. In a macro level, how do both nature of activities can coexist in a virtuous model? Which mechanisms can be enabled to support integration instead of competition considering resource constraints? And, in a meso level, how do strategic innovations can be reintegrated back to core business, considering the transferring challenge under an innovation life cycle management?

Theoretical Background

In order to enable and facilitate a virtuous balance between exploitative and exploratory structures, most recent research has brought wide lens on both integration (Jansen et al., 2009) and transition modes for reintegration (Gassmann, Widenmayer, & Zeschky, 2012), to overcome exploration–exploitation interface challenges (O'Reilly & Tuschman, 2008; Hansen et al., 2019).

Govindarajan and Trimble (2005) propose three main tasks to face this challenge, bringing initial elements on how to manage the tensions identified by the ambidextrous literature between exploitation and exploration. They state the importance of forgetting, borrowing and learning as fundamental tasks so that innovation (newstream) and core operations (mainstream) coexist and not cannibalize.

An exclusive focus on forgetting can lead to isolation of strategic innovation, while a sole focus on borrowing would suggest full integration of NewCo and CoreCo, limiting innovation flexibility. Also, the learning capability is impacted by both sides if they don't balance the relationship (Govindarajan & Trimble, 2005).

Exploration and exploitation definitions

There's a dominant and disseminated use of "exploration" and "exploitation" terms since March's (1991) seminal publication about these twin concepts. However, unlike wide consensus about “exploration” meaning, regarding the search and acquisition of new knowledge, learning, experimentation and innovation; there’s not the same clarity whether “exploitation” refers exclusively to the use of past knowledge or if it also considers the pursuit of new knowledge, although different from the one that features “exploration” (Gupta, Smith, & Shalley, 2006).

In a deeper evaluation, “exploration–exploitation should be viewed as a continuum rather than a choice between discrete options” and the “distinction between exploration and exploitation is often a matter of degree rather than kind” (Lavie, Stettner, & Tushman, 2010, p.114).

For the purpose of this research, “exploitation” concept is adopted as a refinement of existing knowledge (Levinthal & March, 1993), targeting better execution and efficiency in core operations or incremental innovation focusing on present markets, which also contributes to maintain and reach short-term results for organizations (Benner & Tushman, 2002).

“Exploration”, whereas, represent strategic or radical innovations which are innovations with great potential in creating or shaping new businesses, shifting technological paradigms, characterized by unpredictability and high uncertainty (O’Connor et al., 2018). That type of brand-new knowledge creation is responsible for sustain long-term competitive advantages (O’Connor, 2008).

Besides March’s (1991) appeared clearly secure about the essential need of both types of activities for organizational learning and prosperity for lung-run advantage, he also assumes their fundamental incompatibilities, and bring light to the inherent contradictions that need to be managed (Lavie et al., 2010; Tushman & O’Reilly, 1996).

Balancing Exploitation-Exploration interface

The fundamental challenge in balancing short-term efficiency (exploitation) and long term effectiveness (exploration) are the distinctive demands, given the different outcomes and conflicting organizational routines associated with both activities that result in a hard management of trade-offs (Tushman & O’Reilly, 1996; Lavie, Kang, & Rosenkopf, 2009). An exclusive focus on exploitation leaves the organization threatened by any environmental hazards, as it limits its ability to adapt and adjust. Likewise, a dedicated focus on exploration burdens the organization with the costs of experimentation without the gains in immediate opportunities, which strategic innovation does not guarantee in the short-term (Lavie et al., 2010; Levinthal & March, 1993; March, 1991)

There are many strategies approached by a diversity of authors about balancing modes and alternatives to address exploration-exploitation interplay. Even though the majority of scholars assumes the use of ambidexterity to overcome the balance challenging, Lavie et al. (2010) highlighted that ambidexterity is only one approach for pursuing exploration exploitation balance.

There’s a fundamental question about the appropriate level of balance, and whether exists an ideal proportion for organization to pursuit, according to its industry conditions, mission, and competitive context (Miles & Snow, 1978). Even if there aren’t consensus about the perfect proportion, considering the precise mix is hard to specify (Lavie & Rosenkopf, 2006; Levinthal & March, 1993), most of studies agree and concur that organizational survival requires some sort of balance.

Gibson and Birkinshaw (2004) states the importante to build simultaneous capacities for alignment and adaptability, reinforcing organizational factors as the key elements to the organizational ability to balance rather than environmental contingencies determinations. Smith and Tushman (2005) propose buffers in innovation activities in order to provide a tension relaxing between both activities. Lavie and Rosenkopf (2006) discuss balancing beyond organizational boundaries, presenting how exploration and exploitation equilibrium can be achieved in their alliance portfolios. One step further, Brix (2019) sought subsidies on absorptive capacity advances and inter-organizational learning literatures, an updated model inspired in Simsek et al.'s (2009) typology, which added both interactive and integrative inter organizational perspectives.

In a nutshell, literature advanced about the recognition of exploration-exploitation balance need, but also the importance to achieve it within and across organizations, at multiple levels and over time (Lavie et al., 2010).

The question that follows is how organizations achieve and maintain this balance, and that's the fundamental point of attention for recent studies in this field. Lavie et al. (2010) consolidated prior research that identified four fundamental modes for coping with the conflicting demands of exploration and exploitation: contextual ambidexterity (no separation), organizational separation, temporal separation, and domain separation (see Table 1).

Table 1 – Modes of Balancing Exploration and Exploitation

Balancing mode	Contextual Ambidexterity	Organizational Separation	Temporal Separation	Domain Separation
Locus of balance	Individual and group levels	Organizational level	Organizational level	Organizational level
Mechanism of balance	No buffers between concurrent exploration and exploitation	Separate units dedicated to either exploration or exploitation, simultaneously coordinated at the corporate level	Sequential shifts over time from exploration to exploitation and vice versa	Exploring in one domain while simultaneously exploiting in another
Management role	Management provides a supportive infrastructure	Proactive management is essential	Proactive management is essential	Proactive management is not a necessary condition
Challenges	Managing contradictions within organizational units	Coordinating across units and managing contradictions at the senior management team	Managing transitions between exploration and exploitation and dislodging from inertial pressures	Identifying applicable domains and deciding whether to explore or exploit in any given domain

Source: Adapted from Lavie et al. (2010)

Integration mechanisms in innovation transfer

The modes of balancing give a great notion of options to help top managers analyses about structures they decide to take in order to simultaneously explore and exploit by either structure, time, or domain. But it does not necessarily entail coordination of conflicting activities in organizational routine (Lavie et al., 2010; Smith & Tushman, 2005).

Raisch and Tushman (2016) argue that the traditional ambidextrous designs offer a static perspective that limits the analysis of exploration transition to new core businesses as they scale up. "A more dynamic view of ambidexterity" (Raisch & Tushman, 2016, p.1) is considered necessary to assure cross-fertilization by adopting formal or informal integration mechanisms in innovation transfer (Jansen et al., 2009; Gassmann et al., 2012). Authors have been claiming about in-depth studies on explicit integration mechanisms which exploration exploitation interface is better addressed and managed (Gassmann et al., 2012).

Transition process (exploration-exploitation transfer) begin after the initial ambidextrous design has been put in place, and can be understood as the moment in which innovation translate from exploratory phase to exploit their new offerings in the market space (Lavie et al., 2010; Raisch & Tushman, 2016). That's considered a reintegration of strategic innovation projects back into the institutionalized processes, also referred as the actual transfer (Hansen et al., 2019). This transfer is crucial for successful strategy execution considering the uncertainties and risks in innovation projects for bridging the gap and find their way-out of the exploratory unit (Hansen et al., 2019).

This transition process covers a considerable time period from (a) linkages in early phases before transfer, (b) the actual transfer from the exploratory unit to the receiving core business unit to (c) the reorganization and related activities necessary after transfer (Hansen et al., 2019). That's a special risk of failure in transition processes considering plenty of trade offs associated with integration mechanisms approach, because benefits obtained for cross fertilization also leads to cross-contamination risk.

Hansen et al. (2019) led a longitudinal study with radical innovation failures, which addressed a framework of integration trade-offs in resource-constrained contexts linked to three phases in the transition process (before, at, and after transfer). Early phases of the transition are characterized by loose coupling, most times, which focuses on knowledge flows between differentiated units, otherwise later phases challenge the development of reintegration mechanisms to assure innovation might benefit of exploitative space in commercialization.

O'Connor and DeMartino (2006) proposed three main sub-phases before actual transfer take place, in early stage of transition process: (a) discovery, with the generation of new and potential ideas; (b) incubation, with new business plans; and (c) and acceleration, with new product commercialization. Radical innovation units often lack allocated resources and specialized capabilities for the incubation and commercialization of strategic innovation.

Gassmann et al. (2012), in turn, find five transition modes on how interfaces between strategic innovation units and core business are managed on a company level in order to overcome risks of failure in innovation transfer:

(1) External validating: this transition mode identifies external partners in order to transfer innovation to compensate missing internal linkages (Kauppila, 2010);

(2) Liaison channeling: transfer of strategic innovation through boundary spanners, where personal ties are used to establish channels for knowledge flows and spread innovation throughout the company (Durisin and Todorova, 2012; Simsek et al., 2009);

(3) Showcasing innovation: transfer of strategic innovation through making innovation tangible from pictures and prototypes (Gassmann et al., 2012);

(4) Network building: transfer of strategic innovation through exchange platforms (Gassmann et al., 2012);

(5) Integrative innovation planning: transfer of strategic innovation through collaborative decision making (Gassmann et al., 2012).

In summary, the approach of Gassmann et al. (2012) presented distinct management mechanisms to balance separation and integration of exploration-exploitation in innovation transfer. Hansen et al. (2019) complemented Gassmann study by considering challenges to deal with existing tensions and proposed additional integration mechanisms related to six trade-offs, as follows in Table 2.

Table 2 – Integration trade-offs in transition processes of innovation

Integration Trade-offs	Based on	Related integration mechanism
Complementary linking vs. contamination	Taylor and Helfat (2009)	Complementary asset linking
Seeking legitimacy early on vs. Frustration on discontinuation	Gassmann et al. (2012)	External validating; internal showcasing
Boundary spanning vs.carring over of old culture	Durisin and Todorova (2012); Gassmann et al. (2012); Simsek et al. (2009)	Job rotation
Early vs. Premature transfer	O'Connor and De Martino (2006)	Reintegration (at transfer)
Reorganization vs. Capability mutation	Durisin and Todorova (2012); Simsek et al. (2009)	Reintegration (after transfer)
Better acess to resources vs. Resource starvation	O'Connor and De Martino (2006); Chen and Kannan-Narasimhan, 2015)	Reintegration (accomodation with core business)

Source: Adapted from Hansen et al. (2019) and Gassmann et al. (2012)

Methodology

Case Selection

This is a Brazilian Official Public Laboratory for the development and production of medicines and supplies for health, with an extensive product portfolio and a history of large scale supply to meet the Brazilian Unified Health System (hereby SUS) needs, and also humanity international organizations.

In the referred company, mainstream operations are represented by an intense manufacturing activity with incremental innovations primary focused in process and industrial improvements. Newstream activities are represented by radical innovation biotech projects that have to borrow resources from mainstream in order to fulfill R&D and scale-up activities. Either exploitative (manufacturing) and explorative (R&D) functions are different organizational units with specific team members, processes and business rules. Although there are shared resources between both functions and supportive processes (management, logistics, purchasing, marketing, and others).

Research design

The case information was gathered through ten semi-structured interviews conducted with different project team members and sponsors (project managers, portfolio managers, researchers and others) involved in strategic innovation projects carried out within the organization, in view of their trajectory and relationships with the core operations. For the research purpose, we are considering core operations the overall mainstream organizational functions (incremental innovation, production, marketing, and so on). The qualitative method was based on an inductive and interpretive analysis (Corbin & Strauss, 2008). Data were analyzed using NVivo software in an iterative process that supported an inductive generation of categories which were organized in second and third-order themes of interest, and allowed the exploration of different dimensions and their relationships.

Therefore, we adopted an inductive qualitative research, based on a grounded-theory approach, following Corbin and Strauss (2008) perspective. The strategic innovation project is our analysis unit, considering its trajectory and relationships with the core operations.

It is noteworthy that complementary documents were accessed, such as status reports, presentations and performance evaluations of the projects, but the central axis of the information analysis was based on the content of the interviews following the thematic coding strategy emerging from the participants' reports.

Four innovation projects were selected after an introduction interview with the Innovation VP, who indicated the cases that had more fit with research objective – two concluded (retrospective analysis) and two in advanced pipeline – covering representations in the three product segments that make up the organization's portfolio (vaccines, biological molecules and diagnostics) (see Table 2)

Table 3 – Interviews description

Projects	Product type	Number of Interviews	Participants	Project start	Project end	Project status (present time)	Brief analysis
A	Vaccine	2	Portfolio manager; Project manager	2000	2024	On going Phase 3	• Internal development • Lost time-to-market • Turned to incremental
B	Vaccine	3	Portfolio manager; Executive manager; Technical manager	2009	2019	Discontinued	• Co-development • Market is still open • Discontinued by technical reasons
C	Biologic	3	2 Portfolio manager; Project manager	2005	2025	On going Phase 1 Licensed technology	• Internal development • Market is still open • Product is not yet cost-effective for market access
D	In Vitro Diagnostics	1	Portfolio manager	2012	2023	On going Market implemen-tation	• Internal development • Dominated public market • 2nd Generation of endougenous development accessing national market

Data analysis

Results were extracted from interviewers' discourses, which were represented in a data structure analysis following Corbin and Strauss (2008) methodology. The objective was to understand what would prevail in the speeches of the interviewees and how exploration exploitation interface would be approached by them. In this stage, 114 sentences were extracted from the speeches, which represented 21 first-order initial concepts. The references associated with these concepts underwent a new analytical round of review in order to refine the categorization and advance to coding in 2nd order themes.

In second-order themes data were organized by discourse elements that represented critical factors in exploration-exploitation interface. From the set of 1st and 2nd order codes and their relationships, we move on to the thematic aggregation in research dimensions that turned in two groups - the integration mechanisms (inspired by Hansen et al. (2019) and Gassmann et al. (2012) studies) related to managerial dilemma of exploration-exploitation, and the perspective of analysis. The analytical structure of the research (Corley and Gioia, 2004) is illustrated in Figure 1.

Figure 1 – Data structure of research

Results

We proposed a conceptual framework, inspired in Hansen et al. (2019) and Gassmann et al. (2012) works, to discuss and elucidate main integration mechanisms in organizational ambidexterity and related innovation transfer process, at organizational and project levels (see Figure 2). The first dimension is associated with a "coexistence perspective", at organizational level, related to structural ambidexterity (Gibson and Birkinshaw, 2004) with several challenges of borrowing and sharing in constrained-resource context between innovation and core business; and the second dimension is related with a "translational perspective", which addresses the transition challenges in converting from newstream to mainstream at project and team level.

Each critical factor identified on the in-depth study in biopharma organization represented a positive or negative impact, in the sense of enablers or constraining factors for integration. The analysis of data structure showed that competency transfer from core business to exploration space behaved as an enabling factor for exploration-exploitation coexistence, as well as transferring innovation to an external partner contributed to compensate missing linkages and, therefore, enabled translational process.

Otherwise, negative impacts were identified when it comes to allocation of resources, especially in resource-constrained contexts that demands a short-term choice between ongoing manufacturing and incremental initiatives over strategic innovation projects. Such negative factors usually appeared before or at transfer when project hasn't proved itself and core business attracts most of the organization attention (support processes, capacity, human resources, budget, etc).

The Coexistence Dimension

The coexistence dimension represents the ambidextrous perspective of integration view (Gibson and Birkinshaw, 2004; Brix, 2019) that argues about complementary benefits between the two approaches (exploration-exploitation) to learning. The research question lays on "how do organizations enable resource integration between exploration and exploitation?".

The in-depth research identified three main integration mechanisms associated with this research question.

a) *Resource allocation strategy*: we observed, in general, that the logic of conducting innovation projects is hostage to the institutional priority of the manufacturing operation that sustains deliveries to clients and short-terms financial returns. Actual business rules prioritize (1) manufacturing routine, (2) incremental innovation projects, and then (3) radical innovation projects when it comes to allocate shared resources in one direction. Perception of research participants is that strategic innovation hasn't been priority and that's necessary to review the way innovation demands are settled.

Considering mainstream struggled with core business maintanence, the integration mechanism requires an adequate review of the prioritization and pipeline management criteria, and in addition, the ability to focus, which requires the establishment of choices of what not to do (Thomke and Donald Reinertsen, 2012) in order to better redirect resources avaiability and allocation.

b) *Reorganization in differentiated units:* The case studied showed the organization tendence in differentiate innovation business units according to its focus on strategic innovations, with positive perception about the R&D spin-off from specialized formulation team, which were allocated in manufacturing departament, originally. However, this strategy separated units but but kept the support functions shared (marketing, financial, logistics, and so on). Besides, Raisch and Tushman (2016) have already emphasized the tensions and dysfunctional effects involved in differentitation associated with integration trade-offs (Hansen et al., 2019).

c) *Complementary asset linking:* Knowledge and capabilities flows from established units in exploration of new core technologies, using complementary assets (such as marketing, production, financing) (Taylor & Helfat, 2009). This leads to the need to prevent cross-contamination from old culture established in mainstream.

In the perception of the interviewees, despite the difficulty of formally establishing a stable flow in this interface, in the projects in which it occurred, the results were positive, especially in the early involvement of the competences of productive platforms in the stages of advanced technological development.

This integration mechanism, however, occurred in situations of conjoint development with external partners, in which the institutional legacy in terms of knowledge, facilities and platfoms absorption was contractually foreseen. The same was not observed for cases of own development, in which the transfer of internal technology between departments does not have the same formal terms.

The Translational Dimension: rejection-reintegration process

The translational dimension represents the deepening of the transition modes of innovation towards the core business, in order to favor its actual implementation and commercialization (Gassmann et al., 2012). The research question lays on “how exploratory innovations can ultimately be transferred back into the exploitative structures of core business?”

It’s important to highlight that, while the coexistence dimension is established in the analysis of organizational perspective of newstream vs. mainstream, the translational dimension lays on the project level of analysis and challenges are focused in team efforts to transfer innovation, although obviously two dimensions are intrinsically related.

The in-depth research identified five main transition modes for integration, considering that all projects’ sample reached the actual transfer stage, some prematurely and others late. Just one project suffered discontinuity related to technical issues identified in pre-clinical stage. Problems and enablers were identified before, at and after transition, in order to cover the entire innovation life cycle.

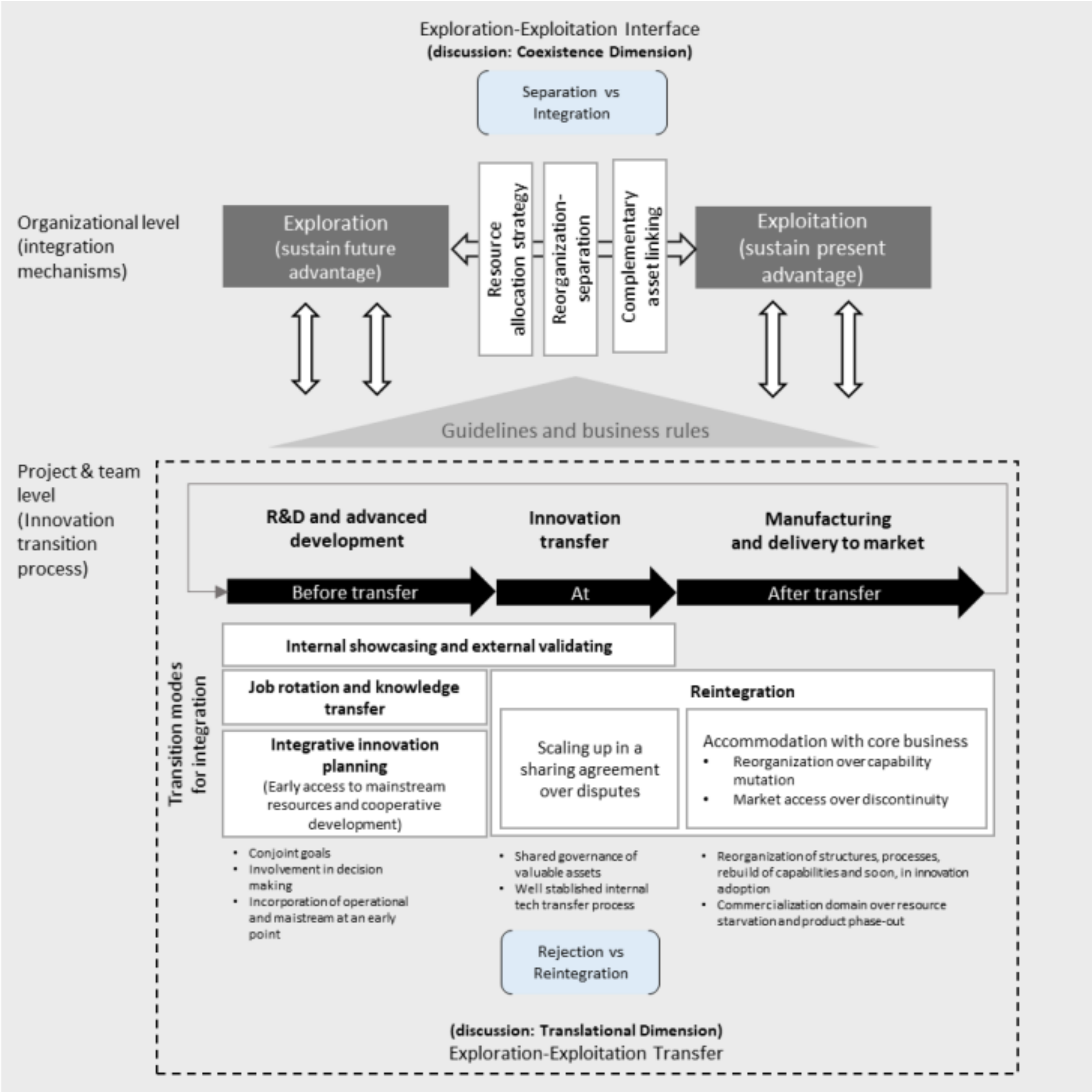

Figure 2 – Integration framework for innovation transfer

Source: Author's elaboration, based on Hansen et al. (2019) and Gassmann et al. (2012)

a) *Internal showcasing and external validating*: Internal showcasing allows likelihood on innovation projects and results. Communicate early results for internal staff or through external partners/clients about innovation potential increases legitimacy. However, it brings more expectations to manage eventual failures in the future (Gassmann et al., 2012). External validating occurred in two of four projects in the sample, as partnership searching and modulation of demand. However, one of them didn't reach desirable results, and it reinforced the need to tie expectations from the beginning. Internal showcasing, on the other hand, was considered insufficiently adopted, with the need for improvement.

b) *Job rotation and knowledge transfer*: Competencies can be rotated through personnel transferring between exploration and exploitation units in order to facilitate reintegration once back in exploitation unit. There's a risk of cross-contamination considering old culture carrying over (Durisin & Todorova, 2012; Gassmann et al., 2012; Simsek et al., 2009). This transition mechanism was specially highlighted by participants, considering good experiences in knowledge flows from mainstream to exploratory innovations before transfer (helping incubation and acceleration stages). However, unlike literature suggests, the in-depth study showed low rate in knowledge transfer and job rotation in exploration-exploitation direction. Most projects have benefit borrowing personnel from mainstream, but quite few professionals were transferred from newstream, which limits virtuous organizational learning (Brix, 2019).

c) *Integrative innovation planning*: transfer of strategic innovation through collaborative sense of belonging and decision making (Gassmann et al., 2012). Participants found especially important to sharing the big plan, while prioritization decisions are made, even if they don't favor radical projects immediately. That mechanism could bring a sense of belonging in the search for a win-win solution to resource allocation and negotiation, and if it's well combined with internal showcasing, can achieve even better results.

d) *Reintegration (at transfer):* Early reintegration reduces resources' spending and may help the use of established core business structures, but it's important to assure incubation and acceleration phases before proceed to actual transfer in order to prevent premature transition and eventual rejection (O'Connor & De Martino, 2006). Critical factors related at this point were mainly associated to disputes and competition for manufacturing plant usage, considering phase 3 efforts in scaling up new products. Reintegration mechanisms could be arranged with shared governance with well established rules for valuable assets access, including strategic buffers for exploratory projects use (Thomke & Donald Reinertsen, 2012).

Reintegration of exploratory innovations back into core business structures demands reorganization of processes, structures, responsibilities and capabilities. If organization underestimate efforts in this direction, there's a risk of strong capability mutation and loss of money, time and competencies (Durisin & Todorova, 2012; Simsek et al., 2009).

e) *Reintegration (after transfer):* After reintegration, exploratory innovation can better access core business resources in a pathway of accommodation. However, premature innovation transfer can struggle in constrained contexts of budget limitation and lead to resource starvation (O'Connor & De Martino, 2006; Chen & Kannan-Narasimhan, 2015). Accommodation problems were mainly evidenced in research sample when exploratory innovation loses adequate market access because of time wasting with scaling up barriers and other reintegration factors at transfer time. That's rare to mainstream receive radical innovation projects with breakthrough prototypes to be scaled and produced, and resource sharing, at time required to maintain competitiveness. It causes impact at next stage of transition process, when innovation gets in commercialization routine. Problems were also observed in the loss of technical competence in the transfer to the core business, as warned by the literature.

Discussion

A first reflection on the research results refers to the importance of getting into the critical factors of the internal innovation transfer process. In order to better understand the dilemma of the interface between newstream and mainstream, it was observed the importance of materializing this paradox from the organizational level to the concrete barriers of the routine of transition from innovation to the core business, at the level of analysis of the project and its team (Andriopoulos & Lewis, 2009; Hansen et al., 2019).

It's known that treat transition innovation process is one perspective to reach success ambidexterity, but we defend as a major and relevant one, due to its powerful evidence-based approach in integrative decisions and routines (Brix, 2019; Gassmann et al., 2012). Although each transition mode represents a distinct mechanism of innovation transfer, in most cases, they were observed in combined ways in our sample.

In terms of additional contributions, the proposed framework arising from the in-depth study, illustrates that the integration mechanisms originally tied to certain moments of the innovation transfer process (as proposed by Hansen et. al, 2019), can have expanded borders along the innovation continuum depending on context found. For example, the reaccommodation of processes in reintegration phase may be necessary even before the transfer moment itself, including integrated planning mechanism that foresees the migration of competences and information without creating gaps to transition flow.

Also, from the inductive analysis, we consider that integration mechanisms applied may face different rules according to companies' reality - governance, recognition, leadership roles, structure, etc. These different business rules can change guidelines and assumptions adopted in deployment of these mechanisms in actual transition modes. That's an opportunity for future studies deepening.

Conclusion

"The coexistence of exploration and exploitation does not negate the inherent trade-offs between them, so that scholars should avoid assuming away these trade-offs and ascribing a positive association between exploration and exploitation to complementarity" (Lavie et al., 2010, p.117).

We proposed a conceptual framework to differ coexistence dimension from translational dimension, and indicated critical factors within and between the two dimensions that could potentially help to overcome the exploration-exploitation interface dilemma and become more efficient in obtaining endogenous and strategic results to innovation-driven organizations. That framework was inspired in Hansen et al. (2019) compilation of integration trade-offs and Gassmann et al. (2012) transition modes. We sought to add and highlight which mechanisms could be employed to better overcome barriers for integration and exploratory transition to core business.

The two dimensions of analysis contribute to overcoming the exploration-exploitation dilemma, but require different coping approaches.

The first dimension focuses on the fundamental role of integration mechanisms and seeks to answer "how can knowledge flows and organizational learning between exploration and exploitation units be organized?"

The second dimension focuses on the role of transition modes related to these integration mechanisms, which seeks to answer "how to enable the transfer of strategic innovations to core business structures, allowing their commercialization and dissemination?"

The study narratives suggest a potential way for convergence between exploratory innovation and mainstream activities associated with the establishment of integrative mechanisms, that could enable collaboration and project execution without struggle teams in a competition run.

About research limitations, despite the declared strategy of strengthening endogenous innovation and organizational movements to empower the newstream processes, the chosen case has a challenging context related to certain restriction for newstream-type innovations in the face of the natural difficulties of the public environment, specially associated with human resource performance system and technology transfer predominance. Thus, it would be interesting to expand the sample with other types of organizations and test the framework in different realities that can increase the results and eventually identify patterns or trends related to each context.

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Innovation capacity evaluation of companies and public administrations: what is the difference?

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Abstract: Innovation processes are increasingly implemented in a wide variety of structures, not only companies but also local administrations (especially urban or rural agglomerations). These entities seek to develop through innovation but also to respond to major societal challenges: climate change and digitalization among others. Therefore, their innovation processes, like any other activity, need to be managed and therefore evaluated. The evaluationof innovation processes is a field in which research is being conducted at international level. However, these research works mainly concern the industrial sector and companies and the assessment of the innovation capacity of a public administration as a local organizational structure remains little addressed in the literature. So, relying on the recommendations of the ISO 56002 standard (2019) and adopting a Living lab approach, this paper reports intermediateresults obtained from a 6-month experimentation within the city hall of Nancy (France), highlighting a set of differences between companies and public administration evaluation systems.

Keywords: companies, public administration, evaluation, innovation, practices, Living Lab

Introduction

Innovation processes are increasingly implemented in a wide variety of structures, not only companies but also local authorities (especially urban or rural agglomerations) (Lopes et al., 2021). These entities seek to develop through innovation but also to respond to major societal challenges: climate change and digitalization among others.

These innovation processes, like any other activity, need to be managed and therefore evaluated. The evaluation of innovation processes is a field in which research is being conducted at international level. As far as the processes have to be adapted to the kind of entity there are implemented in, an adaptative corpus of knowledge is required in the field of evaluation. Various points of view are adopted in innovation metrology. One can consider the output evaluation as a result-based view of the innovation process. It relies on metrics enabling to evaluate innovation performance such as profitability, idea generation, launches of new products on the market, time to market, number of patents, and turnover (James et al., 2008; Miller, Morris, 2008). However, these metrics are regularly questioned (Perry, 2010) in favor of an input-oriented assessment strategy, in line with the resource-based view, for which the means allocated to the innovation process constitute strategic resources (Barney et al., 2001). Finally, one can consider the concrete practices carried out by the people involved. It refers to a process assessment strategy considering innovation management as a whole process putting forward the benefits of a combination between the resource-based view and the capability view (Teece, 2018). Therefore, various concepts are mobilized, such as the absorptive capability (Liu et al., 2021), defined as a firm's ability to recognize the value of new information, assimilate it, and apply it to the commercial end; or the innovation capacity (Boly et al., 2014a; Pierre & Fernandez, 2018), defined as the continuous improvement of the overall capabilities and resources that the firm possesses for exploring and exploiting opportunities to develop new products to meet market needs (Szeto, 2000).

However, all the dimensions of an evaluation system are likely to change depending on the entity where the innovation processes are evaluated: the collection and processing of data, the analysis frameworks, the measurement scales, etc. Furthermore, the transfer of innovation processes models from the private to the public sector is not immediate and, despite similarities, divergences have to be mentioned (Hartley, 2013). So, in the present work two situations are distinguished: industrial companies and local authorities, with the following gap seeking to be filled: what differences exist between a system for evaluating the innovation capacity of a company and a local public administration. Note that we adopt a practice-oriented assessment strategy, in order to question the variability of the entities to be assessed. This research is therefore increasingly integrating the existence of a normative reference standard: ISO 56002 (2019).

The originality of the research consists in adopting a Living Lab approach for the design of the evaluation system. In practice, within a large public administration (City of Nancy, around 105 000 inhabitants), we created a group to co-adapt a capacity to innovate evaluation tool, previously dedicated to companies to our purpose. The Living Lab concept is at the intersection of open innovation and user-centered design (Hossain et al., 2019). It consists in an organized set of methods and stakeholder, which focus on user involvement, user-centric research methodology for sensing, prototyping and validating solutions in evolving real life contexts (Dell'Era and Landoni, 2014). It is an R&D concept which aims to create innovations in a multi-contextual, real-world setting (Konsty et al., 2014). A six-month experimentation has been conducted with a group of 13 people from different services of the city hall with also different hierarchical levels. The research process was iterative: combining training (improving skills of contributors about innovation and metrology), co-design (design of the data collection and treatment approaches, and, of the visualization of the outcomes with a particular focus on the vocabulary used) and experimentation (in parallel, evaluation actions were managed toward projects in the field of services targeting young children). The approach allows a dynamic design of an evaluation system while integrating the specific culture of a public structure and the multi-hierarchical visions of employees. Moreover, the dynamic between design and experimentation/return on experience all along the process helps getting data about the efficiency of the system (decision-making), its applicability and the possible deployment to other services.

This paper reports intermediate results obtained from this experimentation, highlighting a set of differences between companies and public administration evaluation systems. These differences mainly concern: the nature of the value generated by the innovation processes of both entities, the specific implementation of the practices related to strategy, as well as the variable scope on which the evaluation system has to be focused. In the following sections, the theoretical background of innovation metrology will be presented. Then, our methodological background as well as our research design will be exposed, before presenting the result of our 6-month experimentation within the city hall of Nancy (France). These results will finally be discussed in order to draw some research perspectives in the field of public administration innovation management.

Theoretical Background

Innovation capacity: companies vs public administrations

The literature in the field of innovation management recognizes certain similarities between public and private innovation. However, an immediate transfer of innovation processes from the private to the public sector is not envisaged and, despite some parallels, divergences must be mentioned (Hartley, 2013). Indeed, several differences appear to be crucial in differentiating a public and private entity in terms of innovation. First of all, innovation in companies has as its objective an impact on economic development, while innovation in public administrations focuses on the impact on social and territorial development (Fuglsang, 2010). Moreover, the notion of public funding implies that, in essence, there can be no shared ownership, except in university structures (Falk et al., 2016). Innovation processes in these organizations are often open (Karvonen et al., 2018). They traditionally seek to share and exchange ideas with citizens, the media, or other public institutions, potentially leading to public debates about the level of their priorities or added value. Regarding the type of innovation, Hartley (2013) points out that the transfer of private innovation processes might make sense in the case of service or organizational innovations but shows some inconsistency when it comes to new product development processes. Seeking to make an impact on their city and given often severe financial constraints, the attention of local managers (both local politicians and administrative executives) is usually directed toward defining overall development strategies and driving continuous improvements in project management methods. Finally, the notion of uncertainty, inherent to any innovation process, is also a factor of divergence. In the case of public administrations, the customers of private companies are replaced by citizens and local actors who are looking for new services but who do not accept the volatility that exists in the corporate world. Failure to innovate can have serious consequences if the media or opposition parties get hold of it. Thus, the approach to innovation diffusion differs between the private sector, which seeks novelty as a competitive advantage, and the public sector, which sees it as easier and less risky to implement an innovation that has already been adopted by another organization rather than starting from scratch (Hartley, 2013).

Innovation metrology: a process-oriented evaluation

Considering the different innovation evaluation strategies (input-, output- or process- oriented), and examining them in the particular context of public administrations, it seems that the process-oriented view offers interesting perspectives. Indeed, it may be inappropriate to consider public innovation management in terms of outcomes. The general functioning of these institutions is rarely oriented towards performance. In the same way, since the management of resources, particularly budgetary resources, is specific to public operations, it does not seem coherent to consider an evaluation strategy based on the resources mobilized. On the other hand, a process-based approach makes it possible to take into account the day-to-day functioning of these structures and to highlight the best practices implemented within their organization as well as their potential replicability (Fuglsang, 2010). In this way, we come closer to the recommendations of the recent ISO 56000 standard on the innovation management system, which also adopts this process-oriented vision.

Across this process-oriented spectrum, several theoretical notions have been proposed in the literature to evaluate innovation. For example, absorptive capacity has been defined as the ability of a firm to recognize the value of new information, assimilate it, and apply it for business purposes (Cohen, Levinthal, 1990). Dynamic capabilities (Teece, 2018), on the other hand, correspond to timely responsiveness and rapid, flexible innovation, as well as the ability to effectively coordinate and redeploy internal and external competencies (Teece, Pisano, 1994). Specifically, O'Connor (2008) suggests seven elements that support innovation when applying the concept of dynamic capability: (1) an identifiable organizational structure; (2) mechanisms for interfacing with the core organization, some of which are tightly coupled and some of which are not; (3) exploratory processes; (4) development of required competencies; governance and decision-making mechanisms at the project and innovation system level; appropriate performance measures; and (7) an appropriate culture and leadership context. Similarly, the Potential Innovation Index (PII) proposed by (Boly et al., 2014; Galvez et al., 2013), based on a multi-criteria assessment model, considers six innovation practices: strategy, idea generation, design, human resources, project management and knowledge management.

However, it is important to note that the studies carried out on innovation capacity assessment models mainly concern the industrial sector and companies. In view of the differences identified in section 2.1, the question of the transferability of these results to the public sector context, and more specifically to the scale of a public administration, arises. While some studies focus on the evaluation of innovation within territories, they propose different evaluation frameworks to better understand the impact of public policies on the economic sectors of the geographical area under consideration (Magro, Wilson, 2019) but do not focus on the innovation activities of public administrations with a process-oriented vision. Thus, the assessment of the innovation capacity of a public administration as a local organizational structure remains little addressed in the literature (Appio et al., 2019; Audouin, Dugué, 2018).

Methodological Procedures

Background

With the aim of identifying differences in innovation management systems between the private and public sectors, this research work mobilizes a methodological framework based on two foundations. The first one is the evaluation of the innovation capacity according to a set of best organizational practices. For this purpose, we rely on the reference model of the Potential Innovation Index to describe the organizational routines of a structure. This model has a long history of development (Boly et al., 2000; Rejeb et al., 2008; Rodriguez et al., 2013) and is based on the assessment of 6 practices that foster innovation: Strategy, Idea Generation, Design, Human Resources and Knowledge Management. These practices are then divided into different sub-practices, forming a framework of 18 elements to be evaluated.

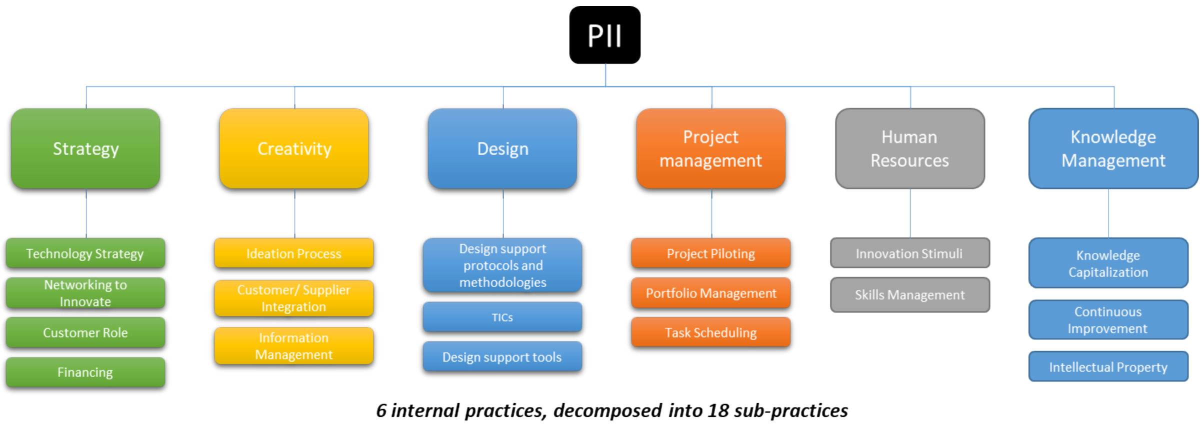


Fig 1: The PII Framework (Boly et al., 2014; Galvez et al., 2013)

Each sub-practice is evaluated via a number of tangible indicators, structured in the form of a maturity grid. The maturity grid allows describing the typical behavior of an organization (García-Mireles et al., 2012) and is regularly used to measure the internal processes of organizations (Antunes et al. , 2014), especially since they allow identifying short and medium term progress objectives. Although le PII is an evaluation model initially designed for SMEs, several theoretical and empirical comparisons allow its extension to different types of organizations as well as to different contexts (multinational companies, service sector, multiple geographical contexts...) (Boly et al., 2014; Galvez et al., 2013). Moreover, it will demonstrate the adaptation of a framework dedicated to companies to the specific context of public innovation.

The second methodological foundation mobilized in this research work is the Living Lab approach. Associated with the two paradigms of open innovation and user-driven innovation, the Living Lab approach is defined by the authors as a combination of a research methodology, a user-driven open ecosystem, an experimentation environment, an innovation intermediary, a system, a public-private-population partnership (PPPP). To improve the understanding of this concept, several authors such as (Evans et al., 2015) ; indicate that there are common determinants of Living Labs such as: multi-stakeholder mobilization and participation according to public-private-population partnership (PPPP), user involvement and end-user centrality, co-creation, multi-method approach that mobilizes many tools and use in a real-world context. A living lab approach is then mobilized within this research work in order to implement an adaptation process of the PII framework toward a public-oriented context, relying on empirical observations and involving stakeholders from the field.

Research design

We choose to implement our research in the scope of action research (Yin, 2013). Therefore, our research design is based on the methodological framework of (Arnould et al., 2022). It is composed, on the one hand, of a theoretical framework including five steps, dedicated to the implementation of a living lab approach (Fig 2):

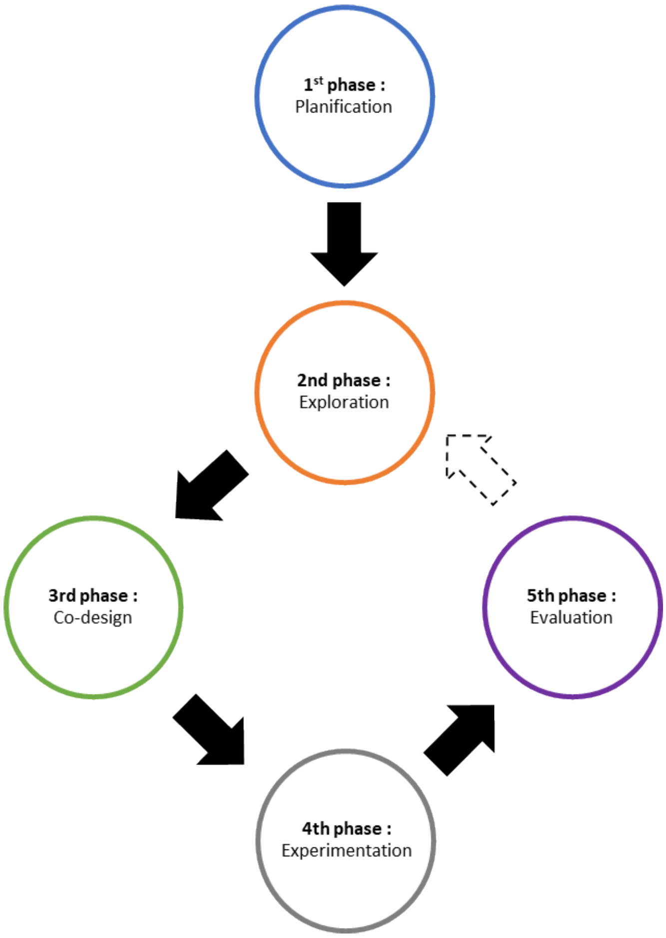


Fig 2: Research Design

Planning: The objective of this phase is to plan the objectives and deadlines of theproject and to define a problem.

1- Exploration: The objective of this phase is to carry out a shared diagnosis of the environment in which the project will take place.
2- Co-design of solutions: This phase aims to co-construct solutions based on the shared diagnosis in response to the identified problem.
3- Implementation and experimentation of the solutions: This phase aims to test in real conditions the solutions co-constructed by the stakeholders.
4- Evaluation of the solutions: The objective of this phase is to evaluate the implementation of the solutions according to criteria defined by the stakeholders

On the other hand, we build our reasoning on empirical observations, collected through a 6-month experimentation within the French city hall administration of Nancy (France). We adopt a practice-oriented evaluation method to illustrate the general principle of innovation management within a public administration at a local scale, by observing, analyzing and understanding field practices in real context and in a longitudinal perspective. Through the organization of regular working sessions with a group of employees of the city hall, we implemented a data collection and analysis process leading to the formalization of several intermediate constructs enabling to highlight the specificities of innovation management within a public administration.

Results and discussion

Phase 1: Planning

Implementation: This first step illustrates the preliminary phase presented in Figure 1. It represents the beginning of our co-design circle. The aim of this phase is therefore to question the implementation of our research design, in order to draw the objectives to be reached. For this purpose, a 6-month experimentation has been built with the city hall administration of Nancy (France). The Nancy public administration was chosen as a research partner because of the facilitating context that this organization could offer. Indeed, the mayor of the city under mandate at the time of this experiment was aiming for a more structured internal innovation dynamic, the heads of the departments globally consider research as a means to train people in the basics of innovation, and an engineer specialized in innovation processes had just been hired.

Results: This planning phase results in the proposal of a working sessions schedule, involving a group of 12 stakeholders from the Nancy administration. Ten working sessions were organized. These working sessions were conducted as focus groups between February and July 2019 and engaged elected officials, administrative department heads, state employees, and project/public leaders.

Phase 2: Exploration

Implementation: This second phase aims to implement a common language around the notion of innovation. The first two working sessions planned aimed to lay the foundations for collaborative work around the notion of innovation capacity. Combining training (improving skills of contributors about innovation and metrology) and group discussions about their own experience, the Potential Innovation Index framework was exposed to the participants. Innovation practices and sub-practices were defined and discussed. The objective was to explore, on the basis of a framework dedicated to companies, the issues of divergence and misunderstanding that could emerge among public service actors.

Results: The main result of this phase was the construction of a common language and a first step in the connection between theoretical concepts and empirical phenomena of the innovation capacity of a public administration. It was determined that the terminology used within IIP needed to be revised to better reflect the values and vocabulary used within a public organization. As a result, several practices/sub-practices were renamed. For example, the practice of "New Product Development" was revised to clearly incorporate the notion of service. The notion of "Research and Development", initially present in the diagnosis dedicated to companies, has also been put in perspective with the notion of experimentation capacity. The human resources practice was also discussed, highlighting the importance of stimulating the spirit of public service, as well as the notion of societal responsibility. These elements were previously absent from the diagnosis dedicated to companies. Finally, the notion of governance was widely discussed during the exchanges concerning the notions of strategy. On the other hand, certain practices such as those related to project management or knowledge capitalization appeared to be much more in line with the operating habits of the stakeholders in the working group.

Phase 3: Co-design

Implementation: Based on the first two working sessions, six additional sessions were held in order to deepen each innovation practice of the IIP framework. Each session was dedicated to a specific innovation practice. The objective of each session was to define each of the practices with titles (based on discussions in the "exploration" phase sessions) and to verify that the practice corresponds to: 1) activities that people perform when they participate in innovation,

2) practices known from other municipal governments, since Nancy belongs to networks of innovative cities, 3) activities considered transferable to a municipal government. For this purpose, for each practice considered, the maturity grids of the IIP reference framework were presented to the participants as a basis for discussion. Based on this, the working group set out to :

Reformulate the vocabulary used

Delete irrelevant sub-practices

Adding sub-practices specific to the operation of a public organization

Discuss how to implement the sub-practices and identify what is considered a mature deployment or not based on their own experience.

Results: At the end of the 6 working sessions dedicated to the Co-design phase, a new innovation evaluation framework has been provided by the stakeholders. Fig. 3 presents the changes that have been made within the initial PII framework dedicated to companies.

Of the 6 original IIP practices, only the "New product development" practice has been changed to "New Product / Services development". Major changes were made at the sub-practice level as follows:

Practices	Original PII Sub- Practices	Modifications	Adapted Sub-practices
Creativity andnew concept emergence	P1 - Creative process	lexical adjustment in the maturity grid	P1 - Agent creative process
	P2 – Integration of theclients and suppliers	Split into 3 different sub- practices in order to collect theideas on the whole value chain. 2 sub-practices added: “Elected officially integration”& “Other partners integration”	P2 – Integration of users/citizens
			P3 - Impulse/integration of elected officials
			P4 – Integration of the other partners of theecosystem
	P3 – Monitoring/ information gathering for idea generation	kept	P5 – Monitoring/ information gathering for idea generation
New Service/product development	P4 – Design protocolsand methods – R&D	lexical adjustment in the maturity grid + split to includethe ability to experiment solutions	P6 – experimentation ability
			P7 – Design methods
	P5 – Supports and tooling	lexical adjustment in the maturity grid	P8 – Resources/material means (tools, equipment..)
Human resource management	P6 – Innovation stimulation	Kept	P9 – Individual stimulation to innovate
	P7 – Internal communication	lexical adjustment in the maturity grid	P10 – Communication about Innovation
	P8 – Skills management	Replaced by “Learningorganization” to highlight the ability to learn a strong leverage	P11 – Learning capability
		Added to reflect the public sector stakes, ie innovation as away to bring added value to the public	P12 – Social responsibility, public service spirit
Strategy	P9 – TechnologicalStrategy	Replaced by “Political strategypromoting innovation” asinnovation fields should be defined with the political strategy	P13 – Political strategypromoting innovation
	P10 – Networking Strategy	Lexical adjustment in the maturity grid	P14 – Networking Strategy
	P11 – Customer relationship	Added to consider the citizen as a stakeholder of the strategy	P15 – Participative democracy
	P12 – Financing	Adjustment to reflect thestrong financial constraints of the public finance	P16 – Financial strategy
Project management	P13 – Phasing project	Lexical adjustment in the maturity grid	P17 – Phasing project
	P14 – Portfolio management	Lexical adjustment in the maturity grid	P18 – Multi-project management
	P15 – Organization of the innovation tasks	Lexical adjustment in thematurity grid	P19 – Competence management and responsibilities
Knowledge management	P16 – Continuous improvement of the innovation process	kept	P20 – Continuous improvement of the innovation process
	P17 – Intellectualproperty	Replaced by “Innovation value recognition” as public sectorrises projects for common good.	P21 - Innovation valuerecognition
	P18 – Knowledge management	Lexical adjustment in the maturity grid	P22 – Knowledge capitalization and reuse

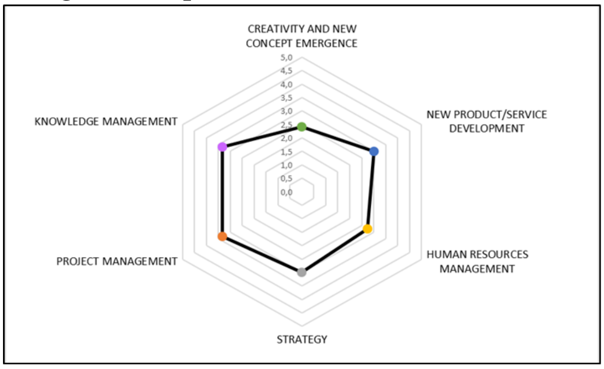
Fig. 3. Modifications of the original PII at the sub-practices level

Phase 4: Experimentation

Implementation: Based on the practices' framework co-constructed with the stakeholders, a specific working session were dedicated to testing this framework within the Nancy administration. For this purpose, a functional prototype was proposed in order to materialize the framework in the form of a questionnaire allowing to build a maturity profile of the evaluated organization. The test was carried out on the perimeter of a public policy. This choice made it possible to adopt an interservice vision while limiting the scope in order to maintain a sufficiently operational vision during the evaluation.

The public policy of the family was therefore designated as the test perimeter of the prototype. The working sessions therefore brought together the following actors around this theme: Director of education service, Director of childhood service, manager of the innovation capacity project, Elected official (Education and Digital Public politic), Project manager (digital service), Prospective manager, Director of digital service, employee of the senior service, Employee of the childhood service, Director of the executive secretariat.

Results: The result of this experimentation phase led to bring to the teams of the Nancy City Hall an operational prototype establishing a common language on what could be the public innovation within their own organization (6 major practices, declined as a set of 21 sub- practices that have all their own maturity grid) -– see the illustrative example of figure 4 – (showing fictious data for confidentiality reasons). This prototype has been tested at the level of a specific public policy but this experimentation paves the way for further experimentation. It appears as a leverage in the continuous improvement way of the administration and support the innovation team recently in place through several potential outcomes: Public innovation evaluation, methodological support for innovative projects, design and experimentations and innovation awareness.



Practices	Sub-Practices
Creativity and new concept emergence	P1 - Creative process
	P2 – Integration of users/citizens
	P3 – Impulse/integration of elected officials
	P4 – Integration of the other partners of the ecosystem
	P5 – Monitoring/information gathering for idea generation
New Service/product development	P6 – Experimentation ability
	P7 – Design methods
	P8 - Resources/material means (tools, equipment, ...)
Human resource management	P8 – Individual stimulation to innovate
	P9 – Internal communication
	P10 – Learning organization
	P11 – Social responsibility, public service spirit
Strategy	P12 – Formalized and shared political strategy
	P13 – Networking Strategy
	P14 – Participative democracy
	P15 – Financial strategy
Project management	P17 – Phasing project
	P18 – multi-project management
	P19 – Competence management and responsibilities
Knowledge management	P20 – Continuous improvement of the innovation process
	P21 – Innovation value recognition
	P22 - Knowledge capitalization and reuse

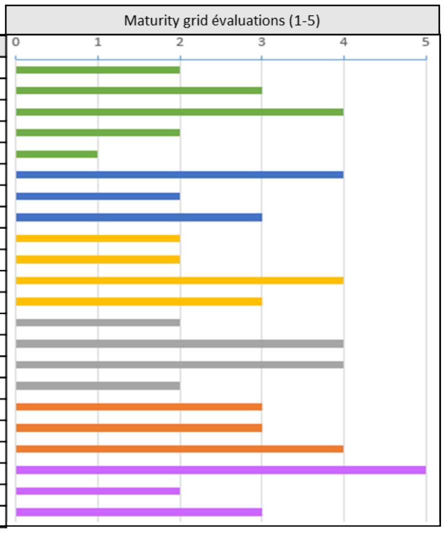


Fig. 4. Illustrative example of the prototype

Phase 5: Evaluation

Implementation: The objective of this last phase is to propose an analysis of the implementation of the evaluation framework of the innovation capacity within the public administration of Nancy. Following a process of adaptation of the Potential Innovation Index reference framework from an industrial application context to a public context, this last phase aims to highlight the specificities of public organizations compared to companies in terms of innovation capacity as well as the particular points of vigilance resulting from the co- construction cycle implemented. Thus, a final working session was held with the manager of the innovation capacity project from the Nancy administration in order to draw working perspectives.

Results: This working session resulted in the identification of several insights. First, this experimentation brings the demonstration that public innovation can be evaluated on the same way as companies, adjusting the lexical field and the set of practices that are the whole component of public service. Some innovation practices appear as very similar to those of companies, in the way they are implemented (project management, knowledge management...) while others appear as really specific in the context of a public service, such as strategy for example. Among the particularities identified, the notion of value, at the heart of the definition of innovation, seems to be addressed in a completely different way. In the case of local public administrations, the financial value is exclusively considered as cost reduction, while an added value relates more to public marketing and communication. Finally, a real difference appears when considering the scope of the evaluation. The perimeters of action are not always the same: in companies, evaluation systems are applied to services or to the whole company (organizational entities), in the case of a city, global politic fields or even projects themselves may also be considered (strategic entities).

Conclusions

This study contributes to the elaboration of an evaluation approach to assess innovation management within city administrations. Based on a framework initially designed for private organizations, a Living lab approach was carried out within a city administration, in order to identify how the best innovation practices are implemented in the specific context of municipal administrations. Some are strictly specific to the governance of urban innovation, such as participatory democracy or the development of a public service spirit. Others may correspond to best practices in companies and the private sector, as project or knowledge management, but both the literature and the empirical confrontation with stakeholders attest to certain specificities in the way they are carried out.

The decision to conduct practices' co-construction workshops with the various stakeholders following a Living Lab approach is the main contribution of our research work. We implemented an action research approach integrating both a multi-stakeholder mobilization and user and end-user involvement. Furthermore, we mobilized a multi-method approach that lead to the co-creation of a new PII framework, dedicated to public administration and relying on empirical observations and stakeholders from the field.

This paper reports intermediate results obtained from one local administration in Nancy (France), but the panel of public administrations associated with this theme aims to become much larger. Several case studies in public administration are planned in order to confront our framework with various empirical contexts using a constructivist approach.

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Innovation function resourcing: balancing external and internal sources

Abstract ID#312

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Purpose

This paper's research question is: How do strategic innovation projects, in large companies, manage to get access to resources from the mainstream organization?

We consider strategic innovation projects as projects surrounded by substantial levels of uncertainty, which differentiates them from incremental innovation projects, more focused in risk management. The existence of such levels of uncertainty demands differentiated capabilities in comparison with current operation ones, justifying the specialization of a specific organizational function to manage strategic innovation projects (O'CONNOR et. al., 2018). In this article, we name this type of function as an innovation function, distinct from traditional R&D because it is able to deal equally with both technological and market uncertainties. However, these functions often do not have all the resources necessary for the development of projects of this nature, having to resort to the parent company to access them. These resources go beyond financial, also encompassing physical resources, human resources and knowledge (information and know-how). In particular, this situation includes innovation projects that, in addition to being strategic, are also considered adjacent. Such projects, at the same time that, in technological or market terms, diverge from the existing product lines of the parent company, in some of these dimensions, also converge with the base of existing resources, increasing the economic bias in sharing them.

Literature Review

Managing risks and uncertainties in innovation projects belong to such different logics that the existence of a differentiated structure to deal with strategic innovation projects is justified. However, such a choice implies in the challenge of integrating these specialized structures with the parent company, especially with regard to resources access. While some theoretical streams argue in favor of a full resource duplication (CHRISTENSEN, 1997), the economic viability of such decision, especially for adjacent projects, is questionable. The challenge of accessing resources outside the structure dedicated to the project is, to some extent, also experienced in teams dedicated to managing incremental innovation projects. However, in these cases, matrix structures were developed to formalize lateral communication and allow the necessary level of integration between the project team and the operational areas (GALBRAITH, 1973). However, the challenges of such an integration for strategic innovation projects are different due to the mutually incompatible logics between exploitation (in operation) and exploration (in the innovation function).

Such a challenge in the flow of resources between the parent company and strategic innovation projects are very well described in the literature. Some theories seek to understand the problem of resources access based on the characteristics of each individual's social networks, bringing the discussion to the individual dimension and simultaneously encompassing formal and informal aspects of the company (BURT, 1992). However, solutions "in the organizational level" to overcome it, are poorly described (SALERNO et. al., 2022).

Methodological Procedures

We addressed the research problem through inductive, interpretive and longitudinal qualitative methodology, following the phenomenological tradition and based on grounded theory (GIOIA et al., 2013), with the aim of promoting an in-depth analysis of the phenomenon within the specific organizational context of our single case. Our case is a multinational company whose main product line is embedded in the automotive supply chain and whose main generic competition strategy is cost leadership. This company's innovation function emerged approximately 1 year ago, the same period in which we started to follow the evolution of strategic innovation projects in the company, especially adjacent ones, managed by the area. We collected research data through interviews, carried out both with members of the innovation function and with members of the operational areas that served as an interface with the parent company to enable resources negotiation. Respondents belonged to different hierarchical levels, such as top management, middle management and operational management. We followed 3 projects and had 17 interviews with an average duration of approximately 1 hour each.

Findings

The necessary connections between the innovation function and the mainstream organization were carried out without any problems, relying on the operational management existent social network or through new connections made by the middle management, without the need of formalization. However, this resource flow was limited to resources that would be inimitable outside the company, such as specific knowledge of the production process or the productive capacity of specific components. Even when there were very well-established resources in the parent organization (technological expertise or laboratories), the choice of the innovation function was to temporarily duplicate these resources by accessing them via external research partners. This option was made, however, in the view of the expectation of budget availability for partnerships and the identification of government incentives that would reduce the financial barriers of this choice.

Implications

The research illuminates the interrelationship between different types of resources needed for adjacent strategic innovation projects, depending on the availability of internal access to each of them. In the case studied, the expectation of financial support from the company, as well as public subsidies, supported decisions to temporarily duplicate physical, human and knowledge resources via external partnerships, reducing the need of internal negotiation for them to be shared between newstream and mainstream company. This demonstrates how managers of the innovation function can balance access to internal and external resources, in order not only to make their projects viable, but also to have greater autonomy and control over their developments.

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SERVICE INNOVATION I

May 2nd: 3h10 pm – 5h pm

Chair

Lia Hasenclever (Cândido Mendes University and Federal University of Rio de Janeiro, Brazil)

Papers

Transformation or destruction? The potential effects of digital transformation on value co-destruction of digital services

Darci Borba, Amarolinda Klein

The cashless town: A service ecosystemic approach for understanding mobile banking diffusion of innovations in a rural community

Juan Tavera-Mesias, Aaron van Clayton

Investigating service innovation of e-commerce platform: The case studies

Chia-Hui Yu, Yi-Ning Huang, Feng-Shang Wu

New business models in industry 4.0: An analysis from the value cycle of smart service providers

Marco Antonio de Araujo Ventura, Dimária Silva e Meirelles

Transformation or destruction? The potential effects of digital transformation on value co-destruction of digital services

Abstract ID#169

Darci de Borba, Amarolinda Klein (University of Vale do Rio dos Sinos)

Purpose

Digital Transformation (TD) has a recognized ability to generate opportunities, while its challenges affect individuals, organizations, ecosystems, andsociety (Dąbrowska et al. 2022). TD contributes to the creation or changes in business models and their generated value. It involves the emergence of customer networks, business platforms, data as value assets, increasingly rapid innovation and radical adaptations or changes in value propositions (Verhoef et al. 2021). The literature on value creation and destruction assumes that value in services is created or destroyed in collaboration with the customer, thus, relationships result in Value Co-Creation (VCC) and/or Value Co-Destruction (VCD). The main lens that analyzes the effects of VCC and VCD is Service-dominant Logic (Echeverri and Skålén 2011; Vargo and Lusch 2004). Based on this lens, our research question is: How can Digital Transformation initiatives influence the co-destruction of value in digital services? A systematic literature review was carried out to map the main authors and references on the subject, categorize the main related elements and propose a theoretical framework that demonstrates DT mechanisms that can generate VCD.

Literature Review

DT is a change in the way organizations uses digital technologies to develop new or improved business models that help to create and appropriate more value for the company. DT is multidisciplinary in nature, as it involves changes in strategy, structure, IT infrastructure, supply chains and marketing (Verhoef et al. 2021). DT is focused on the transformation of business models, products, processes, organizational and sociotechnical aspects related to new technologies (Matt et al., 2015). DT effects on business dynamics can be analyzed in five dimensions: customers, competition, data, innovation, value and finance (Rogers 2017; Verhoef et al. 2021). Value is understood through the lens of Service-dominant Logic (SDL) as a result of interaction between providers and customers, through the integration of resources and exchange of services (Vargo and Lusch2004). However, the same interactions, practices, and resources that can generate VCC can result in VCD. VCD is an interactive process between provider and customer that, based on the value proposition and influenced by resources and practices, results in a reduction in perceived value (Echeverri and Skålén 2011; Grönroos and Voima 2013).

Methodological Procedures

The method used was systematic literature review (RSL). The research objective in this phase was to explore VCD in the context of DT. However, as research with this specific focus is still incipient, articles from related research on SDL and VCC were sought to help in the broad understanding of the theoretical lens and its nuances. The research procedures were: 1) project: definition of search terms, databases, inclusion and exclusion criteria; 2) conduction: in May 2022, a systematic search for articles was carried out in the Web of Science, Scopus and Proquest repositories for sample construction, was not publication time range limit and the selection procedure of articles was through title and abstract, scope of research after reading full article and impact of the journal or document; 3) analysis: definition of research questions to guide the search for information, coding of excerpts, classification of findings and writing of analyses; and 4) structure and write the review:

statement of the purpose of the review, writing of the report with the findings and manifestation of the review's contribution. The selected 63 articles were read in full after removal of duplication and out-of-scope material out of a total of 143 articles.

Findings

The data suggest that VCD results from the interaction between providers and customers, during the value creation process that is guided by the provider's value proposition and the customer's value in use. By possessing operating and operated resources (Grönroos and Voima 2013), and exercising practices directly or indirectly related to the provision of services, providers and customers imbricated in the context of DT act cooperatively to create and/or destroy value. The result of this creation or destruction is appropriated to the service provided, consolidating the perception of value of the digital service in the market. The starting point for considering the CCV or CDV is the value proposition prior to the TD because, in this way, it is possible to understand what effect the TD had on the perceived value of the service. Some of the sources of value destruction related to TD are: use of AI in the service and provision of digital services; use of customers' own resources, such as devices and network connections; lack of customer skills in the use of digital technologies; practices of the very provision of services that cause frustration; and the value destruction built into the value proposition during the transition to digital service.

Implications

The work contributed to elucidate risks of VCD related to DT and help managers and researchers to better understand this phenomenon and prevent the destruction of value that, depending on the magnitude, can affect the entire economy of a sector. The limitation of the study is related to the research scope/search string. Future studies could propose a scale to measure the VCD potential of a service in the context of DT.

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The cashless town: a service ecosystemic approach for understanding mobile banking diffusion of innovations in a rural community

Abstract ID#203

Juan Tavera-Mesias (University of Antiquia); Aaron Van Klyton (Kean University)

Purpose

This paper studies the case of Concepción, Colombia, a small rural municipality that was chosen by a bank to carry out a cashless society pilot through the implementation of a mobile banking platform and its promotion in the locality. A first proposed aim was to ensure that for one day all purchase and sale transactions in the municipality were carried out digitally through the application called Daviplata. An innovative proposal with radical characteristics, given that Concepción did not have bank branches, an ATM to withdraw money, truly little experience with financial products and even less with those mediated by technology. They branded the town as the first cashless society.

How to understand the ecosystem processes of diffusion of mobile banking innovations for financial inclusion in rural communities? What factors are deciding factors for mobile banking in its diffusion and what are its barriers in rural contexts? Answering these questions was the main aim of the case study that is presented.

Literature Review

The processes of diffusion of innovation in rural communities stand for an important study context for emerging countries (van Klyton et al., 2020). Rural populations tend to be poorer, with fewer possibilities for digital inclusion and with less access to offers of goods and services aimed at their particularities (Chitungo & Munongo, 2013).

In addition, technology and innovations can be the most cost-efficient way to solve the gaps in economic, financial, and technological inclusion, however, individuals in this context have less preparation for the use of technology and less experience with it (Tavera-Mesias et al., 2021; Zhu et al., 2022).

Service ecosystems (Akaka & Vargo, 2015; Chandler & Vargo, 2011) can be a suitable framework for the study of innovation ecosystems in rural communities, since it recognizes, in addition to the normal interactions between a supplier and a demander around an innovative value proposition, there are other actors with whom they develop interactions that facilitate the mutual exchange of services at levels or layers that indirectly affect the interactions between the innovative agent and the user of the innovation (Vargo et al., 2017). A service ecosystem integrates actors and resources as an aggregated social entity that, in time, supplies meaning to the interactions that occur repeatedly between actors (Vargo et al., 2017).

This approach to innovation ecosystems favors the understanding of institutionalization as a phenomenon that affects the establishment of relationships between community actors and that can favor or disfavor the diffusion of innovations (Akaka & Vargo, 2014; Vargo et al., 2015). Little has been written about it in academic literature despite its relevance in terms of development for vulnerable communities and the academic understanding of this type of phenomenon.

Methodological Procedures

A qualitative study was executed for exploring and comprehending the innovation diffusion of Daviplata, a mobile banking application around which a service ecosystem was structured. We developed a mix of methods for approaching the municipality case. We developed 30 semi-structured interviews with merchants, mobile banking application users, local government representatives, bank representatives, and other relevant actors of the community. We also developed participant observation and semiotics analysis, which helped the approach to the study phenomenon and thus allowed the development of complementary theories to understand banking innovations in rural territories.

Findings

Among the determining factors to favor the innovation diffusion process, the linking of the local government, the overlapping of new practices around mobile banking, reinforcing traditional rural consumption as an institution, the use of young people and children as innovative pioneers and the ecosystemic vision stand out. initial investment that the bank had and its impact on the potential value proposed by the banking initiative. Among the barriers to the process, the non-permanence of an educational strategy, the simultaneous coexistence of institutional processes that came into contradiction (the intention to institutionalize digital money, and traditional rural consumption as an established institution) and the lack of commitment of the national government to the digital initiative

Implications

The conclusions that emerge from this case focus on the need for more time to accompany the strategic support activities that support mobile banking initiatives, the relevance of service ecosystems as a framework for understanding an innovative ecosystem around banking mobile in rurality, the understanding of the proposed value as the result of the aggregation of valuable exchanges between ecosystem actors and the relationship between the potential value that a service ecosystem can propose in mobile banking and the real value experienced by end users of the ecosystem.

This article is an original approach to the study of banking innovations in rural communities and supplies an understanding of the particularities that can appear in diffusion of innovations in these types of communities. The value proposals associated with banking services that are mediated through technology must consider the enabling factors and the barriers that may arise in the social dynamics of rurality.

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Investigating service innovation of e-commerce platform: The case studies

Abstract ID#209

Chia-Hui Yu (National Taipei University of Business); Yi-Ning Huang, Feng-Shang Wu (National Chengchi University)

Purpose

The previous research focused more on platform strategies and business models, seldom discussed how a platform company introduces service innovation to their users, especially not for an e-commerce platform. Therefore, this study aims to shift the focus from the platform itself to the process and the factor of a platform company's service innovation through the observation of network effects and platform mechanism, as well as the induction of a new service development process and six-dimensional model of service innovation.

Literature Review

Service Innovation: Voss (1992) proposed the development process of new services, including: (1) concept development and analysis, (2) service prototype development, (3) service prototype testing, and (4) innovative service implementation. Then, Den Hertog et al. (2010) proposed a representative and highly complete theory of service innovation delivery system: (1) New Service Concept (2) New Customer Interaction. (3) New Business Partners (4) New Revenue Models (5) New Delivery System (6) New Delivery System (Den Hertog & Bilderbeek, 1999).

E-commerce Platform: Osterwalder and Pigneur (2012) gave a clear definition that a platform is a medium for connecting and gathering at least two different but interdependent customer groups, and they also emphasized that the key to the operation of a platform is that "it must attract and serve all its customers at the same time. Then, customer groups can create value". This means that the value of a platform to a specific customer group depends on the number of customer groups on the other side. Therefore, successful platform design should have three indispensable functions of "Pull", "Facilitate", and "Match", but each function does not necessarily need to have the same strength. Eisenmann et al. (2006) believed in the existence of cross-side network effects. The value of the platform to users depends on the number of users on the other side. Hence, network effects can be subdivided into four types: Positive Same Side Network Effects, Negative Same Side Network Effects, Positive Cross-Side Network Effects, and Negative Cross-side Network Effects (Parker et al., 2016).

Business Model: Osterwalder and Pigneur (2012) defined a business model includes nine major elements: (1) Target Segments; (2) Value Proposition; (3) Channel; (4) Customer Relationships; (5) Revenue Streams; (6) Key Resources; (7) Key Activities; (8) Key Partnerships; (9) Cost Structure.

To sum up, this study found the gaps that scholars rarely examined e-commerce platforms from the perspective of service innovation, and seldom explored the influencing factors of service innovation in e-commerce platforms.

Methodological Procedures

The study aims to explore the impact of the e-commerce characteristics and the platform operations on service innovation in e-commerce platform companies. Therefore, we use a multiple case study approach with semi-structured interviews as the research method. We select two Taiwanese e-commerce platforms of M and S companies with representative industries as the case study samples. We judge the indicators of management performance including the turnover and profit rate, as well as customer-related data such as average monthly page views and APP rankings. Then, we propose the research framework as follows.

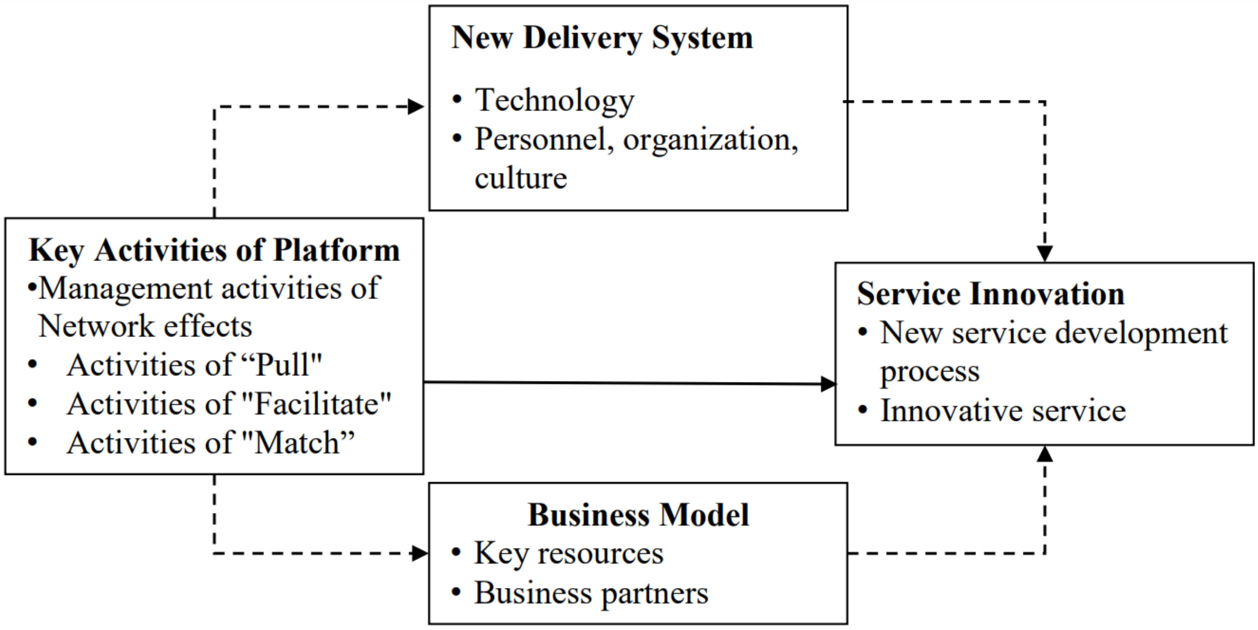

Figure 1 Research Framework

Conclusions

The major conclusions of this research include:

1. The money side of an e-commerce platform is the merchants, while the subsidy side is the consumers and the merchants with growth potential. For the merchants with growth potential, an e-commerce platform will provide formal training programs or informal counseling to support their growth and enhance the positive same-side network effect.

2. For the consumers, an e-commerce platform will provide new services, new customer interactions, and content to enhance the platform's attractiveness and reduce the subsidies.

3. For the money side, an e-commerce platform will provide new revenue models and user interactions, as well as the operation of hierarchy and substantial exclusivity in order to reduce the negative same-side network effect; moreover, it will intervene in transactions between the users for quality control.

4. When an e-commerce platform develops service innovation, it will enhance the effectiveness of innovation through observing externally related industries, connecting with partners, building an internal organizational culture that encourages innovation, effective resources consideration with organizational goals, and through frequent cross-departmental coordination and communication.

Contributions

We provide several contributions as follows.

Contribution 1: This research especially combines the platform theory and service innovation conceptions to discuss, and the research results extend the research scope of platform theory and service innovation theory at the same time.

Contribution 2: Previous literature has emphasized that network effects are only affected by the "quantity" of users, but this study found that the network effects of e-commerce platforms are affected by both the "quantity" and "quality" of users.

Contribution 3: Previous literature emphasized that platforms only provide a medium for merchants and customers to exchange or communicate. However, this study finds that ecommerce platforms also play the role of "content providers".

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New business models in industry 4.0: An analysis from the value cycle of smart service providers

Abstract ID#262 | Full Paper ID#428

Marco Antonio Araujo Ventura, Dimária Silva e Merelles (Mackenzie Presbiterian University, BR)

Abstract: Industry 4.0 is a concept from the last decade that reflects the combination of severaltrends in countries that lead the technological frontier, such as Cyber-Physical Systems and Artificial Intelligence. Together with Big Data and the Internet of Things (IoT), these technologies generate value for industrial activities, mainly from greater productivity, speed and efficiency in decision making. At the same time, companies face challenges when dealingwith new technologies, requiring the support of support services, with a high degree of digitalization, called smart services. However, smart service providers face significant challenges in structuring their business models, especially as we are at an early stage of contouring the industry's architecture. The objective of this paper is to understand how these companies are structuring their business models from the analysis of value creation, configuration and appropriation strategies.
Keywords: Industry 4.0, Smart Service Providers, Value Creation, Value Configuration, Value Appropriation

Introduction

Industry 4.0 is a concept from the last decade that reflects the combination of several trends in countries that lead the technological frontier, encompassing different activities and tools (Lasi et al, 2014), such as Cyber-Physical Systems and Artificial Intelligence (Zhong et al., 2017; Wang et al., 2016; Lee et al., 2014). Together with Big Data and the Internet of Things (IoT), these technologies generate value for industrial activities, mainly from greater productivity, speed and efficiency in decision making (Frank, Dalenogare, Ayala, 2019). For this reason, Industry 4.0 is also known as high value-added manufacturing processes (Lee et al., 2017) or high value-added services and products (Wang et al., 2020; Verdejo, 2016).

Companies face challenges when dealing with new technologies require the support of services with a high degree of digitalization, called smart services (Frank et al., 2019). However, smart service providers face significant challenges in structuring their business models, especially as we are at an early stage of contouring the industry's architecture. These are companies that are in the early stages of the value cycle of their business models (Silva e Meirelles, 2019), where there are an intense process of search and learning, be it from the perspective of value creation, configuration or appropriation (Teece, 2010; Osterwalder & Pigneur, 2010).

The question that guides the research is: how these companies are structuring their business models? The objective is to identify the value creation, configuration and appropriation strategies of their business models and to what extent they have already a well- defined business models.

The contribution of the paper is both from the theoretical and practical perspective. From a theoretical point of view, the analysis of the structure of a business model based on the value cycle provides a dynamic view suitable for contexts of changes in technological paradigms (Silva e Meirelles, 2021). We are facing what Jacobides, Knudsen and Augier, (2006) call a new industry architecture. The result of this new ecosystem of technologies, products and services is increased added value, both for companies and consumers and the public sector.

From a practical point of view, by focusing on intelligent service providers, this paper contributes to supporting the digital transformation process of companies, whether from the point of view of strategic changes or public policy. In research carried out by Project I-2027 (IEL, 2018) it was found that 36.8% of companies in Brazil are in a late stage of automation and that 38.8% had digital systems installed only for some functions (some monitored lines by PCPs, non-integrated management and control modules), that is, 75.6% of our industry is still far from the 4.0 paradigm and had not even completely mastered the stage of lean production.

Theoretical Background

Technology Use from Industry 4.0: scope and functionality

Industry 4.0 collectively refers to a wide range of concepts, without a clear classification against a discipline or a precise distinction: Smart Factory, Cyber-physical Systems, self- organization, new distribution and purchasing systems, new systems of development of products and services, adaptation to human needs and corporate social responsibility (Lasi et al., 2014)

Defined as smart manufacturing, it consists of delivering an intelligent product, where customer information and data are integrated into the production system.

Basically, the technologies that support Industry 4,0 are Artificial Intelligence, IoT, Big Data and Machine Learning. Artificial Intelligence is human intelligence displayed by mechanisms or software. It is one of the most recent fields of engineering and "has many definitions linked to process approaches. of thought and reasoning or behavior" (Norvig, 2013). IoT is the utilization of smart devices like sensors for enhancing manufacturing and industrial processes and "leverages the power of real-time analytics and smart machines and takes advantage of the data that machines have generated" (Bali, 2022 p. 10).

In turn, as stated Bali (2022 p. 16): "big data generated in IoT gives practical information concerning decision making and provides insight into the improvisation of functions". Finally, "Machine learning algorithms, associated with a sub-field called deep learning, provide computers with the ability to make predictions or recognize patterns in complex data" Bali (2022 p. 74).

Together, these technologies provide value creation for industrial activities, above all from greater productivity, speed and efficiency in decision making. For this reason, Industry 4.0 is also known as high-value-added manufacturing processes, generating high-value-added services and products (Dalenogare et al., 2018).

According to Frank et al (2019), it is possible to visualize a subdivision of technologies related to smart manufacturing into six main purposes: (i) vertical integration, (ii) virtualization, (iii) automation, (iv) traceability, (v) flexibility and (vi) energy management. There is a varied set of technologies for each of these purposes (Table 1).

Vertical Integration in Industry 4.0 consists of the integration and interoperability of information (Xu, Xu, Li, 2018) by modern sensors and software that allow remote control and planning of industrial process (Patnaik, 2020). It includes not only machine to machine communication, an evolution of the former concept of telemetry (Bali et al, 2022), but also and the whole activities of manufacturing planning, operation and execution system (Misra et. al, 2021). Other functions, such as virtualization, automation and flexibility, involve mainly robotics, artificial intelligence and 3D (design software and printing).

Table 1. Smart Manufacturing Technologies and Functions

Function	Smart Manufacturing Technologies
Vertical Integration	Supervise Control and Data Acquisition (SCADA) Manufacturing Execution System (MES) Material Requirement Planning (MRP) Enterprise Resource Planning (ERP) Machine to Marchine communication (M2M)
Virtualization (planning and prediction)	Virtual Commissioning Simulation and Modelling Machine Learning and Artificial Intelligence
Automation	Robots (industrial robots, autonomous vehicles, etc.)
Traceability (Inputs and final products)	Sensors, actuators, and programmable logic controllers (PLC)
Flexibility (Additive manufacturing)	3D printing and design software
Energy Management	Monitoring system Smart grids

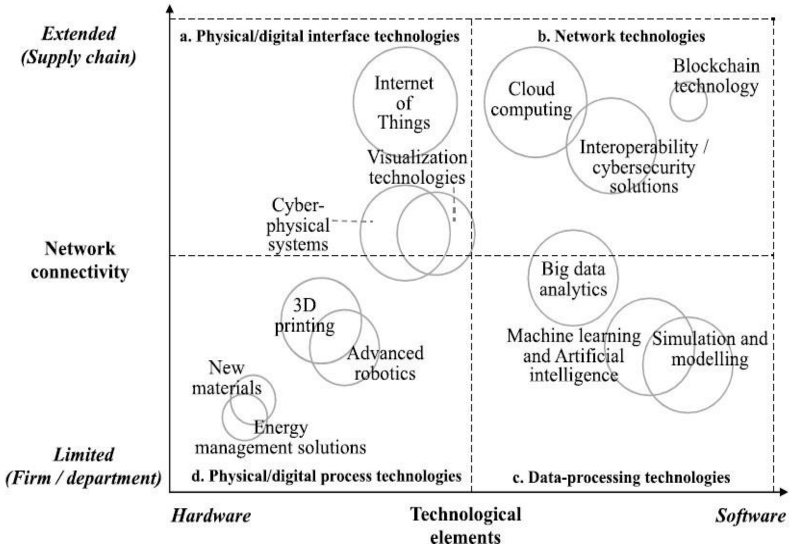
Source: adapted from Frank, Dalenogare Ayala (2019)

Seeking to map the technological components of Industry 4.0, Culot et al., (2020) proposed a classification according to predominance in hardware or software and degree of connectivity. An application of technologies (hardware or software) ranges from an isolated unit, such as a department or company, to a more extended business concept, that is, an entire supply chain. As shown in Figure 1 below, the first level (quadrant d) includes technologies focused on hardware and low network connectivity. These are local technology processes, more tangible, but which in recent years have become increasingly intertwined with digital technologies: 3D Printers, New Materials, Advanced Robotics, and energy management solutions. As this hardware increase connectivity, extending to the entire production chain, we find visualization technologies, the internet of things, and cyber-physical systems in general (quadrant a).

In the group of software technologies, which support the analysis of data and information for control and decision-making, there are those with low network connectivity (quadrant c), such as big data, machine learning and artificial intelligence, and modeling/simulation. High connectivity technologies, that is, network technologies (quadrant b) are those that provide online functionality, such as cloud computing, Blockchain technology, and interoperability/cybersecurity solutions.

Figure 1 - Industry 4.0 enabling technologies according to technical elements and network connectivity (bubble size proportional to the number of occurrences in the examined definitions).

Source: Culot et al (2020, p. 7)



Smart service providers are par excellence users of Industry 4.0 technologies, whether from the point of view of process technologies and physical/digital interfaces, as well as network technologies and data processing. As presented next, the different uses of Industry 4.0 technologies by smart service providers, as well as the different relationships with customers, involve different degrees of complexity in business implementation (Frank et al, 2019).

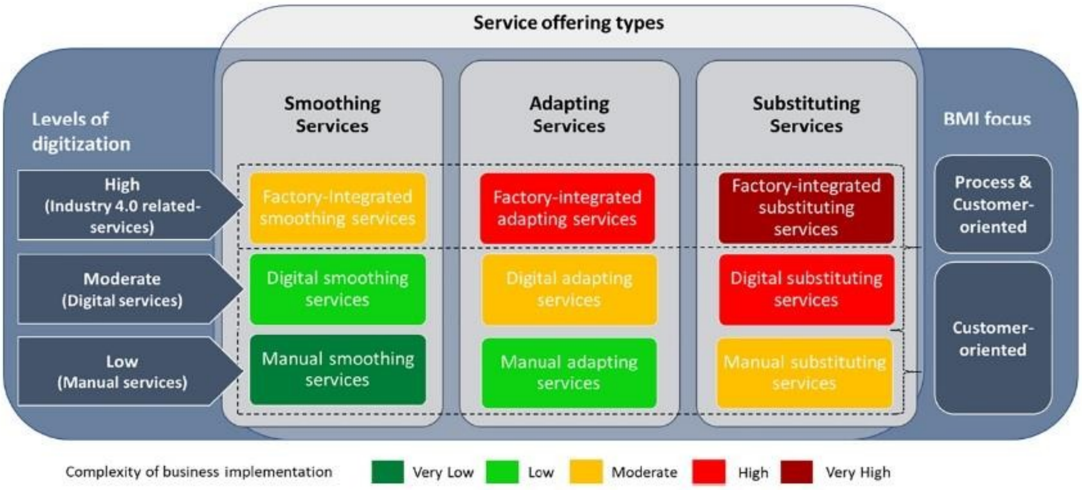
Smart Services' Business Model Structuration: an approach from the value cycleperspective

The business model describes how the company creates and delivers value to customers and then converts incoming payments into profit. However, it is a conceptual, hypothetical device that describes how the company reaches the market (Teece, 2010). Finding the ideal business model is not an easy task, especially when it comes to disruptive businesses, such as those smart services linked to Industry 4.0.

Business model structuration involves three strategic decisions: value creation, value configuration and value appropriation (Silva e Meirelles, 2019). Value creation is defined the composition of products or services offered, the customers segments selected, and the resources and partners needed to support the value preposition.

According to Frank et al (2019), there are three service offerings to Industry 4.0: support, adaptation, or replacement. In each of these modalities, there are varying degrees of digitalization and complexity of business implementation, resulting in different business models, whether oriented only to customers or to processes and customers (Figure 2). The first group includes services with a moderate and low degree of digitization (manual services). The second group is the one with an elevated level of digitalization, these are services effectively related to Industry 4.0, all involving high complexity of business implementation, both from the point of view of the use of technology and industrial integration.

Figure 2 - Conceptual framework for servitization and Industry 4.0 convergence



Source: Frank et al., (2019 p. 345)

As presented next in Figure 3, value creation in Industry 4.0 includes the gains and benefits offered, both from an economic point of view, as well as from a knowledge, market, and strategic point of view. Together these aspects result in increased market share; reduction of the innovation period; individualization/customization; product and production flexibility; mitigation of risks and uncertainty; decentralization of the decision-making process and efficiency, which includes both mechanization and automation as well as digitization and miniaturization (Lasi et al., 2014).

Value configuration is defined by the way activities are organized and how internal processes relationship with suppliers and customers. It includes a set of strategic decisions carried out in the configuration of value chain activities, as well as aspects of the governance structure of assets and the negotiation of internal negotiation of organizational structures, constituting a fundamental aspect of business models (Silva e Meirelles, 2019, p. 794).

In the specific context of smart service providers, the broader the integration of the technologies related to Industry 4.0, the greater the need to define a governance structure and mechanisms for internal coordination of organizational structures. These aspects of value configuration act in the value appropriation to allow an efficient and effective performance, especially in innovation efforts.

The value configuration decisions operate in the appropriation of the value, in order to allow an efficient and effective performance. Value appropriation is defined by the strategic positioning regarding prices, innovation and growth, in a dynamic perspective of value cycle renewing. Together These tree processes compose a continuous cycle of value. An evaluation of the strategic positioning directs future formats of products and processes to satisfy the dynamic goals of customers during the user experience, accompanying the evolution of the technology and the own perception that it has of the product/service.

The strategic decisions crucial to value appropriation are the definition of organizational limits most fitted to protect innovation from imitation and maximize results (Silva e Meirelles, 2019). Some aspects of the value configuration in Industry 4.0 can be understood from horizontal integration strategies across the value creation network, end-to-end engineering, throughout the product lifecycle, as well as vertical integration and network manufacturing (Stock & Selinger, 2016 p. 537).

However, smart service providers are part of the Industry 4.0 architecture, which is in a typical stage of a new configuration of the industry's architecture (Jacobides; Knudsen; Augier, 2006). At this stage, companies can create an architectural advantage, that is, they explore value appropriation without the need to engage in vertical integration (Jacobides; Knudsen; Augier, 2006). So, the profit of these companies' innovation depends on the creation of an architectural advantage, that is, the important thing is to be present in an articulated network of partnerships that signals consistent growth in the future. When a company has an architectural advantage, it can afford not to worry about protecting or investing in complementary assets (Teece, 1986). Instead, it should focus on maintaining its edge by staying in one part of the production process (or assets) while increasing mobility in the other part. The objective becomes to increase complementarity and mobility in parts of the value chain where companies are not active (Jacobides; Knudsen; Augier, 2006).

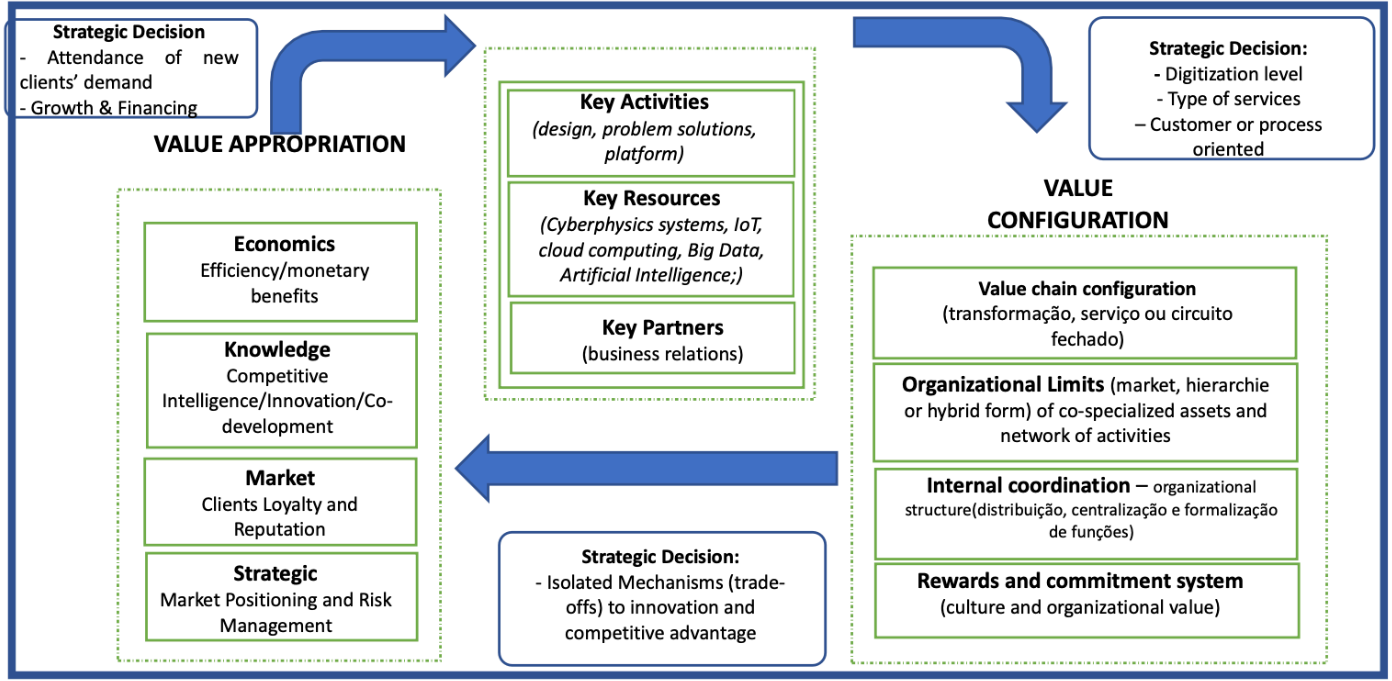
So, here in this paper, we adopt three propositions regarding each process of value creation, configuration and appropriation of smart service providers business model:

Proposition 1: Value creation is defined by the way companies use and develop the technologies and activities of Industry 4.0, expressed in the degree of digitalization, and customization of the services provided.

Proposition 2: Value configuration is defined by the way in which the smart service providers are articulated with the activities of the Industry 4.0 production chain.

Proposition 3: Value appropriation is defined by how the company will secure an architectural advantage in Industry 4.0.

Figure 3: Value Cycle of Smart Services Business Model Structuration



Methodological Procedures

This is qualitative research, based on the collection of primary data via a semi- structured interview script. At first, a specific branch of Industry 4.0 was not selected, since there are diversified experiences in other sectors, from the financial sector, agriculture, pharmaceuticals, automobiles, etc. Based on the analysis of enabling technologies observed on companies' websites, such as Artificial Intelligence, IoT, big data, and other disruptive technologies, 124 companies were initially identified with the potential to be interviewed. Of this total, seven were available for the interview phase (Table 2). The interviewers were owners, CEOs, Founding Partners, or Directors of Technology, mostly engineers, masters, or doctors, with extensive experience in the Industry 4.0 market, consulting, and projects.

Table 2 - Smart service providers

Company	Services	Total Employees	Annual Revenue	Number of clients	Age
Telefônica TEC	IoT and Big Data to agribusiness sector (solution to equipment, soil, clime, irrigation and transport)	27	2 million	11	10 months
iCubics	Consultancy to smart cities, health and environment, residential automation and IoT (sensor to collect information and monitor)	1	1 million	4	2 years
StackX	Training to Industry 4.0 (inspired in Lambda School)	19	500 thousand	250	2 years
Infinity	Modelling and Simulation	10 (Brazil) and 6 (Portugal)	2 and a half million to 3 million	20 - 25	5 years
SUIV	Autotech (smart register)	9	3.2 million	22	6 years
LSI-TEC	Project Consultancy (hardware, software and firmware)	15	-	5	23 years
IPFacens	Technological Institute	500	25 million	550	45 years

The interview script followed the dimensions of value creation, configuration and appropriation in the business model structuration, as presented before in the conceptual model here proposed (Figure 3). We used content analysis technique (Bardin 2009), to identify the categories that emerged from each aspect of the value process. First, we organized data (tabulation) that reduction (a single phase) and then categorization (two or more words).

Results

The value creation strategies developed by each smart service provider were analyzed based on the following categories: opportunity explored, products and services offered, customer segments served, product/process orientation, attributes desired by Industry 4.0, and form of service integration. As shown in Table 3, the companies here studied provide replacement services in factory integration and mostly are process and customer-oriented, operating in the categories of vertical integration, virtualization, automation, and traceability. Most of them are companies with an elevated level of digitization. Customers of smart service providers seek on the one hand, efficiency in processes and economic efficiency and, on the other hand, in the field of technology for decision-making, they seek connectivity, integration, innovation, big data monitoring in real-time, assertiveness in information, virtualization, and creation of scenarios, in addition to the potential provided by technology.

From the perspective of value configuration (Table 4), the following categories were analyzed: activity stream; application of technologies in departments; support activities; feedback on the service provided; partnerships; partners for application of advanced technologies; organizational structure; inventories and receivables; Supplier quality; service improvement information.

The companies here studied provide different degrees of complexity in their service supply chain and are structured in different ways to better apply technology. The activity flows are more complex in two companies (IPFacen and TelefonicaTEC), while in two others it is more concise (SIV and LSI-TEC). In two companies there is a medium complexity (Infinity and iCubics) and in StackX it depends on the customer's need, remaining undefined.

The application of technologies presents different aspects, being focused on the 8 R&D centers of IPFacens, on a single component of the company in iCubics, or on a specific sector, linked to data, in the others. Only one company, LSI-TEC, is verticalized, the others have support areas linked to support and Marketing activities. There are several ways to get feedback on the service provided.

For the most part, such companies seek partnerships to complement some expertise and enhance their ability to offer more advanced services. Several partner profiles were pointed out, the partnership procedure being very necessary to meet demands that are beyond the scope of the service offered or to complement internal needs areas of IT. With the exception of SUIV- Unified Vehicle Information System, which performs the service by itself, and Infinity, which tends to verticalize, all other companies frequently seek partnerships. Eventually, they were partners for specific technologies or, as in the case of Telefonica TEC, through partnership contracts coordinated by the headquarters.

Considering the diversity of possible projects to be attended to and the size of the client portfolio, these companies assume structures that range from the most hierarchical, with several divisions, to those supported by a single professional. There is a distinct flexibility in the feedback processes, characteristic of startups in their early stages, as well as in the processes linked to quality assessment by customers. Companies like SUIV see the possibility of achieving absolute integration with their customers through cloud computing and investment in big data, with the support of artificial intelligence, expanding their service beyond offering just one platform.

Technology applications were left to more technical departments and more informal feedback, with some presence of meetings or specific software. When monitoring supplier quality and internal processes, as well as information about partners, an informal process usually prevails, with companies very focused on customer feedback. None of the companies have inventories or receivables.

Finally, the appropriation of value (Table 5) was analyzed through the following categories: pricing and profit, growth rate, potential customers, new technologies / markets, competition, innovation and patents, abandoned opportunities, how the company is seen.

Price is defined by project or contracted module, specially through measuring man- hours. The companies LSI-TEC and IPFacens, TelefonicaTEC are focused on costs, StackX, on the customer's perception, and the other companies are based on hours worked on each project.

Most companies present high rates in addition to the search for new potential markets. SUIV's growth rate is around 150% and iCubics is 10%, while at the other extreme, TelefonicaTEC, the youngest company, is between 18% and 25%. The others show an average of 30% to 50%, and LSI-TEC is waiting for the market reaction and all claimed to have had difficulties during the pandemic period. However, profits are reinvested, There are a variety of options for potential customers, as well as ways to seek new technologies in new markets, with the exception of SUIV, which operates in a niche where the market owns it and it offers the platform. The competition is also very diversified in the performance of each company and, regarding the strategic level (innovation), most do not generate patents, only, eventually, the brand or the solution, and IPFacen has a patent office and TelefonicaTEC directs them for ANATEL. Only IPFacens and TelefonicaTEC did not abandon any opportunity, while the others voluntarily or involuntarily did so in their past.

The last dimension of value appropriation, how companies are seen, we identified that most of them are well regarded for several positive reasons, being references in their respective niches. The exception is TelefonicaTEC, who is not yet well defined in the market because, since it is still seen as a telephony company, VIVO's heritage.

Table 3 – Dimensions of Value Creation of Smart Service Providers Business Model

	Dimensions	Telefônica TEC	iCubics	StackX	Infinity	SUIV	LSI-TEC	IPFacens
Opportunity (product/services offered); customers	**Initial idea**	Telecommunications company	Master's project	Adaptation of training to the market	Society (Brazil and Portugal)	dificulties with Vehicle information	Technological Institute of USP	Research of the Institute
	Business Orientation	Process	Product	Process and Product	Process and Product	Product	Process and Product	Process and Product
	Benefits	Economic Efficiency	Costs and efficiency	Machine integration	Integration	Registration and cleaning information	connectivity and big data monitoring	virtualization and scene creation
	Service Integration	Production	Process analyses and evaluation	Consultancy	Total integration with product and process	Total integration with product and process	Manufacturing integration	Consultancy
Key resources and physical, intellectual, financial and human inputs	**Digitization Level**	100%	100%	10%	100%	100%	100%	100%
	Technological Resources	100%Machine learning, big data, AI	Sensing, AI	Cloud Integration	All technologies of Industry 4.0	Big data and cloud computing, by API	Platform and others tools of Industry 4.0	8 Technological Centers
	Human Resources	Engineers	Engineers	Masters and PhD (various)	Diverse	Technology and Data	Engineering (Masters and PhD)	Masters and PhD
	Needed skills	-	Business vision	Not offered in the market	Digital game experience and Engineering	APIs Customization	AI improvement	Student vision
key partners	**Partners**	Three suppliers (companies and startups)	Small companies	billing and contact	Hardware suppliers	Automobile supply chain	Manufacturing, Hardware and Cloud	Diverse
	Service Coordination	Contracts	By Project	Technology related	Service buying	Automation of adherence to machine components	Intermediation and link	Permanent suppliers

Table 4 – Dimensions of Value Configuration of Smart Service Providers Business Model

	Dimensions	Telefônica TEC	iCubics	StackX	Infinity	SUIV	LSI-TEC	IPFacens
Value Chain Activities	**activity stream**	complex	medium complexity	depends on the customer	medium complexity	more concise	more concise	more complex
	application of technologies in departments	Digital products team	sole member	Information Technology	R&D is the center	*big data*	data-base and Sync	8 innovation centers
	Support Activities	legal and marketing	outsourced finance; own marketing and sales, network	commercial, marketing, commercial, administrative, support and academic	Administration, Finance and Marketing	technical support and marketing	horizontal structure	*Shared Services*
	feedback on the service provided	Meetings	indication by the customer	*Net promoter score*	Design, networking tools	service audit	platform or communication tools	by Software
organizational limits	**seeks partnerships**	Often	yes	yes	tendency to verticalize, except hardware	acts alone	Cloud, AWS, and Manufacturing	yes
	partners for application of advanced technologies	supplier with own tool	AI Partners	integration of drawings, products and items	indicated by customers	direct with the customer	Industry 4.0	by *software* (NIMB)
Internal Coordination	**organizational structure**	hierarchical	Single component of the company	three divisions	100% horizontal	three partners	independent business units	Executive Board, a CEO and three verticals
	inventories and receivables	no	no	no	no	no	no	no
Servitization Activities	**Supplier quality**	There's no way to keep up	project management	depends a lot on suppliers	trust relationship	by algorithms	informal	informal process
	service improvement information	*customer feedback*	events	conversation with customers	customer controlled	system	direct customer feedback	*Project sprints*

Table 5 – Dimensions of Value Appropriation of Smart Service Providers Business Model

	Dimensions	Telefônica TEC	iCubics	StackX	Infinity	SUIV	LSI-TEC	IPFacens
Economic	**pricing and profit**	costs	time/consultancy	customer perception	working hours and square meter	contract/requisitions	man/hour and reinvested profit	man/hour Profit is reinvested
	growth rate	From 18% to 25%	100% year	30%	From 30% to 35%	From 120% to 150%	waiting for market reaction	From 30% to 50%
Strategic	**potential customers**	BDM	Small and medium-sized industries	B2B, big companies	depends on the market	automotive chain	whatever comes from the market	market gaps
	new technologies / markets	agribusiness forums	Health, Smart Cities, Industries	global market demand	scale the supply chain of automakers	market owns	edge of technology	freedom to climb
	competition	Other telecommunications companies	Small tech consultants	work on the Lambda School model	scanning companies	insurance company data-base	ICTs	other ICTs
Strategic	**innovation / patents**	yes (ANATEL)	There is not	in progress: brand	no (patent solutions)	Do not. Brand registration.	no	patent office
	abandoned opportunities	no	Agribusiness	do not do initial filter	sports, smart cities and other	popular insurance automation	not having the platform as a service from the beginning	no
	how the company is seen	phone company	Small and depends on the owner	reference in the region	well regarded in both countries	automotive data-base specialist	reference for being linked to USP	Reference in the region

Discussion

The question that guided our research was: how smart service providers are structuring their business models?

The analysis has contemplated three declared propositions. First, regarding value creation. We proposed that value creation of smart service providers is based on the degree of digitization and customization of the services provided, with reference to the technologies and activities that support the creation of intelligent systems and Cyber Physical Systems.

It was observed that the origins of the companies interviewed in this research are diverse. While some are closer to technology retail than to Industry 4.0, as they migrated from sectors more linked to hardware and, opportunely, started offering automation infrastructure and offering services in projects for the autonomy of cyber-physical systems, others, migrated from sectors more connected to software and are looking to retail for a partnership to consolidate their position as intelligent providers.

As observed, there is a convergence toward Industry 4.0, reiterating central aspects of this paper, since emerging technologies can generate value for industrial activities and create a scenario industry, empowered by the internet of things (IoT), cloud computing, big data and artificial intelligence.

From the point of view of services offered, the field research suggested that there is an effort by service providers to offer a high added value service, oriented towards the client's process or product, however, clients are still becoming aware of the economic, knowledge, market and possible strategies. High technological content has not yet been explored. Customers' "pains", shared by respondents in the process of proposing the service, are usually understood through an initial consultation, suggesting that Industry 4.0 customers often have problems and doubts that even they cannot explain.

Parallel to the irreversible trend of products being transformed into services, customers being transformed into users, audiences being transformed into communities and markets being transformed into networks, we realize that technologies such as "digital twins", through virtual commissioning and gamification, they are migrating factory models to the metaverse and creating a new dimension of industrial plant simulation, reducing costs, and increasing efficiency.

While engineers with great knowledge of high technology seek sensors in digital retail for projects in different areas, such as health, smart cities and sensing, large higher education institutions invest in technological centers, which add the generation of disruptive knowledge to the potential of specialized laboratories.

In this scenario, companies in the telecommunications area are repositioning themselves to offer services related to agribusiness, while opening the market for professionals who integrate the offer of different services as platform with the possibility of strategic partnerships in technology. Some others adapt their functionalities to integrated customer service or take advantage of new teaching models, focused on software demanded by Industry 4.0.

Regarding value configuration, we proposed that this process is defined by the way in which the smart service providers are articulated with the activities of the Industry 4.0 production chain. The integration of the different enabling technologies predominantly begins with the capture of data by sensors. This data is stored in the cloud and, through big data and data mining tools, is used as information for service projects by providers, through Artificial Intelligence and machine learning solutions.

Finally, we proposed that the value appropriation is defined by architectural advantage in Industry 4.0. The interviewed companies usually create partnerships to obtain some support to meet specific demands and add value to products, in addition to composing the product/service mix, as presented in the servitization approaches.

Conclusions

The main conclusion of this research is that the business models of smart service providers here studied are not yet completed. The companies are in the initial phase of the value cycle, where there is an intense process of search and learning. There is a search for a business model that is more suited to the complexities of the markets and the diversity of disruptive technologies, dynamically integrated by Artificial Intelligence, IoT and big data, as analyzed, given the immaturity of an industry incipient and fluidity of concepts in this ecosystem.

So, these startups circumvent their limitations and are making the best possible use of opportunities, trying to make the market more aware of the potential value of their services and closer to the technological reality of more developed countries. Despite the State agendas, government programs, development institutes and various bodies, the challenge is to grow in a sector that is still at the frontier and that requires remapping and redesigning processes. However, some of them present well-defined value creation and configuration strategies, with a clear value proposition.

In order to promote further improvements of research, future studies of companies at different stages of business model development should be engaged.

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SUSTAINABLE DEVELOPMENT II

May 2nd: 3h10 pm – 5h pm

Chair

Daiane Neutzling (University of Fortaleza, Brazil)

Papers

Analysis of the differences in the levels of regional development with a sustainable sense from an adaptive complex systems approach

Diego Andres Carreño, Walter Lugo Ruiz

Sustainable procurement contribution to the UNSDGS

Raji Sivaraman, Breno Nunes, Donato Mais

Mission-oriented policy approach for innovation and diffusion of low-carbon hydrogen technologies

Vanessa de Lima Avanci, Yohanna Juk, Karen E F Pinto

Competitiveness and environmental performance: A stalemate?

Karen E F Pinto, Carolina Cristina Fernandes, Felipe M Borini

Social business ecosystems: Stakeholder engagement in social environmental impact

Daiane Neutzling, Keysa Manuela Cunha de Mascena, Lucas Lopes Ferreira de Souza

Analysis of the differences in the levels of regional development with a sustainable sense from an adaptive complex systems approachs

Abstract ID#166 | Full paper ID#457

Diego Andres Carreño, Walter Lugo Ruiz (National University of Colombia)

Abstract: The research proposal aims to identify the causes of the differences between the levels of development of the regions for the case of Colombia, with a view from the complex adaptive systems, looking for those elements that are still to be identified and related, with the purpose of expanding the understanding and interpretation of this phenomenon, while identifying new tools and instruments in order to better understand the phenomenon of sustainable regional development.
Keywords: Regional sustainable development – Complex adaptable Systems

Introduction

In the last three decades, phenomena such as globalization and neoliberal policies of free competition and the market, as well as a marked tendency to decrease the size of the state (Useche Arévalo, 2002), have caused Colombia to face complex situations of an economic, political And social; Within the socioeconomic context, one of the most evident problems is the inequity in the distribution of income per inhabitant, usually measured with the GINI coefficient, with the national total for the year 2021 being 0.544 (DANE, 2021), indicating a one of the highest inequality rates in the world, also finding that monetary poverty was 42.5% and extreme monetary poverty was 15.1% of the national total.

In addition to inequality, our country has environmental and climate change challenges; an armed conflict that has been going on for more than 60 years and that continues today despite the peace agreements signed with ex-combatants of the FARC; high levels of corruption and little trust of citizens in institutions (Acclab, 2021), added to the above, in Colombia we find social and cultural diversities, thus increasing the degree of difficulty in the analysis of the phenomenon of inequality (Moncayo Jiménez, 2003); Faced with this panorama, it is a challenge to identify and characterize its causes, which is why a specialized and unconventional approach is required to analyze this complexity.

For (Coccia, 2018), regional disparities can generate poverty, unemployment, social problems, income inequality, violent crime and underdevelopment; for (Barcenas, 2016), inequality is a historical and structural characteristic of Latin American and Caribbean societies, which has been maintained and reproduced even in periods of growth and economic prosperity; (Manet, 2014), states that although economic growth is a fundamental factor for poverty reduction, inequality can significantly limit this process; Complementing the above, we find the work of Capello and Nijkamp (2019), who mention that regional differences can have significant negative consequences on socioeconomic costs, this is due to non-transfers of social welfare, to inefficient production systems, given by a misallocation of resources and undesirable social conditions.

Given the above, (Capello, 2006) highlights that after more than half a century of theoretical developments in Regional Economics studies, the main trend has been towards theoretical development at the regional level, called regional development. This trend arises from the need to introduce greater realism into the approaches, which are sometimes conceptually abstract (Merchand, 2007);In this sense, regional economic theory tries to respond to the causes of the existence of regional disparities in economic development and within this theory as an alternative analysis, we find Regional

Development (Pike et al., 2020), whose main The objectives, according to Coccia (2019), are to reduce regional disparities within countries, to support a general development of nations as a complete system.

In this sense, the theory of Sustainable Regional Development broadens the interpretative panorama and configures new academic challenges since, by incorporating the issue of caring for the environment, as recognized by authors such as Jovovic et al (2017) and Balanzo et al. (2020), tensions inherent to regional development arise between economic growth, social inequality and environmental sustainability; In the context of Sustainable Regional Development, Barreneche (2017) mentions that the concept of sustainable regional development includes the interactions between complex systems, the world economy, global society and the physical environment of the earth and its governance.

However, for Uriona and Grobbelaar (2017), an alternative way of analysis is to use approaches based on simulation to study complex social and economic phenomena; For Naudé (2012), from the point of view of the analysis of adaptive complex systems, sustainable Regional development is an adaptive and complex social system that evolves, changes and produces emergent behaviors in an unpredictable way, where an alternative to the analysis of the approach Traditional is to use a complex adaptive systems approach.

In this sense, the research proposal described here aims to identify the causes of the differences between the levels of development of the regions in the case of Colombia, with a look from the complex adaptable systems, looking for those aspects that still need to be identified and related, with the purpose of expanding the understanding and interpretation of this phenomenon, while identifying new tools and instruments in order to better understand the phenomenon of sustainable regional development.

Theoretical Background

The theory of regional development with a focus on institutional policies, is in charge of analyzing the reasons why some regions grow and prosper, while others lag behind and even decline (Dawkins, 2003); In reviewing the literature on regional development, the following questions are frequently found: How do regions grow and develop? Why do some regions grow and develop faster than others? and Why are the differences in levels of economic and social well-being between regions so persistent? (Dhimitri, Aida, & BELLO, 2015; Feldman & Storper, 2018; Galvis-Aponte, Galvis-Larios, & Hahn-de-Castro, 2017; Merchand, 2007).

These questions have attracted the attention of a diverse group of academics over the last fifty years (Capello, 2006), leaving questions to be resolved and approaches that help answer them. The topic of regional development, initially it was of interest only to economists and geographers, is now being investigated by sociologists, political scientists and researchers from other disciplines (Buchholz & Bathelt, 2021); This growing interest in regional development studies is partly due to the persistence of inequalities in the levels of development of the regions and the recognition that the processes that drive innovation and national economic growth are fundamentally of a spatial, geographic or regional (Pike et al., 2020).

Since welfare positions between regions generally show large differences that often remain over time, it is especially important to measure regional development (Nijkamp & Abreu, 2020). The measurement of regional development is not static in nature, but refers to the complex spatio-temporal dynamics of regions, changing regional welfare positions are often difficult to measure, for this reason, gross domestic product is used (GDP) per capita as a statistical approximation (Nijkamp & Poot, 1998), alternative or complementary measures are also used, such as per capita consumption, poverty rates, unemployment rates, labor force participation rates or the access to public services and the human development index (IDH), (Cárdenas & Michel, 2018); these indicators are more social in nature and are often used in OECD and United Nations welfare comparisons (Barreneche, 2017).

In this sense, the measurement of the different socioeconomic conditions of each region creates implications for the scope of government intervention in each different area. This difference in the level of development between regions gives rise to differences in the level of well-being between regions, if this occurs will have an unfavorable impact for a country (Putri & Salahudin, 2021). Now, if economic development is left to the power of the market mechanism that normally tends to widen and not even reduce the inequality that occurs between regions, economic activities will accumulate in certain places and regions, while others will be left behind. (Merchand, 2007).

Regional development is presented as an economic and social complexity; however, recently with the urgent pressure of environmental destruction, scientists and politicians have started working to find solutions for sustainable development (Jovovic et al., 2017), for this reason, the trend in regional studies in recent years focuses on research that covers not only economic performance, but also the social, political and environmental dimensions, which influence at the regional level (Rocha, Kunc, & Audretsch, 2020), in this sense by including the environmental aspect in regional development, the concept of sustainable regional development is configured, integrating the environmental, economic and social dimensions, this implies the implementation of complementary and coordinated actions in different areas, that is, economic development to achieve objectives without endangering the planet's scarce resources (Jovovic et al., 2017).

Theoretical advances related to sustainable regional development have had configurations that have refined and modeled this concept; In the work of Ingaramo, Bianchi, and Vivenza (2009), he mentions that in the economic field, when an alternative theory appears that seems to explain and, therefore, predict the consequences of the facts and actions under study with a greater degree of certainty , the previous theory is usually abandoned for a while and often is taken up again. The above situation is not alien to regional development, where theories, schools and practices overlap and show their advantages, defects, limits and possibilities; For Capello and Nijkamp (2019), this trend in theoretical evolution is justified by the constant need to expand the interpretative capacity of theoretical instruments in this field of research, seeking theories and instruments that better reflect the real world and thus improve accuracy. in interventions.

In the work of Cárdenas and Michel (2018), mention is made that economic growth is only one element of development, that is, development is seen from a more comprehensive perspective, since it is not only economic, but also human and with an environmental aspect; In this sense, growth theories and development theories differ, since the vision of development is broader and integrates quantitative and qualitative variables.

Regional development includes various categories and factors, from economic and social to cultural and ecological, some authors who have dealt with the subject (Capello, 2006; Nijkamp & Poot, 1998; Rodríguez-Pose, 2009), among many others, coincide and complement each other in the definition of sustainable development as: The will and determination to provide a constant improvement in the quality of life of current generations, preserving the appropriate relationships between three types of capital: economic capital, human capital and natural capital, for Cvetanovic, Filipovic, and Nikolic (2015) regional development means the process of initiating, structuring and achieving sustainable development, taking into account the complex regional characteristics, through the use of appropriate instruments and measures. This and many other definitions coincide in the claim to integrate economic, social and environmental objectives to achieve the general objective, which is to improve the living conditions of current generations, while allowing future growth.

Regional development in the current context is at a critical juncture, with multiple crises (financial, food and energy) that force us to reassess the economic (Wei, 2015); In this sense, the work of (Silva-Rincon et al. (2021), comments that it is necessary to evaluate how to better address the unfulfilled promises that currently have been left for the future in the areas of employment, social progress, quality of life and respect for nature, related to sustainable regional development. In this sense, the purpose of regional development theory is to analyze how to reduce regional disparities within countries to support a general development of nations as a complete system (Coccia, 2019).

In the work of Uriona and Grobbelaar (2017), the strengths of using simulation-based approaches to study complex social and economic phenomena, such as innovation, regional development and industrial districts, among many other studied phenomena, are highlighted. Faced with this reality, it is possible to develop a convincing model that includes the microterritorial, micro-behavioral and intangible elements of the regional development process (Capello, 2006) and that gives a close response or broadens the analytical and argumentative heritage to the problem of disparities or inequalities in regional development.

The persistence of inequalities in the level of development of the regions in Colombia and in the world; even after more than 5 decades of theoretical evolution in the field of regional economy (Capello, 2019), as well as caring for nature and guaranteeing the provision of resources for future generations, are the objectives studied by theories of economics. regional development (Huggins & Thompson, 2013); however, it is still necessary to understand the dynamics of the economic, social and environmental dimensions of the phenomenon of regional development.

This understanding, analysis and interpretation of reality can be achieved from an alternative and complementary approach (Pejic Bach, Tustanovski, Ip, Yung, & Roblek, 2020), which is why an approach is proposed that takes into account the perspective of theory of sustainable regional development and, also, from the perspective of the theory of adaptable complex systems; frameworks that can offer an alternative analysis and interpretation that provide an opportunity to increase understanding of reality and facilitate a novel approach to the phenomenon, which is reflected in the differences in the levels of sustainable development between regions.

In this sense, the theory of adaptive complex systems since its creation at the Santa Fe Institute and with the intention of being applied to economic systems (Arthur, 2018) and social systems (Gomes, 2012), has rapidly gained space in various domains, ranging from environmental policy and management, with the works of Fiddaman (2002) and Turner (2008), accounting and finance (Cui, Hastak, Halpin, Shehata, & Warren, 2010), urban planning (Forrester, 2003), political economy (Radzicki, 2011), just to name a few among many others found in different bibliographic sources.

Methodological Procedures

In this section it is intended to link the economic study from the regional level with a look from the adaptable complex systems; Under this look, we seek to classify the systems in which global behavior depends more on the interactions between the parts than on the actions (Holland, 2006), there are some examples of these systems, mainly in economics, computing, biology, sociology etc

Now, this theoretical framework tries to shed light on how the study of the regional can be approached with a transdisciplinary approach that integrates knowledge from various fields of science; For Merchand (2007), this can be achieved through the approaches that come from the general theory of systems, and the theory of chaos, which seem to surpass all the previous methodologies that in the past have tried to explain the region. as a whole phenomenon.

There is a growing interest in developing innovative, creative and new ways of understanding Sustainable Development by approaching it holistically and integratedly. For Naudé (2012), sustainable regional development can be defined as an adaptive and complex social system that evolves, changes and produces emergent behaviors unpredictably; therefore, for Neely (2015), an alternative to the traditional analysis of economic systems is to use an adaptable complex systems approach, having a multidimensional perspective, they can include political, economic, social, technological, cultural and physical aspects, which influence each other. each other and as a result change their environment; according to Levin et al. (2013), these interrelationships and interdependencies of adaptive complex systems are characterized by continuous change and development, which are dynamic frameworks that provide a better understanding of the phenomenon, which can reveal alternative solutions to adequately address this phenomenon.

In this sense, for Neely (2015), the adaptive complex systems theory approach has been acquiring increasing recognition by the main currents of development policies and management, in his work he examines the correlations existing between development theory and the theory of adaptive complex systems; an approach that is also found in the work of Beaussier, Caurla, Bellon-Maurel, and Loiseau (2019), where it is emphasized that during the last 20 years, the use of tools developed mainly outside the traditional economic field, such as theories of Complex adaptive systems have gained credibility and importance in the modeling of socioeconomic phenomena, highlighting the ability of these models to provide exhaustive and quantitative information to policy makers for decision making.

By linking the concepts of the analysis of sustainable regional development and complex adaptable systems, the present proposal takes into account the methodologies developed in both fields. In the case of simulation models oriented to economic analysis, there is the work of Radzicki (2011, p. 730-731) where three main ways in which system dynamics have been used for economic models are presented.

- The first involves translating an existing economic model into system dynamics.
- The second way involves creating a model from scratch following the rules and guidelines of the system dynamics paradigm.
- The third way that system dynamics can be used for economic modeling is a "hybrid" approach in which a known economic model is translated into system dynamics, the model is critiqued, and then improved to make it more closely related. to the principles of modeling in system dynamics. This approach tries to combine the advantages of the first two approaches, although it is more closely related to the first.

In the case of the proposal, the first form is taken as a reference, in this sense, a review of the models of sustainable regional development that have been developed is made and its suitability will be determined compared to the ease of modeling and the variables it includes and the information sources.

As a complement to the previous approach and in the case of complex systems of tools developed for the analysis of economic and social phenomena, as is the case of the levels of development of the regions; there is the work of ten Broeke and Tobi (2021), their work shows a methodology to develop research projects with an adaptable complex systems approach, where system dynamics is found, which is applied to a wide variety of problems. in a multitude of academic disciplines; specifically for the case of economic models (Homutinin, 2014).

Results

In some of the works found specifically in the context of statistical analysis of regional development, GDP per capita and its changes over time are often used (Capello & Nijkamp, 2019; Cárdenas & Michel, 2018; Coccia, 2019; Filenta & Kydros, 2022; Rojas-Rivera & Rengifo-López, 2021), for Nijkamp and Abreu (2020) the change in prosperity is not easy to measure and alternatively, indices such as per capita consumption, the poverty rate , the unemployment rate, the labor force participation rate or access to public services, that is, social indicators that allow comparisons between states and regions, these indicators will be the basis for the development of the model that is intended to be developed in the present proposal.

Now answering the question of the analysis of regional development, by means of complex adaptable systems and of the total works of the reviewed databases, 24 works were found in Scopus, 10 in Web of science and 4 in Elsevier. Of the works found that have dealt with regional development with a sustainable character associated with the principles of complex adaptable systems, in the bibliographical review various works were found that deal with the subject, however those that had the greatest coincidence in the search are mentioned.

Works were found with Neural Networks, in (Churikanova & Lysenko, 2021) and (Shi et al., 2019), with Fuzzy Logic, (Shevchenko, 2021), with Agent-Based Simulation (Sebestyén & Varga, 2019) and (Bakhtizin, Nizamutdinov, & Oreshnikov, 2019), System Dynamics (Nieto et al, 2016) and (Lektauers, 2015), just to highlight some.

In previous works found, a large number of elements that have been used in the analysis of the regional economy that are taken from the framework of complex adaptable systems can be unraveled, the common component stands out, a clear orientation towards the analysis, of how generates an improvement in the quality of life in social and regional communities, which depends on the increase in prosperity tending to care for the environment.

Complementary to the above, it was found that, in the works found there are methodologies to select indicators of the existing levels of regional development, as well as to design and determine them, in some of these works there are indices that are related to economic, social and environmental factors. It is noteworthy that in these models in many cases the effects of implementing policies aimed at strengthening and improving the levels of regional development are analyzed, which are studied in different scenarios; This reveals the relationships between regional development indices and the design or formulation of public policies, in which case the models are tools that could support a better analysis of reality, facilitating decision-making.

In the reviewed papers, the indicators that have been taken into account to measure the levels of regional development are presented, however, a clear exploration is not made regarding the description of the relationships and interdependencies of the elements considered to integrate regional development. sustainable; on the other hand, the validating element of the models is not of significant relevance. In this sense, the focus of this proposal is mainly oriented towards the analysis of the causes of inequalities in the levels of sustainable regional development.

Within the review developed and as a complement to the above, there are the works of Moulaert and Mehmood (2010), who recognize the need to link regional economic analysis and the design of better regional policies, using methods and techniques based on information technology. In Harmaakorpi (2007), a description is made of the development of a technological platform or computational model to analyze regional development, in order to assess the regional potential to be sustainable and competitive and thus build a competitive advantage.

There is evidence that the models developed from this perspective have provided numerous insights for the analysis of regional policies; however, there are still many other models to be developed, especially in the regional aspect, including models, input-output and econometric models and also including the environmental aspect (Wheat, 2014); Considering that these models are of an open type, where different attributes can be found in the economic agents, they can easily become a tool for the analysis of regional economic development, and within this analysis, determine the origin of the disparities between regions (Munir Ahmad & Alaskari, 2014). Partridge et al. (2010), make a recommendation on the need to include the time variable in the models, since this situation has probably contributed to the fact that its use in the analysis of regional economic development policies has been limited; They complement on the need to design a model with empirical evidence that includes the relevant components of the policy and the structure of the region under study and the analysis of the differences between the regions and their sustainable performance.

It is worth noting, the work of modeling the regional economic dynamics with a systemic orientation developed by Wheat and Pawluczuk (2014), in this work it is demonstrated, how the knowledge-generating characteristics of a static input-output economic model can be structurally integrated with a system dynamics simulation model, the purpose of said integration is to add value to the regional economic modeling, it is analyzed how the restrictions inherent to the traditional static model can be overcome in a dynamic model. The static condition of the input-output model arises from the assumptions of fixed technology, fi combinations

Discussion

Even though more than 50 years have passed in the formal development of regional development analysis and after a theoretical and conceptual advance in which authors such as Paul Romer, Paul Krugman, Amartya Sen and Jean Tyrole, all Nobel Prize winners in Economics and many other authors and scientists who have been interested in the issue of inequalities in the levels of regional development; this reality has been maintained over the years and in some cases with a tendency to make a greater difference; In this sense and to increase the degree of complexity in the analysis, the world is experiencing climate change that becomes evident every day and that has been caused in part by the depredation of natural resources, it is pertinent to adopt alternative visions of analysis that allow identify elements that perhaps have not been taken into account and can probably promote the development of the regions with a sustainable character, so that from the adaptable complex systems, tools have been developed that can give these novel, alternative, systemic and complex visions.

Conclusions

A Within what can be concluded from the research work carried out up to now, the scarce development of works that are in charge of analyzing the phenomenon of sustainable regional development under an adaptable complex systems approach, in the review of the databases, is striking. data shows little progress in the investigation of the subject of consultation in Latin America; Of the 424 papers reviewed as a result of the search equation, in the 3 databases consulted, 9 research papers that integrate the query topic are reported.

However, the growing interest coincides in the last 5 years in the analysis of regional development using techniques and methodologies outside the economic spheres, this accounts for the interdisciplinarity of the research topic given by the multiplicity of areas that address it from engineering through computer science and social and human sciences.

The tendency to use regional per capita GDP as the first measure of regional development and later indicators of per capita consumption, poverty rate, unemployment rate, labor force participation rate or access to public services stands out, however, in recent works of less than 5 years, other indices of a social nature have begun to be associated, among the most used is the human development index (IDH).

Although relatively frequently there are works that mention the integration of social, political, economic, cultural and environmental elements within sustainable regional development, no inquiry has been made about the cultural aspects that could influence the behavior of regional development...

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Sustainable procurement contribution to the UNSDGs
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Abstract: This research investigates how the stakeholder relationships impact sustainable procurement (SP) decisions and their alignment to the United Nations Sustainable Development Goals (UNSDGs). Currently there is a lack of comprehensive understanding on the roles and influences of stakeholders on the SP practices and how those contribute towards the UNSDGs and are impacted by them. This research addresses the gap in the literature through a case study approach. In interviews with senior managers of two large multinational companies, the role of stakeholders such as suppliers, buyers, business units, NGOs, governments, customers, and end users were discussed as well as the impact of UNSDGs on sustainable procurement practices. The originality and value of this paper resides on how SP contributes to the UNSDGs. Further data analysis will be performed through the lens of the institution logic theory.
Keywords: Sustainable Procurement (SP), United Nations Sustainable Development Goals (UNSDGs), Stakeholder influences

Introduction

Sustainable development (SD) aids in seeking an equilibrium between achieving the social wants and protecting the environment (Olawumi and Chan, 2018). Combining business goals with SD with scalability (Chakravorti, 2017) to address SD, the stakeholder interactions for small, medium and big infrastructure projects make a difference to protect the environment and human distress stemming from them (Duchin, 2017). But the SD definition that still holds true used in this study, is from the Brundtland Commission report of 1987 "to meet the needs and aspirations of the present without compromising the ability to meet those of the future". The Brundtland Report is also called the World Commission on Environment and Development (WCED).

Various explanations of what SD involves; and how strategic management is key to advancing the influences of firms on SD has been discussed (van Zanten and van Tulder, 2021). There are several SD problems that needs to be solved (Dos Santos et al., 2019) and there is a deficiency in the comprehension and knowledge of the ecological ruin among the society at large and the business population (Kumar et al., 2021).

To simplify these issues, the UNSDGs were formed. Seventeen SD goals (shown in Figure 1) were adopted by the United Nations in 2015 as a universal call to action, to end poverty, protect the planet, and ensure that by 2030 everyone enjoy peace and prosperity. But with less than a decade left, this research aimed to find out the contributions of SP in firms aligned with the UNSDGs.

Source: United Nations Development Programme website
Figure 1 – UNSDGs

Today, sustainability takes a pivotal role with supply chains when combined with managing businesses (Bag et al., 2018). Larger companies have the capacity to integrate sustainable supply chain management (SSCM) more than the smaller companies as the partner relationships and resources enable this (Zhou et al., 2020). Besides the size, selection of technology impacts suppliers and sub suppliers (Lalwani et al., 2018). Yet another perspective is that the distributions of the UNSDGs is more prudent than tackling the triple bottom line (TBL) (Silva and Figueiredo, 2020). Therefore, in this research more emphasis was given to the UNSDGs.

Various definitions are written about SSCM, but the following definition is chosen for this research as it is still valid to this date. “The chain-wide consideration of issues beyond the narrow economic, technical and legal requirements of the supply chain to accomplish social (and environmental) benefits along with the traditional economic gains which every member in that supply chain seeks” (Spence and Bourlakis, 2009). This definition of SSCM gives a broader perspective of its influences beyond the technical and legal requirements. These correlate well into the objective and the scope of this study.

Many definitions for procurement exist, but this research used the definition, “procurement activity is specified and defined as the activity of an enterprise with competent suppliers for purchasing goods and proving services necessary to meet the effective demand of ultimate consumers of products, the success of which is based on building relations with suppliers that can ensure the improvement of the results of business activities, conditions and the expected effects of cooperation” (Iastremska, 2018). This definition goes further than the enterprise-wide activity of buying goods. The author explains that procurement includes demand building, business relationships and the acquisition of the necessary resources to orchestrate the buying activities. This compels us to look at the interaction among internal and external stakeholders, the community, and the procurement activities’ resultants.

There are many SP definitions found in literature (Meehan and Bryde, 2011), (Aghili et al., 2019), (Walker et al., 2012b), ISO 20400:2017 and others. Different countries in the Organisation for Economic Co-operation and Development (OECD) have different definitions for SP (Walker et al., 2012a). But for this research the definition used is; “while green procurement involves the environment, SP involves a lot more that can definitely be tied to the SDGs” (Sönnichsen and Clement, 2020). Furthermore, there are many companies that are using the UNSDGs targets and indicators to inform stakeholders about the existence of the UNSDGs and are including them in their communications. But the question remains whether and how stakeholders influenced SP and if SP is aligned to the UNSDGs?

Luthra et al. (2017) talk about the various criterion of selecting sustainable suppliers. But it is easily said than done due to barriers that exist (Fritz, 2019). The author has further linked each of the

UNSDGs to SSCM as it is scalable globally. This entails trade-offs, but how can good trade-off decisions be made by stakeholders (Lemaire and Limbourg, 2019)? This prompts the question of finding the appropriate inputs for SP (Walker and Brammer, 2012). A detailed understanding into the SSCM stakeholder roles, and their management is needed to analyse their practices (Siems and Seuring, 2021) as firms are swayed by different categories of stakeholders having very distinct roles when it comes to SP (Song et al., 2017).

When aligning SP to the UNSDGs, many lower-tier providers are not familiar with the firms at large, and thereby not noticed enough to feel the stakeholder pressures such as NGOs and media (Villena and Gioia, 2020). Moreover, stakeholders' objectives frequently overlying each other, resulting in trade-offs (Montabon et al., 2016). When looking into the firms' intricacies and stakeholders' engagements, there may be an overlapping of social and commercial relationships where varied styles are employed (Pullman et al., 2018). This point is considered as well when implementing SP.

As such, a gap is evident showing complex stakeholder interactions which are not clarified yet in the scientific literature as there are several stakeholder relationships that can influence SP in firms, and the contribution to the UNSDGS. Therefore, the research questions (RQ) for this research are

RQ 1 - How do stakeholders influence sustainable procurement?

RQ 2 - How does sustainable procurement align with the UNSDGs?

A qualitative methodology using semi-structure interviews and a case study approach is used for this research. Contribution to unexplored stakeholders whose support are sought by the procurement department who influence the SP activities aligned to the UNSDGs, have emerged from the empirical results in the discussion section.

The next section presents the theoretical background on sustainable procurement and on the role of stakeholders for sustainable procurement.

Theoretical Background

Sustainable Procurement

Procurement processes often include trade-offs as substitute resolutions underscoring other attributes that may be more beneficial (Byggeth and Hochschorner, 2006). The authors emphasize that the decisions to support the alternatives should include social sustainability in addition to the sustainable ecology. Stephen and Helen (2011) write about sustainable supply chain actions to be looked into in a holistic way where the environmental and social aspects are combined especially in SP, but note that there is a deficiency of SP understanding and implementation capabilities. Different sectors have to deal with SP differently within their particular needs of the procurement aspects and can only do as much as the senior management commitment allows (Walker and Brammer, 2009). Another complexity that arises is that the actors in SP may have competing objectives (Häkkinen and Belloni, 2011).

One way to mitigate these issues is by using sustainable suppliers to compete with the current suppliers in use which would allow the activities to move from the micro to macro level, paving the way for a long-term vision as well (Pagell et al., 2010). Another way is to raise awareness about SP with comprehensibility of information availability (Häkkinen and Belloni, 2011). To lessen these gaps of SP knowledge, collaborations and partnerships between suppliers, buyers and the end users are crucial (Witjes and Lozano, 2016). SP can also assist to investigate the business dynamics, and companies' platforms that need to be ready or scalable to connect member companies as well. Then, the question is – can rivals work together for advancing sustainability (Sharma and Bansal, 2020)?

Some of the drivers highlighted by Govindan et al. (2021) are that even though firms may have increased their spend to become sustainable, they may be driven towards becoming greener to avoid paying penalties, risking validity in the eyes of the stakeholders, losing competitive advantages and finally bringing down their market share. The integration of the stakeholder viewpoints in firms will aid to gauge the challenges and opportunities for implementing SP (Hasselbalch et al., 2014).

Some barriers for clean technology are lack of resources, less clarity on the impact on sustainability and business, lucid strategic focus, and not enough knowledge on the present regulations itself(Álvarez Jaramillo et al., 2019). Perey et al. (2018) write that the demand for brand new goods is higher because revamping products seems to be seen as lesser quality to some end users. It could also be due to initial expenditure, absence of knowledge and absence of prioritization (Masi et al., 2018).

Inputs from stakeholders (internal and related to the firm), and the consideration of UNSDGs impacting the business, motivates (drivers) and questions (barriers) how SP can be executed in firms that align with the UNSDGs While there are many barriers, and drivers written by various authors, this study considers the following as shown in Tables, 1 and 2 for this research. These barriers and drivers were used as variables to explore the RQs. The level of measurement for the qualitative variables were nominal scales according to the data collected.

Drivers	**Reference**
Linking excess emissions to carbon tax & carbon cap and trade, supplier and transportation mode selection with the carbon cap and trade mechanisms	Gökçe Palak, Sandra Duni Ekşioğlu & Joseph Geunes (2014)
Government regulations	Devika Kannan(2021)
Big data helps in enhancing SP operations such as integration of supplier and carrier selection	Harpreet Kaur & Surya Prakash Singh(2017)
Customer green logistics practices demands not addressed may lead to fines, incompatibility, legitimacy, weak competitive position, loss of customers	Kannan Govindan, Merve Kilic, Ali Uyar & Abdullah S. Karaman (2021)
ISO accreditation, FTSE good index	Shaw. S, Grant. D.B. & Mangan. J(2010)
Awareness of social and environemntal impacts leading to self committment	Guojun Ji, Angappa Gunasekaran & Guangyong Yang (2014)
Cost of ownership and client requirements	Ruparathna & Hewage (2015)

Table 1 - Relevant drivers for the research

Barriers	Reference
Narrow consumer knowledge of SD	Meehan & Bryde (2011)
High cost of implementing systems and unavailability of required skills	Riccardo Accorsi, Susan Cholette, Riccardo Manzini & Alessandro Tufano (2018)
Operational issues - vehicle routing and delivery scheduling, material handling & inventory	Riccardo Manzini & Riccardo Accorsi (2012)
Lack of: safety, environment friendliness, innovation, leadership, performance, reusable design	Adela J.McMurray, Md.Mazharul Islam, Chamhuri Siwar & John Fien (2014)
Reliability of product quality, faulty products, recalls	M.A. Karim, A.J.R. Smith, S.K. Halgamuge, & M.M. Islam (2008)
Green procurement vs local authorities and government agendas, engaging with suppliers vs benchmarking, departmental vs organizational priority, consistency with local circumstances vs each authority priority, management vs procurement department styles in prioritization	Joyce Thomson & Tim Jackson (2007)

Table 2 - Relevant barriers for the research

Walker and Jones (2012), have classified the internal and external influences on firms, according to their typology for SSCM, and developed the classification as shown in Table 3. The stakeholders in this table were used as variables for this study.

External Barriers	External Enablers
Government Regulation (Porter and Van de Linde 1995) ***Competitors*** Competitive pressures (Cooper, Frank and Kemp 2000) ***Customers*** Consumer desire for lower prices (Orsato 2006) ***Suppliers*** Poor supplier commitment (Walker, diSisto and McBain 2008; Wycherley 1999) ***Media*** Green wash (Greer and Bruno 1996) ***Sectoral*** Less regulated industries (Min and Galle 2001; Zhu and Sarkis 2006)	***Government*** Government policy (Carter and Ellram 1998), regulation (Min and Galle 2001; Preuss 2005; Zhu, Sarkis and Geng 2005) ***Competitors*** Competitors (Forman and Sogaard 2004; Preuss 2007) ***Customers*** Customers (Hall 2001; Handfield, Walton, Seegers and Melnyk 1997; Walton, Handfield and Melnyk 1998) ***Suppliers*** Collaboration with suppliers (Seuring and Müller 2007; Sharfman, Shaft and Anex 2007; Vachon and Klassen 2008; Vachon and Klassen 2007; Verghese and Lewis 2007) ***Investors*** Pressure from investors (Green, Morton and New 1996; Trowbridge 2001) ***NGOs*** Influence of NGOs (Hall 2001; Maignan, Hillebrand and McAlister 2002)
Internal Barriers	**Internal Enablers**
People issues Lack of management commitment (Min and Galle 2001) ***Strategic issues*** Resource: cost (Min and Galle 1997; Min and Galle 2001; Sustainable Procurement Taskforce 2005) Performance measurement: traditional accounting methods (Rao and Holt 2005) Organizational size: smaller firms (Ciliberti, Pontrandolfo and Scozzi 2008; Hervani, Helms and Sarkis 2005; Walker and Preuss 2008) ***Functional issues*** Purchasing and supply function: lack of training (Bowen, Cousins, Lamming and Faruk 2001; Cooper, Frank and Kemp 2000), lack of understanding of how to incorporate in purchasing (Cooper, Frank and Kemp 2000), other SCM priorities (Tummala, Phillips and Johnson 2006), Lack of corporate structures and processes (Griffiths and Petrick 2001; United Nations 2003; Walker, diSisto and McBain 2008)	***People issues*** Top management commitment (Min and Galle 2001; New, Green and Morton 2000; Wycherley 1999), Employee involvement (Hanna, Newman and Johnson 2000) including middle management (Drumwright 1994; New, Green and Morton 2000), Culture (Carter and Jennings 2004; Hughes 2005) ***Strategic issues*** Alignment of company strategy with purchasing/supply strategy (Day and Lichtenstein 2006; Narasimhan and Das 2001), Company sustainable SCM strategy (Drumwright 1994; Hanna, Newman and Johnson 2000; Hervani, Helms and Sarkis 2005), competitive advantage/firm competitiveness (Sharma and Vredenburg 1998; Zhu, Sarkis and Geng 2005) Risk management: Reputational and environmental risk (Carter and Carter 1998; Cousins, Lamming and Bowen 2004; Hall 2001; Schwartz 2000; Teuscher, Gruninger and Ferdinand 2006) Performance management: EMS adopters (Chen 2005; Darnall, Jolley and Handfield 2008; Handfield, Sroufe and Walton 2005), Improve quality (Pil and Rothenberg 2003) Organizational size (Hervani, Helms and Sarkis 2005; Min and Galle 2001) ***Functional issues*** Purchasing and supply function: Capabilities within purchasing and supply function (Green, Morton and New 1996; Jennings and Zandbergen 1995; Maignan, Hillebrand and McAlister 2002), Other internal CSR practices influencing SCM (Meehan, Meehan and Richards 2006)

Source: Sustainable supply chain management across the UK private sector by Helen Walker and Neil Jones

Table 3 – Typography in SSCM

Subsection 2

Because SP spans across geographies, verticals, businesses, and communities, stakeholders are a vital part of this study. In the supply chain management arena, Rebs et al. (2018) describe stakeholders as customers or suppliers in the supply chain and players that acknowledge the impact of the performance of the supply chain players.

Stakeholders fall into three categories, namely, "initiating ideas, orchestrating resources, and partaking activities" (Liu, 2020) wherein the roles, efforts and commitments of the stakeholders determine the level of engagement and decisions made by the stakeholders. But in general, the stakeholders fall into two categories, namely the stakeholders that are involved and the stakeholders that are affected that can be distinguished according to their capabilities and the settings of the situation (Vos, 2003). For the purpose of this study, this definition of Vos (2003) fits in well and as such will be used.

Another aspect is the internal drivers such as employees' individual beliefs, accessibility of exciting jobs and eagerness to execute new sustainability initiatives (Rauter et al., 2017). New initiatives must be in the realms of the management and not at the onus of the consultants, specialists, lawyers, or governmental entities (Porter and Van der Linde, 1995). On the other hand some think that the top management titles that portray sustainable efforts makes a firm sustainable, but removing a title such as the Chief Sustainability Officer does not mean that the firm is not engaging in sustainable activities (Strand, 2014). Meanwhile the perceptions of the managers and procurement officers can be guided by factors such as status, culture, and personal network (McMurray et al., 2014).

The collaborations amongst various departments of companies could result in long term gains (Gibson et al., 2021) within their industry to gain competitive advantage in the least expensive and plausible method. Buyers utilize environmental and social criteria very early in the procurement process, creating significant standards that could be useful for the future (Igarashi et al., 2015). However, it is plausible that when some managements do not extend enough resources to individuals at lower levels, they may end up involving in unethical conducts (Gold and Schleper, 2017). So, UNSDGs act as an ethical stakeholder engagement road map for companies to follow for SP implementations. All of the above leads to a broader discussion with external stakeholders and international buyers on the transformation of comprehensive sustainability and UNSDG realization (Hasle and Vang, 2021).

Additionally, buyers in firms are in a quandary when balancing the sustainability and profit objectives (Goebel et al., 2018). In order for the UNSDGs to gain momentum in firms, the business mindset needs to be altered (Gerard et al., 2020). The mindset is a big part of the decision making (Cerutti and Rossi, 2019) as companies face complex SP challenges when they work towards choosing and prioritizing the appropriate UNSDGs.

Moreover, there has been an awareness of the growing need to accelerate sustainability measures, balancing priorities, stakeholder governance influence on social performance in the supply chains (Govindan et al., 2016). Research also shows that profits work together with environmental and social features, generating solutions, while taking into consideration multiple stakeholders (Ghadge et al., 2019) to secure the aims of the UNSDGs. Sustainability is also enhanced by obtaining more knowledge through various stakeholder engagements (Droege et al., 2021). This triangulation helps evaluate past execution methods and improve richness and clarity, although it is more time consuming (Maxine et al., 2017).

Stakeholders can influence SP and try to align SP with the UNSDGs. When they fail to do so unintended consequences may occur. An example would be the foreign investments from the world's textile retail chains to buy from Bangladesh which was well intended to provide for employment and up lift the disadvantaged in that country. However, because of the lack of downstream governance and audit, corruption festered, Occupational, Health and Safety (OHS) suffered, resulting in the collapse of the Rana Plaza garment factory building in Dhaka in 2013 (Sinkovics et al., 2016) (Wolf, 2014). Conversely, Aghili et al. (2019) talk about SP's involvement in finding SD objectives through the management of green buildings in Malaysia. The building industries' contribution to the UNSDGs, are demonstrated here by developing land in disadvantaged communities to uplift the surrounding society by conserving biodiversity. The question also remains as to whether the rewards wane with time and if different motivations have to be put in place.

Circling back to the definition of a stakeholder, the situation, urgency, mandates, and the availability of several factors, determine the path to be taken by firms towards SP. The key variables (stakeholders – direct and indirect) shown in Table 4 are taken into consideration for this research.

Stakeholders	Stakeholder roles and influences on SP	Reference
Direct:		
C level management	Outsourcing decisions for production to lesson costs and decrease rigidity	Nordigården.D, Rehme.J, Brege.S, Chicksand.D, Walker.H (2014)
Senior Management	Lack of senior management support hinders SP	Delmonico. D, Jabbour. C.J.C, Pereira. S.C.F, de Sousa Jabbour. A.B.L, Renwick. D.W.S & Thomé. A.M.T (2018)
Buyers	Minimizing the quantites to be bought whenever necessary and possible	Ogunsanya.O.A, Aigbavboa.C.O, Thwala.D.W, & Edwards.D.J (2019)
Managers	Stakeholder perspective is accepted over shareholder dominance changing the managers' directions	Shin.S, Lee. J, & Bansal. P (2021)
Employees	Motivation, competence, training, rewards, misconceptions of higher workload & time influencing SP	Zaidi.S.A.H, Mirza.F.M, Hou.F, Ashraf.R.U (2019)
Customers	Customer pressures act as facilitators for reverse logistics	Ye.F, Zhao.X, Prahinski.C & Li.Y (2013)
Educational partner institutions (professional & universities)	Academia has the capability to offer help for SCM in an unbiased and organized manner	Treiblmaier. H (2018)
Investors	Investors through corporate citizenship involvements require ethical responsibilities in SSCM	Akbari. M, & McClelland. R, 2020
Transportation Vendors	Transporters find closed loop supply chain have vehicle routing problems	Govindan.K, Soleimani.H & Kannan.D (2015)
Raw material vendors	Controlling the flow of raw materials, end product to proper disposal	Govindan.K, Soleimani.H & Kannan.D (2015)
Trade unions	Weakening trade unions' influence on public activities by certain outsourcing	Harland. C, Knight. L, Lamming. R & Walker. H (2005)
Regulators	Real estate developers are bound by the enforcement for regulation codes, but non compiance often occur	Shen. L, Zhang. Z & Zhang. X (2017)
Governments	More government support needed such as low interest loans and grants for green building technologies	Darko. A, Chan. A.P.C, Yang. Y, Shan. M, He. B.J & Gou. Z (2018)
Indirect:		
Small & Medium sized enterprises(SMEs)	SMEs alleviate adverse effects through SP (leading the charge on sustainably oriented business processes and products) on environmental performance	Shashi.S, Cerchione.R, Centobelli.P & Shabani.A (2018)
Minority owned firms	Developing countries allocating a quota will give resources for minority owned firms	Bamfo.P.A, Nyamekye.T.M, Ahenkan.A (2019)
Societies, communities	Societies' fear that firms make money in the pretext of pursuing sustainability	Walker. H, Seuring. S, Sarkis. J & Klassen. R (2014)
Media	Sustainability efforts via annual reports, meetings, events to create awareness	Walker. H, Di Sisto. L & McBain. D (2008)
NGOs	Stakeholders' sometimes misaligned, eg: social NGO and environmental NGO goals	Eccles. R.G., Ioannou.I. & Serafeim.G (2014)
Civil societies	Communicating sound administrative methods to aid the policy makers	Zaidi.S.A.H, Mirza.F.M, Hou.F, Ashraf.R.U (2019)
Consultants	Advising clients on cost, codes, benefits and processes towards green procurement	Wong. J.K.W, San Chan. J.K. & Wadu. M.J(2016)
Taxpayers	Taxpayers' monies spent on sustainable public procurement services & products	Bamfo.P.A, Nyamekye.T.M, Ahenkan.A (2019)

Table 4 – Stakeholder roles and influences on SP

Methodological Procedures

A qualitative methodology using semi-structure interviews was chosen for this research. Barriers, drivers, and stakeholder influences from extant literature was used for the interviews. The profiles of the participants were from diverse levels in firms such as senior and middle management procurement heads globally. The screening criteria used for the selection of the companies were that they have sustainable procurement activities, are global and have sustainability/ESG reports, or certifications relating to SP. A multiple case study approach was used for this research. Two companies were selected for this paper. One in the global medical device sector and another in the specialty chemicals industry were chosen with rationales proposed (Yin, 2018) for triangulation, contrast, and rich data. They both have a wide array of geography, size, industries, different levels of SP maturity and stakeholders. The questionnaire in the research protocol was validated by external academics. Emails, phone, and video calls were used as channels for data collection. After the data was collected, a PDF file with the case report was sent to the companies to validate the data.

Results

Findings from Empirical data collected – Global Medical Device company

One of the triggers that cost the company millions of dollars was due to a major worldwide recall of one of their products, that acted as a segway towards procurement to be sustainable. Another point is that when the byproducts of the materials harmed the neighbourhoods where the plant is situated, the civil societies took action to shut down the plant. This triggered the company to pivot immediately and come up with different sustainable products. Therefore, the procurement department looked for alternatives and was ready when the shutdown happened.

Additionally, when supplier shortages are inevitable, innovative technologies needs to be investigated within the company, to come up with simpler product versions. This accentuates partnerships between technology, R&D, and the procurement departments. Yet another trigger that accentuated the SP initiatives is the constant queries from the new C levels to learn more about materials used. Recent organisational structure changes centralising procurement helped obtain expertise, queries answered, and working with P&L, legal, commercial, and operational units. It is the reverse for the centralized HR department because it has now become a reactive rather than proactive department as the specific competency for each unit is lost. A solution for this situation may be to proactively staff each department with sustainability knowledgeable personnel.

SP practices has increased due to the suppliers seeking sustainability aspects while tendering to be compliant with RoHS, EUMDR, BSI, TUVSUD, and FDA regulations. In the past the FDA in the USA was the most regulated body. Therefore, Europe is no longer the battleground to test the products with SP. However, the CE Marking that the company is required to obtain to indicate products meet EU HSE requirements, is not valid in the USA. As such, the procurement department may have to trade off buying either in the USA or Europe if cost of getting the regulatory markings becomes an issue. Of recent years, due to adverse effects on implant materials, the CE Marking regulations have become stringent. Consequently, the company lost huge sums and made sure medical grade products were used going forward. The company must go through clinical studies, bio compatibility tests, and look for new suppliers sometimes. This makes SP practices to be embedded throughout, but procurement becomes complex.

Other companies in this industry struggled with EUMDR, and CE Marking to bring about better SP practices due to the exposure of what the companies should have been doing to procure from the start. This is similar to the European GDPR and the Chinese PIPL. Procurement of labels were forced to be changed and the procurement department for this company, having a large market in China, is having a tough time especially with 'China for China' movement. Although regulations are part of the SP practices, the regulatory bodies do not have any sustainability included in their documents.

Second suppliers are vetted, and the suppliers are screened to ensure that they are viable suppliers throughout the life cycle of the product involving 600-page paper documents. Efforts are being made to reduce paper, but at a slow pace which shows that the UNSDGs are less important than the consumers' health. Suppliers are sought with the collaboration of other departments to develop sustainable sterilisation techniques which takes four years to materialise. Initially this effort was shunned by the scientists and other departments.

In this industry, purchasing of liquid materials are done in gallons and not in train cars. Therefore, less suppliers are interested in supplying. Second sourcing is part of the solution that lessens the damage to the environment because they minimize manufacturing resources, encouraging partnerships for common sustainability goals. Second sourcing has brought structure to the procurement department, giving way to easily incorporate SP initiatives. High level of product quality is also enabled through the highly regulated, slow second sourcing sterilsation validation process. Procurement, R&D, and technology teams have put in place strategies for the same.

Low volume needs and high cost of materials, inherent in this industry results in more trips, contributing to more carbon emission because this industry is highly regulated and only qualified suppliers can participate inhibiting economy of scale for SP practices. Additionally, sustainability requirements for buildings and structures existed historically, but not for products and suppliers.

Findings from Empirical data collected – Global Specialty Chemicals company

When Europe pushed for vegan, natural and biodegradable products, SP initiatives jumpstarted, and the company became COSMOS[14] certified. However, it does not mean that all products are natural. Additionally, when the REACH[15] programme became mandatory, the product stewardship department was strengthened to achieve regulatory compliance, for e.g., by using palm oil instead of ethylene oxide. Moreover, a global supplier event hosted by the company triggered brainstorming for innovative solutions and collaborations including joint SP projects. R&D department also sits with the procurement department for a similar endeavour to discover pain points from each side. For example, if there is a monopoly, then the procurement department works with that supplier to educate and inject SP practices. The marketing department also is sought for their input into whether the customers want green suppliers (seek Ecovadis rating and TfS member suppliers) or meet the deadline for delivery or meet halfway.

The downtime during Covid-19 also prompted employee hiring for sustainability programmes, with a rethink for centralizing procurement to enhance SP activities. During this period, SP initiatives such as security of supply was also enabled by cost reduction, warehouse optimization and by inventory control. But security of supply can lead to procuring lesser quality products if the suppliers are also competitors. This scenario can be tricky because:

- on the one hand transparency is needed, but on the other hand too much information cannot be shared with competitors
- the procurement department cannot play one competitor against another
- providing possible false information to supplier who are competitors
- of possible exposure of negotiations of one competitor to another

A Supplier Risk Management System is in the pipelines to be implemented as the procurement department is not well organised. The order in which the risks are mitigated for this industry is raw materials, packaging and intermediates chemicals including environmental risk.

Changing from existing materials to biodegradable natural alternatives is an uphill task. So, the company is buying biodegradable products from the countries where it is produced. Buying materials for the products and then manufacturing in the country of sales requires transportation at very low temperatures using generators, and then heated at destination. This is energy inefficient, and expensive.

Redesigning cartons to fit more in a container lessens the carbon footprint, but this increases the load causing more energy to be used. They also use intermodal transportation to reduce trucks on road reducing carbon emission. This also helps the communities as less trucks are used, lessening pollution, traffic, noise, and accidents. Long-term purchasing contracts help manufacturing/mining communities as well. Mining being energy intensive, labour, and environmental relations are taken into account as well during supplier selection.

Their products are made to stock and not made to order. Therefore, time is not an issue as four rail cars can provide supply for one week. The company uses nationalised railways except in the USA where it is not, and this may cause carbon emissions as trucks may have to be used if there are employee strikes. However, air transportation is used to meet tight deadlines and keep working capital low but increases carbon emissions.

The current ERP systems have limitations because it is not sophisticated to give enough precise requirements to the procurement department. As such, the lack of eprocurement tools restrict the ability to add SP requirements. This makes it harder for procurement decision-makers to derive insights to guide the procurement department to strategise and set them apart from their competitors. As there are no personnel dedicated to sustainability in the procurement department, it calls for an organisational change. As such, some business units must forego their SP needs because of the opposing requirements, such as organic products versus price.

Lack of resources led to reactive sourcing rather than proactive sourcing in the USA where the procurement department is not as mature as in Europe. China is behind USA in this effort. However, staff are incentivised to keep inventory low. This does not work always due to unavailability of storage tanks although bulk buying is cheaper. Therefore, heavy ISO tanks are used to move tolled products causing increased carbon emissions. Moreover, Scope 3 emission reduction has stalled due to the Ukraine crisis and coal usage has increased.

When compared to the other specialty chemical companies, this company has not gained momentum towards the green, ethical procurement, for example, recycling containers, packaging/reusing; and consolidation/reducing carriers. Nevertheless, the sustainability personnel report directly to the CEO showing SP importance. Identifying the key stakeholders for SP has been made important too. They include customers, stockholders, communities, suppliers, and employees.

Discussion

Stakeholder roles in aligning SP to the UNSDGs and stakeholder influences (Villena and Gioia, 2020), with stakeholders' objectives overlying each other, results as trade-offs (Montabon et al., 2016). Stakeholder engagements in firms are varied (Pullman et al., 2018) as well when implementing SP. The theoretical background in various fields of management research does not provide a consensus regarding the stakeholder influences and this research contributes to filling this gap.

After the empirical data collected was analyzed through semi structured interviews of the global heads of procurement of the medical device and specialty chemical companies, three themes emerged. The themes are stakeholder influences on SP, tradeoffs, and alignment of SP with UNSDGs. Some examples from the themes are discussed below.

Elmqvist et al. (2019) write about the trade networks for global supply chains to deliver the sustainability goals, and Aichbauer et al. (2022) write about the Together for Sustainability[16] (TfS) that delivers the ESG standards for chemical supply chains based on the United Nations Global compact[17] (UNGC). The case study conducted with the global specialty chemicals company revealed the same, however, the findings showed that the suppliers themselves don't add any sustainability practices as a value add to sell their products which is not found in the extant literature. A case in point from the specialty chemicals industry case study is the tradeoff of toller scarcity over SP practices inclusions. TfS is not applicable for the global medical device industry.

According to Qazi and Appolloni (2022) stakeholders' priorities vary, creating disagreements that hinder in SP implementations. Other literature, for example, Sönnichsen and Clement (2020) write about educating stakeholders to prioritise SP showing the benefits and difference it will bring. Delmonico et al. (2018) highlight the procurement process priorities and investment preference priorities of the stakeholders as barriers to implement SP. However, the participants of both the case studies in this research revealed the inability to access information in a timely manner due to lack of SP prioritization. An example from the global specialty company is a tradeoff seen with security of supply over information enabling SP prioritisation due to mandatory product rerouting owing to government regulations.

Venkatesh et al. (2020) solidify the need to improve greater transparency among stakeholders in supply chains which include procurement as well by reducing intermediaries and other digital tools. Others such as Kohler and Dimancesco (2020) posit that there is lack of transparency due to shortage of qualified procurement specialists, and decentralized procurement systems is not a solution, rather, good governance in the entire procurement cycle to grow transparency. However, there is still limited research extending what this research findings about transparency brought out. For example, both case study interviewees pointed out that, on the one hand transparency is needed, but on the other hand too much information cannot be shared to a competitor. There is a delicate balance that needs to be dealt with here. It exists to a greater extent in the global chemical specialty company than the global medical device company where less suppliers are competitors. In the global medical device company, there is a tradeoff of control over transparency, when control issues are inherent in outsourcing procurement activities.

While Ogunsanya et al. (2022) postulate the use of regional and global strategic collaborations for SP, Ozoigbo and Chukuezi (2011) and Idoro (2010) posit marginalising local manufacturing. Manufacturing firms are struggling to implement SP practices and partnerships with micro, small, and medium-scale enterprises is an efficient measure say Agrawal et al. (2022) while Joseph and Kulkarni (2020) write that these partnership helps achieve UNSDGs. However, existing literature has not taken into consideration toll manufacturing as a strategic partnership for SP as discovered in this research by both the firms interviewed. For example, per the medical device company, one of the reasons is because, the technology is available although the need for materials is much quicker than it can be produced, resulting in a tradeoff of time over sustainable technology and partnerships.

The two case studies uncover the following in Table 5 about the UNSDGs alignment with SP.

Global Medical Device company	**Global Specialty chemicals company**
Prominent SP aligned UNSDGs 3,8,9,11,12 15,17	Prominent SP aligned UNSDGs 11,12,13,17
Not prominent SP aligned UNSDGs 1,2,4,6,10,14,16	Not prominent SP aligned UNSDGs 1,2,3,6,7,10

Table 5 - SP alignment with UNSDGs

The two case studies conducted enables in-depth examination of the topic and identifies who the stakeholders are and how they influence SP summarized in Figures 2 and 3, adapted from

Boruchowitch and Fritz (2022). From these figures, it is clear that the internal stakeholders influence SP more in the medical device company than the specialty chemicals company.

Figure 3: SP influenced by stakeholders – Model Adapted from Boruchowitch, F. and Fritz, M.M. (2022)

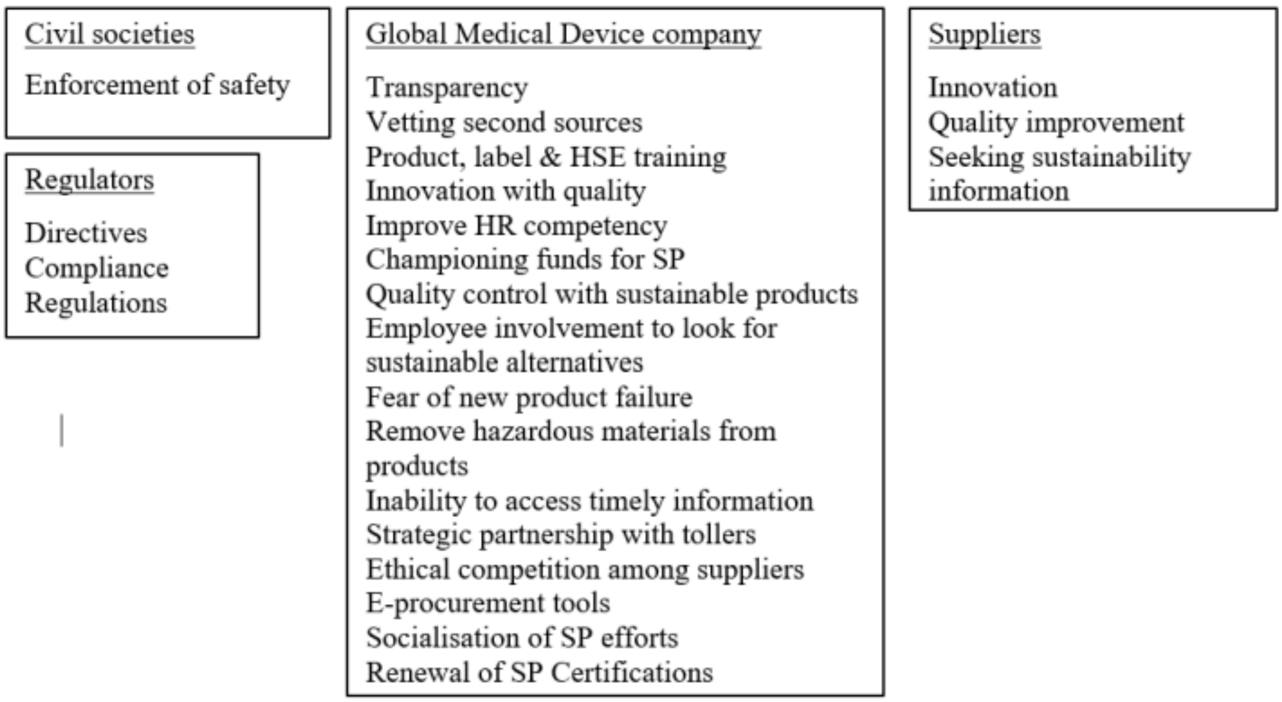

Figure 4: SP influenced by stakeholders – Model Adapted from Boruchowitch, F. and Fritz, M.M. (2022)

Overall, this study encourages researchers, suppliers, customers, and management to rethink the influences that stakeholders have on SP and its alignment to the UNSDGs.

Conclusions

The research implications of this study are to create a better understanding of how stakeholders influence SP and how SP aligns with the UNSDGs. The practical implications help to reduce tradeoffs when seeking to align their SP practices with the UNSDGs by formulating a procurement strategy and becoming more aware of SP's alignment to the UNSDGs. It will also support the suppliers, buyers, business units, NGOs, governments, customers, and end users while responding to triggers, changing organisational structures appropriately and establishing best SP practices. The originality and value of this paper resides in its contribution on how SP aligns with the UNSDGs looking through the lens of the influences of the stakeholders on SP. Many of the findings that emerged in the case studies are not found in the extant literature, adding additional value. This study can also pave the path to future research at the legal and policy levels to be built up. Other theories and methodologies can be used to research this topic as future research directions. The study is part of an ongoing research with more case studies and aims to develop more value for SP contribution to the UNSDGs. Some limitations are that individual UNSDG is not studied separately, and only a few industries are researched.

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Mission-oriented policy approach for innovation and diffusion of low-carbon hydrogen technologies

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Abstract: Recent literature has focused on the importance and many potentials of applying the mission oriented policies (MOPs) approach to responding to social, environmental, and economic challenges. This framework gained attention by defending the role of governments in setting the direction of technical change, promoting innovation, and the diffusion of new technologies. Ultimately, mission-led policies are seen as a helpful way to employ a policy direction that is smart, inclusive, and green (Mazzucato & Perez, 2014). A promising technology that falls under the umbrella of "green growth" is low-carbon hydrogen. Producing hydrogen from renewable sources and its many applications are seen as a global alternative for decarbonizing the economy by 2050. Meeting the missions for energy transition will require the co-evolution among technologies and institutions to address many barriers and the carbon lock-in. This article aims to analyze and discuss the effectiveness of applying the MOP framework in the context of innovation and diffusion of sustainable technologies. We advance the discussion of the potential and limitations of the MOPs framework applied to sustainable technologies by reviewing the case of hydrogen policy and programs in the United States since the 1970s.
Keywords: mission-oriented policy; hydrogen technologies; green growth policies; innovation and diffusion of technologies.

Introduction

Recent literature has focused on the importance and many potentials of applying the mission-oriented policies (MOPs) approach to respond to social, environmental, and economic challenges (Fisher et al., 2018; Kattel & Mazzucato, 2018; Mazzucato, 2018; Mazzucato & Perez, 2018; Miedzinski, Mazzucato & Ekins 2019; Hekkert et al., 2020). This framework gained attention by defending the role of governments in setting the direction of technical change, promoting innovation, and the diffusion of new technologies. Thus, MOPs help create and shape new markets via targeted innovation-led oriented policies and can be considered an opportunity for countries with less mature Research and Innovation (R&I) Systems to accelerate the development of their capacities (Fisher et al., 2018). Ultimately, mission-led policies are seen as a helpful way to employ a policy direction that is smart, inclusive, and green (Mazzucato & Perez, 2014). In fact, scholars do consider that "green growth" is the ultimate goal and the next big technological and market opportunity that can stimulate private and public investments (Mazzucato & Perez, 2014).

A promising energy technology that falls under the umbrella of "green growth" is hydrogen. Producing hydrogen from renewable sources is seen as a global alternative for decarbonizing energy production and economic activities by 2050. To close the gap between rhetoric and action, the International Energy Agency (IEA) has set a roadmap that establishes pathways to reach net zero emissions by 2050 (2021). The different scenarios for the reduction of CO2 emissions in pathways that limit global warming to 1.5°C show the increasing importance of hydrogen and hydrogen-based fuels for the energy sector (IEA, 2021). Similarly, governments from advanced and developing countries launched ambitious national hydrogen strategies and directed economic stimulus funds to this area. Based on this background, producing low-carbon hydrogen is one goal of global policies targeting green growth.

Government policies and programs can stimulate investments in sustainable technologies that are available. However, sustainable technologies can still not be vastly adopted and rapidly diffused because they face specific challenges posed by carbon lock-in. The advantage of MOP is to use the government to set the primary direction of economic activity, driving cross-sectoral investments cutting through the state-market dichotomy to drive investments on the way to the vast adoption of sustainable technologies and out of the carbon lock-in.

This article aims to analyze and discuss the effectiveness of applying the MOP framework in the context of innovation and diffusion of energy technologies applied to hydrogen in the United States over the past decades. We aim to contribute to the MOP and transitions literature with a critical and reflexive analysis of a case of limited achievement of transformative results. To do that we bring to analysis the case of hydrogen technologies policies and programs in the United States comparing the missions and their evolution since the 1970s. This can provide empirical evidence for the need to consider the specificities of sustainable technologies when designing and implementing a MOP for green growth.

Our methodological approach comprehends a literature review of the mission-oriented policies framework and an in-depth literature review of the programs and policies for developing hydrogen technology in the United States since the 1970s. Also, we collected patent information on hydrogen production technologies to analyze the technological evolution in time and by country. This article contributes to the literature by adding a historical perspective on the MOP approach in different stages of development of the hydrogen technologies in the United States. The missions differ in the type of solutions they focus on; the focus of development/ diffusion of those solutions; the number of possible solutions pathways and the ensuing complexities. Our study may guide policymakers who wish to encompass sustainable innovation into the public agenda at the national and regional levels.

The paper is organized as follows: besides this introduction, section 2 presents the theoretical background for the analysis. Section 3 describes the methodological procedures. Section 4 presents a qualitative delineation of the United States' timeline of efforts toward a hydrogen energy economy and its reflections on the technological development in global patent data. The discussion in section 5 summarizes the results and sets the groundwork for the conclusions in section 6.

Theoretical Background

Mission-oriented Research and Innovation (R&I) initiatives have a clearly defined technological or societal goal and a well-defined timeframe and are usually ambitious, exploratory, and ground-breaking in nature (Fisher et al., 2018; Kattel & Mazzucato, 2018; Mazzucato, 2018; Mazzucato & Perez, 2018). According to Fisher et al. (2018), missions tend to have a crucial R&I component. However, they can be broader than R&I alone and require other measures to support and achieve the goals, like implementing specific regulations. The main differences between MOPs and other typical innovation and industrial policies may be in terms of "scale (bigger), scope (broader), and target (more specific)" (Alves, Vonortas & Zawislak, 2021, p.81). Mazzucato and Penna (2020) defend that MOPs are systemic public policies that draw on frontier knowledge to attain specific goals or "big science deployed to meet big problems" (Ergas, 1987, p. 53).

Fisher et al. (2018) define some basic characteristics of mission-oriented research and innovation initiatives:

a) A clear societal or technological target that can be qualified or quantified in terms of % reduction, % increase, or even in absolute terms.
b) A clear timeframe and a definition of how progress could be monitored, preferably by establishing milestones.
c) Large scale, here applied to both the investment needed to implement such a policy and the

expected impact of this policy, which should also be significant.

d) The expected impact should have a 'system or transformative change' aspect. In this sense, the initiatives can be divided into two categories: narrow mission-oriented initiatives, a single well-defined objective, usually in technological terms, or broader initiatives that aim at the system change to address wicked problems.

e) Mission initiatives are mostly cross-disciplinary and should involve different technologies and actors from different sectors, companies, governments, and even countries. In that sense, this type of initiative requires a horizontal policy that can achieve all these governance levels.

Another critical aspect to consider is that, while setting goals and determining pathways, missions will hardly be reduced to a single development path or by a single technology. Establishing a goal or a mission should consider the available innovation capabilities to promote a successful regime change or shape and create markets. MOPs may create an institutional incentive for regime change, catching up, capability building, and, eventually, market creation. However, a MOP approach should acknowledge the many stages of development and diffusion of still immature technologies. Geels' (2002) approach helps understand the dynamics of regime change, the emergence of new technologies and their diffusion processes, and how they interact with extant sociotechnical regimes that are crucial for sustainable societal transformation.

Another relevant aspect of the MOP approach is the usual need to employ tools for continuous policy assessment and adaptation. Long-term policy frames frequently need to re visit original targets, to re-adjust the set goals and instruments, and even rethink the portfolio of technologies (Fisher et al., 2018). For those reasons, it is essential to consider that designing and implementing mission initiatives foresee an interactive learning process as a continuous re-adjustment of policies, programs, technologies, and instruments to set a long-term strategy of new governance for mission-oriented policies.

Thus, missions are instrumental in implementing long-term directionality to policies. Miedzinski, Mazzucato and Ekins (2019) understand that policy directionality "means recognising mission objectives and targets as a central element of the policy, and more concretely integrating them into specific objectives, targets, and the implementation criteria of policy portfolios and programmes" (p. 9).

Directionality can take many forms, either in terms of incentives to limit the use or commercialization of products and services or in elaborating and implementing a specific regulation (Mazzucato & Perez, 2018). When discussing missions that target a green transition, Mazzucato (2018) describes using the taxation system to tax materials more than labor, encouraging businesses to reinvest their profits into particular and openly defined areas to access public subsidies, guarantees, and investments.

Although MOPs have a significant part to play in delivering better quality growth while addressing grand societal challenges, they can also face challenges in their design, implementation, and assessments. Alves, Vonortas, and Zawislak (2021) emphasize that the mismatch between the expected goal and what is feasible (based on the available technological capabilities) creates what the authors call "a fuzzy boundary" that often leads to the unsuccessful implementation of missions.

Kattel and Mazzucato (2018) also emphasize the importance of considering dynamic capabilities to ensure that expected goals can meet already established capabilities. In that sense, six types of capabilities appear to be necessary to guarantee internal consistency and effectiveness of mission initiatives:

a) Scientific-technological capacity: an appropriate scientific and technological knowledge base in the subsystem of education and research.
b) Demand capacity: latent or effective (public or private) market demand.
c) Productive capacity: an appropriate business base in the subsystem of production and innovation.
d) State capacity: appropriate knowledge inside the public organizations formulating and executing the policies about the targeted problem and solution and/or awareness of the roles of the many actors involved in this initiative.
e) Policy capacity: appropriate supply-side and demand-side policy instruments (strategically deployed) supported by complementary policies.
f) Foresight capacity: a fine-tuned diagnosis of the problem and solution, including an analysis of the current situation and prospects for targeted technologies and sectors, formulated with a well-defined mission and vision.

MOPs cannot be successful without the understanding and mastering of innovation capabilities and the characteristics of their technological path. A full understanding of these dynamics can directly impact the success of the implementation of the MOP framework for sustainable innovation. More specifically, in the case of sustainable technologies innovation, the development of capabilities and their technological path finds additional complexity in the form of carbon lock-in. The mission's framework for green growth faces the challenge that the already available energy efficiency and low-carbon emissions technologies are not widely adopted and rapidly diffused even in the context of climate change. The carbon lock-in is explained by the concept of techno-institutional complexes (TIC) which encompasses the physical and technological infrastructures and the managing organizations, institutions, and cultural practices that build and perpetuate them (Unruh & Carrillo-Hermosilla, 2006). These TIC emerge through a path-dependent process driven by increasing returns to scale that can be responsible for the emergence of numerous sources of quasi-irreversibility or lock-in of the system. Thus, regime stability is the result of the influence of engineers, scientists, policymakers, and society toward incremental innovation trajectories. Technological transitions can happen when radical innovations break out of the niches that involve technological changes and changes in elements such as user practices, regulation, industrial networks, infrastructure, and symbolic meaning (Geels, 2002).

In summary, problems like climate change do not depend on technological fixes alone, there is a need for socially innovative solutions. Hekkert et al., (2020) argue that even though the MOP approach has had relevant contributions in dealing with societal challenges, the existing framework still misses a clear operational approach or a sufficiently detailed 'embedded system's' perspective to the policy design and implementation. The MOP approach remains understudied, especially since a framework is missing that can be used to map and evaluate innovation dynamics (Hekkert et al., 2020; Wesseling et al., 2020). Hence, there is an opportunity for studies on the emergent and existing mission-oriented innovation systems and lessons to contribute to the design and implementation of appropriate intervention strategies.

For the reasons discussed above, moving towards a hydrogen economy should be seen as a process subjected to barriers that depend on the co-evolution among physical technologies and social institutions out of carbon lock-in. Based on this background, we address the United States' attempts to develop a hydrogen economy since the 1970s and the limitations of implementing MOPs in the context of innovation and diffusion of sustainable technologies.

Methodological Procedures

The methodology applied to this study can be divided into three main parts:

a) First, we developed a literature review on the mission-oriented policies framework. The research selected papers that discuss the design, implementation, and assessments of MOPs.

b) Second, we conducted an in-depth literature review of the history of the programs and policies for developing hydrogen technologies in the United States. This review covered papers, international reports, recommendations, and cooperation agreements related to hydrogen technologies.

c) Third, we collected information on hydrogen technologies considering two different segments of production: from fossil fuels and from non-carbon containing sources. The patent searches were based on the definitions of EPO (2016) and IEA & EPO (2021) of the hydrogen technology production classification codes. We used the OECD, REGPAT database, version of July 2021 with patent applications ('international applications') filed under the Patent Cooperation Treaty (PCT) at the international phase. The search for hydrogen technologies patents using CPC class symbols resulted in 31,170 observations from the priority date 1979 to 2018. The analyses by country consider the patent inventor's nationality.

Results

Hydrogen Policy and Programs in the United States

Traditionally, Oil & Gas companies have been the largest producers and consumers of hydrogen (in oil refineries) for years. Data from 2018 shows that hydrogen's most common uses worldwide are 51.70% of the total for refining and 42.62% for ammonia production (IEA, 2021). The current industrial processes to produce H2 are based on fossil fuels (natural gas and coal), and so they release into the atmosphere a huge amount of CO2, eliminating any positive contribution to the environment (Germscheidt et al., 2021). To play a critical role in the transition to a low-carbon economy, hydrogen depends on the environmental impact of its production process. The sustainability in terms of carbon emissions from the processes of extracting hydrogen from water (electrolysis) depends mainly on renewable energy sources. The feedstocks for hydrogen production change all processes and influence the prices and chain sustainability (Germscheidt et al., 2021).

The Oil & Gas companies also play a critical role in the emergence of a hydrogen economy because they are one of the leading implementers of carbon capture, utilization, and storage (CCUS) technologies, alongside the industry of ammonia and urea, which uses a gas stream rich in CO2 generated in the hydrogen production process used to produce fertilizers (IEA, 2019). In the next 30 years, the energy transition will demand that fossil fuels be replaced by a clean source of H2, such as water. Technologies for the use of alternative sources of water, such as wastewater and seawater, are considered essential to the future of producing clean energy with social responsibility (Germscheidt et al., 2021).

In the 1970s, the US Government started a direct program to support Hydrogen and Fuel Cell R&D, developing advanced propulsion alternatives to internal combustion engines and evaluating the performance of alternative fuels in vehicles. This first wave of investments and programs toward developing hydrogen and fuel cell technologies was directly related to the petroleum crisis. However, the reduction of oil prices during the 1980s reduced the interest in investments to foster alternative fuels and renewable energy technologies.

The second wave of hydrogen technology development was initiated in the 2000s. The Kyoto Protocol in 1997 renewed interest in alternative energy technologies and objective targets of carbon emissions reduction. In that context emerged a view of global hydrogen production systems progressively shifting from fossil-based toward renewable sources (Barreto et al., 2003). The fuel cells and other hydrogen-using technologies significantly accelerate the decarbonization of the energy mix, increasing flexibility and reducing the vulnerability of the energy system. The United States decided not to ratify the Kyoto Protocol in 2001. However, the country did develop clean technologies such as hybrid vehicles to reduce carbon emissions and the dependence on foreign energy sources.

In 2003, President George W. Bush announced the Hydrogen Fuel Initiative and billions of dollars in research funding to develop clean, hydrogen-powered automobiles. At that moment, the main interest was to introduce hydrogen in the long term as an alternative fuel in the transport sector in the face of the expectations of increasing global energy demand (Ball & Wietschel, 2009). The rise of greenhouse gas (GHG) emissions would negatively interfere with the climate system and energy security in the face of the transport sector's vulnerability to oil supply disruptions. The U.S. Department of Energy (DOE) promoted hybrid vehicles as a solution in the near-term and hydrogen research for the long term. This program involved a strong government R&D role, especially in the Technology Development stage.

Hydrogen and fuel cell technology received the most funds for RD&D among the renewable energy technologies between 2003 and 2012 out of all OECD countries (Andreasen & Sovacool, 2015). According to the same database, the United States spent the most, and Denmark spent the most per capita in the same period. Denmark and the United States exhibit remarkably different Technological Innovation Systems strategies in their approach to hydrogen fuel cell development. As positive externalities in Denmark revolve around energy storage and climate change, they focus more on jobs, energy security, and industrial competitiveness for the United States. The countries' strategies remained focused on performance, durability, and price of technology. They aimed to replace incumbent fossil fueled power plants and vehicles with hydrogen and fuel cell technology (Andreasen & Sovacool, 2015).

The Paris Agreement in 2015 started a third wave of Government support and public policies and programs toward the development and use of hydrogen. This wave of low-carbon hydrogen technology development happened during increased concerns over climate change and green transition. Thus, it focuses on producing hydrogen from renewable energy sources. The recent global programs and policies that aim to accelerate the widespread use of clean hydrogen technologies target cost-reduction and opening new markets for clean hydrogen. Clean hydrogen is seen as essential to decarbonize hard-to-abate sectors (industrial and chemical processes as well as heavy-duty transport) and essential to support the expansion of renewable power by providing a means for long-duration energy storage and flexibility to the system.

The public support for RD&D in hydrogen from the US was marked by discontinuity during this period. In 2008 the United States represented 40% of total OECD hydrogen RD&D (340 million euros), but this reduced to only 17% in 2019 (EUR 107 million) (Cammeraat et al., 2022). Data from IEA Energy Technology RD&D Budget Database, 2021 shows that most countries reduced the average growth of public RD&D spending on hydrogen and fuel cells between 2008-16. The US public RD&D spending on hydrogen and fuel cells annual average growth was -15% between 2008-16, against -9% of total IEA countries. A global scenario change is observed between 2016-2019 with a significant mobilisation of public resources for RD&D on green hydrogen mostly driven by Japan.

Table 1. Public RD&D spending on hydrogen and fuel cells by country

Country	2008	2016	2019	Average annual growth 2008-16	Average annual growth 2016-19	2019 public RD&D per million EUR of GDP
Australia	0.25	2.55	10.85	34%	62%	10.0
Canada	54.99	14.84	12.28	-15%	-6%	9.2
France	64.98	31.02	38.74	-9%	8%	18.3
Germany	29.07	16.49	45.98	-7%	41%	14.8
Italy	28.50	9.92	10.45*	-12%	2%	6.8
Japan	183.11	116.47	254.91	-5%	30%	61.8
Korea	67.87	31.85	28.97	-9%	-3%	21.8
Netherlands	9.83	1.00	14.68	-25%	145%	19.7
United Kingdom	15.93	17.06	32.21	1%	24%	14.6
United States	339.73	95.30	106.64	-15%	4%	6.3
Total IEA	852.88	395.16	637.19	-9%	17%	15.0

Note: Data in million EUR (2020 prices and exchange rates). *Data for Italy is not available for 2019 and is therefore replaced by data for 2018.
Source: (Cammeraat et al., 2022).

Large investments are still a top priority since large-scale production of green hydrogen is not yet commercially viable (Cammeraat et al., 2022). The OECD (Cammeraat et al., 2022) recommendation to countries willing to support green hydrogen follows five types of policy priorities:

1. Ensure greater support for R&D in green hydrogen and demonstration projects;
2. Ensure a sufficient supply of renewable energy where possible, and encourage the creation of an international hydrogen market;
3. Establish clear carbon price trajectories to provide investors with the right incentives;
4. Reduce uncertainties for investors through regulatory action and standardisation;
5. Consider blue hydrogen (produced from natural gas with carbon capture) as an interim solution to facilitate the transition to green hydrogen.

The United States' current policy for hydrogen technologies is based on the program of tax incentives in the President's Inflation Reduction Act (IRA) and the program of investments of the November 2021 Bipartisan Infrastructure Law to develop regional clean hydrogen hubs (H2Hubs) across the United States. These programs represent a move toward addressing climate change and clean energy that aims to help reduce US emissions levels. The clean hydrogen tax credit favours green hydrogen made with renewables over fossil fuel-derived blue hydrogen (which uses carbon capture technologies). The tax credit would reduce the price of qualified clean hydrogen [depending on the levels of lifecycle emissions and staff wages], making the cost of green hydrogen locally cheaper. The National Clean Hydrogen Strategy and Roadmap launched in September 2022 is based on prioritizing three key strategies:

(1) Target strategic, high impact uses for clean hydrogen (where limited deep decarbonization alternatives exist);

(2) Reduce the cost of clean hydrogen across the supply chain;

(3) Focus on regional networks to enable large-scale clean hydrogen production and end use in proximity.

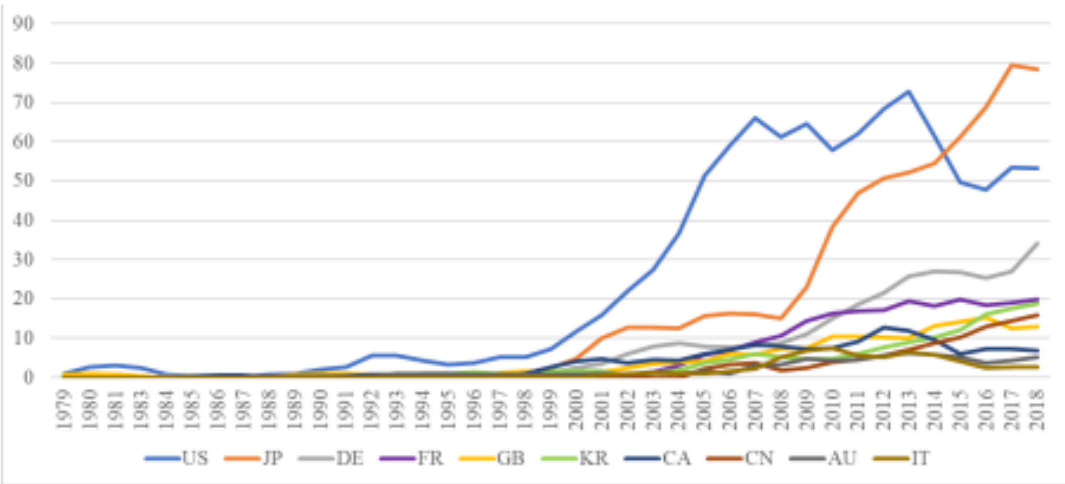
The document of the U.S. Department of Energy (DOE) describes its National Clean Hydrogen Strategy and Roadmap as a pathway to create more clean energy jobs, reduce greenhouse gas emissions, and strengthen competitiveness in the global clean energy market.

Hydrogen technological development in global patent data

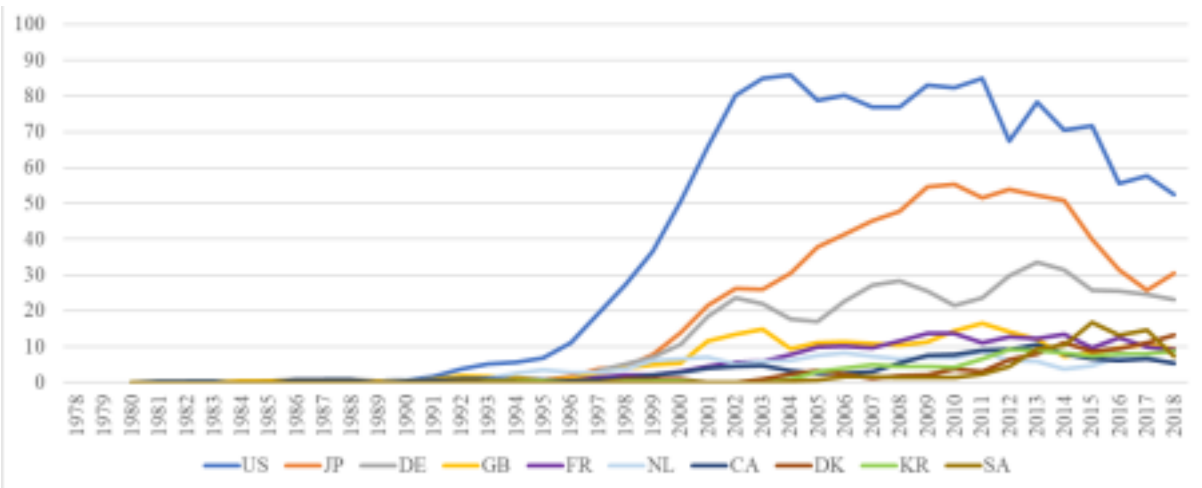
Using patent data, it is possible to observe a relationship between the evolution of the United States' national hydrogen programs and strategies from the 1970s awards and the country's development in each hydrogen production segment (Graph 1).

Graph 1. Three year moving average of the number of patent applications by country

Hydrogen production from non-carbon containing sources



Hydrogen production from fossil fuels



Source: Own elaboration with OECD, REGPAT database, July 2021.

After the oil crisis at the end of the 1970s, there was a modest increase in the number of hydrogen patents during the 1980s by the United States, but also from Germany, the United Kingdom, Japan, and Canada (Graph 1). Technological development of hydrogen production from non-carbon-containing sources was slightly superior to that from fossil fuels in the 1990s, but really increased from the 2000s onwards. The United States' hydrogen technology development was remarkable compared to the other countries during the 2000s. It reflects the country's already mentioned superior public expenditure on RD&D. Together, the United States, Japan, and Germany were the countries that most patented in both hydrogen production segments. The other countries that were among the ten with the most patents in both segments were Great Britain, France, Canada, and South Korea.

From the 2010s onwards, the number of the United States and Japan patent filings on hydrogen production from fossil fuel dropped significantly. However, these countries maintained their numerical superiority among the selected countries. After 2015, clean hydrogen production technologies have a more significant growth momentum than hydrogen production from fossil fuels. Japan had a very significant growth in the number of patents, ahead of the United States. Germany, which is in third place, also increased its average patent numbers for clean hydrogen production after 2015. South Korea and China also showed a significant growth trend in patents after 2015, reaching the fourth and fifth-highest average number of patents in 2017 and 2018.

The United States' programs and strategies to develop hydrogen technologies until the 2000s worked in the trajectory of cumulative and path-dependent knowledge explaining the country's dominance. Japan's spectacular increase in hydrogen from non-carbon sources technologies in the 2010s was also based on an early development during the 1990s but represents a distinct trajectory because the discontinuity only happened to the segment of production from fossil fuels. Meanwhile, the United States' patenting activities in both technology production segments reduced around the midst of the 2010s.

Discussion

A hydrogen-based energy system was already considered in the 1970s during the oil crisis but suffered from the discontinuity of programs and loss of interest after oil prices declined. In the 2000s, many explicit objectives or missions were driving energy-related public RD&D in the United States that ranged from increasing energy security by reducing oil imports, mitigating climate change, and promoting economic competitiveness (Anadón, 2012). Multiple missions imply tensions between them that pose challenges to building and maintaining support from the public and policymakers. Also, there was no public consensus about reducing GHG emissions or addressing the energy security challenges through innovation in alternatives to carbon-emitting energy sources (due to the country's sizeable domestic coal and natural gas resources). All that made it difficult to put in place energy RD&D policies or institutions with climate-change mitigation as a primary mission by the 2000s (Anadón, 2012).

The discussion above is in line with the literature debate on the problem-definition process of mission-oriented policies. The definition of goals is critical for constructing policies or re-arranging policy mixes. For a mission-oriented policy to work, a clear goal and a clear solution (or set of solutions) must be convergent among the interested stakeholders, institutions, and policymakers. One can consider that the problem-solution is divergent (contested, uncertain) or converging (uncontested, well-defined) (Wanzenböck et al., 2020). In the 2000s, the problem-solution process seemed divergent, translating into many different missions. Krattiger (2004) raised a fundamental point by highlighting that the effectiveness of laws and policies depends on the conditions for their application. An expensive and poorly designed regime or policy mixes or missions can discourage actual change instead of promoting it. Therefore, a policy can only be good if implemented and followed.

The hydrogen economy is no longer visioned only as an alternative fuel to the established economy based on fossil fuels. On the contrary, clean hydrogen has several possible uses in transport (heavy), integrating renewables to enhance the energy system flexibility, and decarbonizing hard-to-abate sectors. The new hydrogen policies and programs target infrastructure development and cost reduction across the supply chain.

The recently announced United States' policy and programs for the emerging clean energy economy and the President's Biden goal of a 100% clean electrical grid by 2035 and net-zero carbon emissions by 2050 include investment in renewable energy sources and clean hydrogen to decarbonization across sectors. The ambitious greenhouse gas pollution reduction targets set a clear mission toward energy transition.

The case of MOP for the hydrogen economy in its third wave is internalizing the system innovations features, as defined by Geels (2002) and Schot & Geels (2008). In summary, they are adopting programs that address the necessary co-evolution of technologies and institutions in energy innovation policies that face the barriers and the carbon lock-in.

Conclusions

This article contributes to academic research and literature by providing a detailed study that confirms the effectiveness of the MOP framework applied to the technological development of sustainable technologies. Our analysis demonstrates that MOPs' effectiveness is deeply connected to understanding and acknowledging technology specificities, such as technological trajectories, technological transitions, and regime change.

Two important results from RD&D and patent data were the discontinuity in the United States' hydrogen technologies development activities during the 2010s and Japan's advance in hydrogen production from non-carbon sources technologies after 2015. That also meant a loss of leadership for the United States in the technologies of low-carbon hydrogen production to Japan and the emergence of other countries in this competition for energy innovation frontier.

The RD&D public expenditure data also showed that Japan was expanding more than the United States in 2016 and that their average annual growth from 2016 to 2019 was 30% against 4%.

Can the discontinuity of the hydrogen innovation policy during the 2010s and the continued investment in production from sources with carbon emissions threaten the leadership of the United States in the production of hydrogen technologies? Does the ascendant movement of technologies related to the production of hydrogen from non-carbon-containing sources compared to that associated with the production of hydrogen from fossil fuels characterize a new direction? Could the green mission orientation of policies after the Paris Agreement in 2015 towards renewable energy sources represent a window of opportunity for countries other than Japan, the United States, and Germany?

This manuscript advances in discussing the potential and limitations of the MOPs framework applied to sustainable technologies. MOPs can be helpful tools for addressing significant societal problems and stimulate government and private actions that could not have happened otherwise. However, the detailed comprehension of a technology's technological regimes and capabilities, which is the central discussion of a mission, is essential as this influences the implementation and success of a MOP.

The mission for green growth proposes a wide adoption and diffusion of energy efficiency and low-carbon emissions technologies, such as hydrogen, which needs to internalize the vision of vast technological and institutional transformation. The new ambitious global targets of greenhouse gas pollution reduction set a clear mission towards an energy transition that sheds light on low-carbon hydrogen's importance for decarbonizing energy production and economic activities. The first two hydrogen waves showed that a mission to replace fossil fuels faces many barriers related to the techno-institutional complexes and stability that create carbon lock-in. Past policies and programs meant for a hydrogen economy to solve carbon emissions, but hydrogen technologies were not vastly adopted as expected. The future for successful use of MOP in the energy transition is to address the necessary co evolution of technologies and institutions in energy innovation policies to face carbon lock-in.

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Competitiveness and environmental performance: A stalemate?

Abstract ID#286

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Purpose

In this paper, we intend to verify the relation between competitiveness – here understood as the set of institutions, policies, and factors that determine the level of productivity of a country – and environmental indicators from a country-level perspective. There are some studies that approach and correlate competitiveness with sustainability-related variables from a regional perspective, considering the development level of countries in terms of regulation, firm-related factors, and institutions, and reinforcing the importance of R&D expenditure and high-tech employment to better environmental performance, and their findings lead to somewhat similar conclusions, e.g., sustained economic growth can be accompanied by environmental performance, green competitiveness is relevant for the overall competitiveness of a region or country, the most competitive countries present better performance in sustainability, there is a strong correlation between environmental sustainability and competitiveness, and so on. Needless to say, therefore, that there is significant evidence that environmental-related issues affect the competitiveness of countries. Therefore, we intend to answer the following research question: Do regulation and input and output variables impact the competitiveness of a country?

Literature Review

Even though research has approached the relation between environmental variables and competitiveness at the country level, some relevant issues were left out, such as the relevance of regulation and the influence of environmental input and output variables for competitiveness. Regulation is an important matter for sustainability-related discussions as it is believed that countries with rigorous environmental requirements are often the leaders in the exports of the affected product, thus, stricter standards may actually enhance competitiveness. Nevertheless, acknowledging the role of regulation as a mechanism to encourage companies to re-engineer technology and improve environmental performance does not seem like a principle followed by many countries (Doyle & Alaniz, 2020). In addition, we have found articles that directly relate competitiveness to environmental performance through the Environmental Performance Index (Mirghaderi, 2020; Nogueira & Madaleno, 2021; Popescu, Sima, Nica, Gheorghe, 2017), however, without delving into the specificities of such index, which brings together unique variables that could relate to competitiveness at the country level. More than that, such analysis would add to Systems Theory, in which inputs, i.e., the starting force that provides the material for the operation of the system, here represented by raw materials, and outputs, i.e., the consequence for which elements of the system have been brought together, would be analyzed with the lens of competitivity. Such assessment would emphasize the importance of the holistic view in organizations, which is mandatory in management strategies.

Methodological Procedures

This article defends that regulation – hereinafter measured by the ISO 14001 standard related to environmental management – and input and output environmental variables – expressed by the sets water resources and water & sanitation, and air quality and air pollution obtained from the Environmental Performance Index – affect the competitiveness of countries. We adopt in this cross-sectional study a quantitative research approach in which quantifiable results will be used to answer the research question. Two statistical techniques will be used for such purpose, namely multiple linear regression and Pearson correlation analysis. The results show that ISO 14001 presented a low predictive power in the regression analysis, whereas water & sanitation was the best predictor for the variance observed in competitiveness across countries, thus supporting the Sustainable Development Goal 6. Moreover, there is a negative correlation between air quality and competitiveness, and a positive relationship between air pollution and competitiveness.

Findings

We noticed a low predictive power of ISO14001 to explain the variance observed in competitiveness across countries. A possible explanation for such may be related to the fact that countries still seem to have a more reactive than proactive posture when it comes to certifications. Water & Sanitation is the best predictor for the variance observed in competitiveness across countries, which is also in line with SDG6. The implementation of the SDGs can bring good results in terms of competitiveness at the macro level, in terms of countries, and at the micro level, considering companies and the elaboration of the GRI. The negative correlation between air quality (-0.156) and competitiveness and the positive relationship between air pollution (0.124) and competitiveness is somehow also supported by the literature. The GCI itself indicates that the most competitive countries, according to the scores provided by the index, are also the most industrialized ones. Thus, a high number of industries may imply greater air pollution.

Implications

This article contributes to the literature by adding to the idea of weak and strong sustainability, which brings a relevant theoretical perspective within environmental economics. The systems theory lies behind both weak and strong sustainability concepts: in the weak sustainability, there is entropy; in the strong, negative entropy. According to the systems theory, to overcome weak sustainability, the development of strategy is necessary, i.e., a national environmental strategy that could structure inputs and outputs in a negative entropy process. The most competitive nations, in this sense, would be those strategically oriented toward the idea of strong sustainability. Nevertheless, this article contributes to the Sustainable Development Goals, namely Goal 6 (Clean water and sanitation) and Goal 13 (Climate action), which have a direct impact on public policies. In this sense, our study may serve as a guide for policymakers who wish to encompass these specific SDGs into the public agenda at the national and regional levels.

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Social business ecosystem: Stakeholder engagement in social environmental impact

Abstract ID#259

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Purpose

The criticism of businesses' socio-environmental impacts has led academics and practitioners to argue the necessity of rethinking current business models. Social businesses have addressed a sustainability perspective since their business models are designed under a double mission: solving socio-environmental problems simultaneously with generating profit (Ebrahim, Battilana & Mair, 2014). Such enterprises emerge in innovative formats to positively impact all stakeholders involved in the process. In Brazil, specifically in the Northeast region, which faces complex social/environmental problems, social entrepreneurs have sought solutions to such issues through social business models. However, many challenges exist, such as legal composition, organizational structures, investment access, and market development. Therefore, it is necessary to understand how social businesses are structured and how the institutional arrangements that make up a set of different actors and action strategies contribute to a social business ecosystem (Cruz, Critério & Scretas, 2019). This paper aims to analyze how a social business ecosystem has been developed from the perspective of stakeholder engagement. The study is applied in the State of Ceara, one of Brazil's six first states that have created regional regulations for social businesses and are engaged in a national program to develop regional impact ecosystems (ICE, 2019). Therefore, we consider the relevance of this research in mapping and analyzing how stakeholders engage and the implications for entrepreneurship and the local economy.

Literature Review

Recently, discussions and proposals to transform the capitalist system "from the inside" have intensified, that is, to seek ways to use the system to combat the problems generated by it. Regarding market organizations, alternative business models have emerged that make use of the market mechanisms themselves to solve existing socioenvironmental problems. Social (and environmental) businesses are characterized by intentionally providing innovative value propositions to structural social and ecological problems in areas such as education, health, and housing, among others (Comini, Barki, & Aguiar, 2012; Ebrahim, Battilana & Mair, 2014). These businesses follow the market logic and, therefore, have the search for financial return as one of the drivers and the distribution of dividends to those who consider them as investment options. Stakeholder engagement can be seen as the organizational ability to establish collaborative relationships with a wide variety of stakeholders (Zwikael, Elias, & Ahn, 2012). It includes a set of initiatives or practices (Greenwood, 2007) and can inspire and reward fundamental changes to the core operations of the firm that are beneficial to society and the environment (Sulkowski, Edwards, & Freeman, 2018). In this context, we use this theory under the perspective of entrepreneurial ecosystems from Eisenberg (2011), which conceptualized it in six key domains: finance, culture, human capital, markets, policy, and supports. Therefore, the understanding of stakeholders' relationships and engagement is a perspective to analyze the social business ecosystem that involves a set of interrelated stakeholders (Roundy, 2017).

Methodological Procedures

Basic qualitative research was carried out, with semistructured interviews with entrepreneurs and managers of organizations that compose the impact ecosystem such as business accelerators, universities, financiers, and regulators and governments. Questions aimed to reach the role of each stakeholder along the ecosystem and the level of engagement in practices and strategies among themselves. 20 interviews out of 30 have been carried out so far. The interviews were analyzed following the content analysis method. The analytical categories were defined by stakeholder engagement level: moral, strategic, and pragmatic, and the contents of stakeholder engagement: aims, activities, and impacts.

Findings

The prior results point out that the social business ecosystem in Ceara is composed of stakeholders with different but congruent interests. The actors develop strategies of engagement at different levels that involve communication and joint projects, but the participants highlight that the integration and support activities in the ecosystem need to be improved. In addition, there is the challenge of expanding the ecosystem, involving more actors, and communicating the importance of the ecosystem of social impact on local development.

Implications

The role of institutions that combine activities of social and economic interests in the state can influence the emergence of new social businesses. Initiatives aimed at developing social entrepreneurship ecosystems have been observed, which are the main areas for companies with socio-environmental impact to flourish, with public and private initiatives. It highlights complex social and environmental issues within an emerging country and how the impact ecosystem has developed, with the network of different actors aimed at promoting these impact businesses.

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STRATEGY AND INNOVATION I

May 2nd: 3h10 pm – 5h pm

Chair

Simone Galina (University of São Paulo, Brazil)

Papers

Digital transformation readiness in large manufacturing firms: Proposition of a prognostic model

Clarissa Rocha, Fernando Deschamps

Understanding innovation system in law enforcement agencies

Marina Carelli Reis, Ana Paula France Paes Leme Barbosa, Tiago Paz Lasmar

Innovation labs and(in) business fairs: Reflections and possibilities

Débora Regina Schneider Locatelli, Magnus Luiz Emmendoerfer, Thiago Chagas de Almeida, Alessandro Carlos da Silva Junior

Strategic flexibility, intramural R&D and uncertainties: Understanding their relationship in turbulent times

Leandro Rodrigues, Simone Galina

Circular economy and artificial intelligence: An integrative literature review

Liliam da Silveira Guimarães Gomes, Daiane Johann, Rosana Dangui

Digital transformation readiness in large manufacturing firms: A proposition of a prognostic model

Abstract ID#294

Clarissa Rocha, Fernando Deschamps (Pontifical Catholic University of Paraná)

Context

As digital innovation becomes increasingly crucial to the success of companies in creating new value for their businesses, it is important to understand how incumbent companies can prepare to operate digital projects and practices more effectively. One way to do this is through a readiness analysis whose focus is to survey the status of the company and point out the strengths, weaknesses, and barriers that exist in the organization and should be considered in their Digital Transformation (DT) efforts. Although there are several models of digital readiness and maturity being applied, there is still a significant lack of academic studies that empirically discuss how to prepare for digitalization, especially in developing countries that normally have among other difficulties, external challenges at the governmental, legal, and macro-economic level. Furthermore, there is a gap between digital assessment models that are developed for industrialized countries, and those developed for emerging countries.

Purpose

The objective of this article is to identify the main factors internal and external to the =firm to assess the readiness level of manufacturers to implement their DT.

Literature Review

In the theoretical review, the concept of DT is defined and delimited (Culot et al., 2020; Saarikko et al., 2020). In this definition, it is explained how the digitization process can deliver value and competitive advantages to the business. Subsequently, the complexity and diversity of strategic, managerial, social, technological, and external aspects (Ghobakhloo & Iranmanesh, 2021; Chauhan et al., 2021; Rezqianita & Ardi 2020; Kumar et al., 2021) of the firm are presented and discussed, and their role as drivers for business digital preparation.

Methodological Procedures

Based on the literature review, theoretical propositions were elaborated and evaluated in cases of 5 Brazilian and 4 British manufacturers. Non-participating observations and in-depth semi-structured interviews with tactical and strategic level employees were conducted, and had their content analyzed by codification. Therefore, this research adopted an exploratory qualitative approach to understand the diversity of preparatory aspects that factories should be aware *before* operationalizing digital projects.

Findings

Based on case findings, this article developed a building blocks framework of factors that may assist companies to prepare for the change towards digitalization. As for the main results, the article: (1) proposes a comprehensive forecast on which aspects companies need to consider for digital readiness; (2) concludes that few firms understand the DT concept, its opportunities, and risks in detail;

(3) shows that it is necessary to invest time and money in strategic and socio-management preparation for DT; (4) points out government support as crucial to assisting in the business digital journey; (5) highlights that DT is a human transformation, and people, as technology users, are the main agents of this change. The study also compared and evaluated two different macroeconomic environments (Brazil and the United Kingdom) for organizational DT, and what are the main difficulties faced by each country.

Implications and Contributions

The article can help companies identify the factors they should critically evaluate before operationalizing digital innovation practices, so that they can leverage their business model, whether existing or entirely new. Given the diversity of drivers identified, it is perceived that the operationalization of digital projects is multifaceted and depends on the preparation of a digital infrastructure (Technological Driver), on a reorientation of the organizational strategy that emphasizes and encourage the operationalization of digital innovation projects in a gradual and participatory manner (Strategic Driver), from leadership and digital sponsors that encourage change management. Such management needs, among other aspects, to include a renewal of capabilities, encourage collaborative behavior and foster a digital mindset and a culture of continuous learning for all employees (Social and Managerial Drivers). Digital readiness is also highly influenced by external aspects (e.g., existence and level of pro-digital government policies and incentives; regulations; legal issues) that the firm hardly controls. The proposed model also provides a prognostic view, pointing out possible actions to be taken, generating guidelines for digitalization preparation.

Originality

This is one of the first empirical scientific articles to propose a DT readiness model based on the perceptions of large manufacturers, confronting the differences and similarities of factories located in a emerging versus a developed country. The preparatory factors for DT mapped can provide practitioners, policymakers, and future researchers guidelines for further research and practice in enabling digital projects in manufacturing. The paper provides empirical evidence to spawn other empirical investigations in the domain of digitalization.

Research Limitation and Future Studies

All research findings need to be interpreted according to the realities of the nine cases and their specific industrial segments. Future research might also conduct studies that more specifically examine the role of organizational learning and dynamic capabilities in the DT process, as well as new ways of looking at organizational ambidexterity and business model innovation. Such research could provide detailed insights into how organizational learning occurs and how organizations can reach the next level of transformation.

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Understanding innovation system in law enforcement agencies

Abstract ID#289

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Purpose

Systematic innovation has become an essential endeavor in a fast-paced technological context in which organizations are embedded nowadays. In law enforcement organizations, it is not different. The importance of innovation is also increasing in the sector (Buades et al., 2015; Weisburd & Braga, 2006). However, innovation literature in this type of organization is still sparse and nascent (Matusiak & King, 2020). It has not explored the contingencies and particularities of the innovation systems in this context. In these circumstances, this study expects to fulfill this gap. Thus, the research aims to better understand the innovation management systems in the context of law enforcement agencies by characterizing their main roles and configurations. That said, this research seeks to answer the following question: How do law enforcement agencies organize themselves for innovation?

Literature Review

The literature provides several recommendations to coordinate innovation activities in organizations. For O'Connor et al. (2008), organizations need systems designed for innovation activities to make them function effectively and efficiently. However, even though we have a general understanding of the elements to organize it, there is no best system but the one that better works in interaction with the specific organizational context (Shenhar, 2001). In that regard, law enforcement agencies as part of the public sector have some specifics regarding innovation. In this sector, innovation is usually not as incentivized as in the private sector (Potts & Kastelle, 2010). Due to the stability and development of routines, these organizations tend to become more resistant to change and generally, they are unresponsive in environments that require fast responses to complex and dynamic situations (Engel & Worden, 2003). Yet, these organizations still need to create value, increase their performance, and maintain their legitimacy, requiring innovation (De Vries et al., 2016). Furthermore, the police sector operates in the service logic, which differs from the conventional commercial logic. It presupposes different production characteristics and objectives (Zarifian, 2001). In these circumstances, it is important to understand how the police organize themselves to innovate in a context of public service provision.

Methodological Procedures

We used an inductive strategy to describe and explain how innovation occurs in policing worldwide. We relied on a multiple cases analysis to support theory building in a more robust, testable, and generalizable way (Eisenhardt & Graebner, 2007). Thus, five agencies in five different countries compose the cases studied. Data were collected mainly through semi-structured interviews with the agencies' innovation leaders and document analysis.

Findings

As a result, we have identified that all the studied agencies have a dedicated structure for innovation, which varies in size and position in the agency's hierarchy. They present different levels of breadth and depth of innovation activities and different strategic focuses. Correspondingly, we described two types of Innovation management systems: heavyweight and lightweight. The heavyweight has more substantial penetration in the organization's innovation activities, and the lightweight has a lower penetration. We also highlighted the participation of innovation brokers from within the units, responsible for connecting other functions with the innovation management team, ensuring the alignment of the unit with the global innovation strategy.

Implications

In brief, the different ways to organize offered interesting insights that we discuss with innovation management literature lens. It helped to better understand the roles and characteristics of innovation systems in law enforcement and the challenges they face to innovate systematically. Moreover, our findings can serve as the initial prescriptions for new organizational efforts to systematize innovation in law enforcement organizations. We expect to enlighten other public agencies to move forward in systematically innovating to be able to navigate in a dynamic environment.

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Innovation labs and(in) business fairs: reflections and possibilities

Abstract ID#123 | Full paper ID#390

Debora Regina Locatelli (Federal University of South Frontier); Magnus Emmendoerfer, Thiago Chagas de Almeida, Alessandro Carlos da Silva Junior (Federal University of Viçosa)

Abstract: This theoretical paper aims to discuss the possible articulation between innovation laboratories and trade fairs. It was developed with a non-systematic bibliographical selection involving innovation labs and trade fairs in international databases. Considering their contributions to the study, the selected texts were critically analyzed. As a result, it was identified that the innovation labs have needs that can be attended by the trade fairs, working together with them, adding a differentiated service for exhibitors and visitors through the exchange of knowledge, cooperation, and proposition of innovative solutions, provided by the use of agile methodologies. Thus, this research advances the understanding of the relationship between two mechanisms for collaborative innovation usually discussed by the literature separately: innovation labs and trade fairs.
Keywords: innovation labs, trade fairs, innovation, collaboration.

Introduction

Trade fairs still need to be researched better. Sarmento and Simões (2018) write that conceptual articles are scarce and indicate the potential for building theoretical foundations on the subject. Trade fairs represent markets concentrating the leading industry-related players in a single space and a short period (Rinallo & Golfetto, 2006).

They can be called vertical when they promote products and services for a single industry or horizontal when they generate offers for various sectors (Kijewskia, Yoona & Youngb, 1993). Exhibitors and visitors seek to participate in fairs that provide high-quality business opportunities and services (Jin, Bauer & Weber, 2010). Trade fairs are promotional tools for various products in the experiential world of the 21st century (Rai & Nayak, 2018).

Kirchgeorg, Jung, and Klante (2010) state that trade fair organizers should offer a wide range of services and play new roles, such as brokers and networking facilitators. Sarmento and Farhangmehr (2016) point out that trade shows that provide quality services end up attracting more engaged stakeholders.

Furthermore, the literature highlights innovation as one of the most important objectives for participation in trade fairs (Hansen, 1999; Silva, Vale & Moutinho, 2021). Therefore, when trade fairs place innovation as part of their strategies, this positively affects their performance (Chiou, Hsieh & Shen 2007). Sarmento and Simões (2018) conclude that visitors' overall satisfaction and intention to participate in future editions are determined by the products' quality and innovation and by the experience provided in the interaction with the exhibitors' staff.

Some of these characteristics connect to the attributes of innovation labs. A lab is a participatory process that brings together people with different points of view (Pathways Network, 2018) in arenas where new solutions are developed (Malmberg et al., 2017; Olavo, Beneyto, Nebot, & Emmendoerfer, 2022b). They facilitate participatory processes, encourage innovation and experimentation, are results-oriented, and aim to generate concrete solutions (Asenbaum & Hanusch, 2021).

These laboratories can be configured in different ways, with varying work methodologies, institutional arrangements, teams, project types, and autonomy levels, among other institutional and organizational factors, which ultimately influence their capacity and results (Ferrarezi, Lemos & Brandalise, 2018). Furthermore, they offer opportunities for learning (formal and informal) and creative problem-solving, enabling the creation of new products, services, or processes (Rosenow-Gerhard, 2020).

Based on these characteristics of trade fairs and innovation labs, some questions emerge: could trade fairs support physical and virtual innovation labs to expand the range of services offered, improve the interaction between participants, and intensify the exchange of information and knowledge? What would be necessary so innovation labs could be implanted in trade fairs? Which elements/indicators/factors show that innovation labs can work in trade fairs? Which elements/indicators/factors can limit or inhibit the implantation of innovation labs in trade fairs?

Thus, this study aims to theoretically discuss the possibility of implementing innovation laboratories in trade fairs. This theoretical essay is organized into six parts. The first part contextualizes and presents the subject. Next, the methodological choices are exposed. The third and fourth parts discuss, respectively, innovation laboratories and trade fairs. Then an interrelationship between these two themes is made, and finally, the final considerations.

Methodological Procedures

This study is characterized as a theoretical essay. The main contribution of this type is to consider separate academic work and contemplate an integrative perspective jointly. The theoretical paper has a critical stance, which presents a leap "(...) to the unknown, unusual, and unaccepted by the system" (Boava, Macedo & Sette, 2020, p. 70). Although the theoretical essay does not have methodological rigor, its main strength is in the reflective property to understand reality and be used consciously and intentionally to understand a subject (Meneghetti, 2011).

A non-systematical and exploratory selection of bibliographies about innovation labs and trade fairs in international databases developed the research. The selected texts were analyzed to deepen the subject and provide contributions to the study. Afterward, the selected excerpts were analyzed critically to compose the essay, highlighting the main elements that unite the literature to present a theoretical construction aimed at theoreticians and practitioners concerning innovation environment (laboratories) implementation in trade fairs.

Innovation Labs

Innovation labs are not considered a new phenomenon but have recently become more prominent (Tõnurist, Kattel, & Lember, 2015). Until the 2000s, innovation labs were seen only as a research infrastructure, such as a building or a set of buildings. Later, they started to be used to support innovation projects with a dynamic network of multiple stakeholders (Pino et al., 2013). Their main goals have been to drive and manage user-driven innovation in realworld settings (Pino et al., 2013) and to stimulate interaction between technological and socioeconomic forces (Franz, Tausz & Thiel, 2015).

Although innovation labs have become a popular tool (Franz, 2015), academic and practical studies on the topic are still needed (Gryszkiewicz, Lykourentzou & Toivonen, 2016; Hossaina, Leminen & Westerlundd, 2019; Niitamo, Kulkki, Eriksson & Hribernik, 2016; Tõnurist, Kattel & Lember, 2017). However, this research field has gained visibility, which is not always positive, as studies can become fragmented and diverse (Greve, Vita, Leminen & Westerlund, 2021).

Labs come in different shapes and sizes according to cultural contexts, creators' intentions, participants involved, and other nuances of their creation and management. They can be short-lived events or long-lasting institutions (Feitoza, 2018; Gryszkiewicz et al., 2016). These characteristics provide labs with multiple classifications and nomenclatures, which can result in endlessly complex and ultimately unusable terminology (Asenbaum & Hanusch, 2021). However, there is still no widely accepted definition of innovation labs (Baccarne, Schuurman & Seys, 2013; Leminen, Turunen & Westerlund, 2015; Robles, Hirvikoski, Schuurman & Stokes, 2016). The absence of a widely recognized definition (Grotenhuis, 2017) indicates the lack of a common understanding of the concept and its meanings (BergvallKareborn & Stahlbrost, 2004; Bezerra, Pereira, Brito, & Bresciani, 2022). Table 1 briefly presents some definitions found for innovation labs or living labs.

Tabel 1

Innovation Lab Definitions

Definition	Author(s)
Experimentation environment where technology takes shape in real-life contexts and where (end) users are considered "co-producers".	(Bergvall-Kareborn, Ihlström, Stahlbröst, & Svensson, 2009)
Infrastructure design based on the systematic involvement of users in an innovative process under real-life conditions.	(Leminen, Westerlund and Nyström, 2012)
Collaboration space to create, prototype, validate, and test new technologies, services, products, and systems in real-life contexts.	(Leminen *et al.*, 2012)
Networks composed of heterogeneous actors, resources, and activities that provide a platform for developing and applying user-driven innovation.	(Leminen *et al.*, 2012)
Multi-stakeholder collaboration space and end-user involvement are the core elements of an approach.	(Baccarne *et al.*, 2013)
Emergent approach that involves multiple users to co-create value that leads to innovation.	(Veeckman, Schuurman, Leminen & Westerlund, 2013)
Semi-autonomous organization, in which different actors participate on a long-term basis with open collaboration, to work out solutions to "open-closed" systemic challenges.	(Gryszkiewicz *et al.*, 2016)
User-centered research methodology to detect, prototype, validate, and refine complex solutions in multiple and evolving real-life contexts.	(Niitamo *et al.*, 2016)
Innovative tool that provides opportunities for testing, validation, development, and co-creation at all stages of a design and commercialization process.	(Buhl, Von Geibler Echternacht & Linder, 2017; Leminen, Rajahonka & Westerlund, 2017)
Space for the participatory involvement of various stakeholders who co-create solutions to a given problem, not just verbally, but in practice, whether they are physical or digital objects and must then be tested and validated, if necessary refined or reinvented until approval.	(Asenbaum & Hanusch, 2021)
Innovation labs, or living labs, can be defined as a methodology geared toward two main ideas: involving users in an early stage of the innovation process and experimenting in a real-life context.	(Nguyen & Marques, 2022)

Source: Elaborated by the authors (2022).

When analyzing the definitions of innovation labs, commonly identified factors involve the participation of different actors/stakeholders, collaboration, and the creation of products, services, and processes, not only conception. The stakeholders involved in innovation labs can include suppliers, customers, users, competitors, universities, and other organizations (Leminen et al., 2017).

Network-based multi-actor collaboration may be one factor that has attracted attention to innovation labs (Leminen et al., 2015; McPhee, Leminen, Schuurman Westerlund & Huizingh, 2016; Leminen et al., 2012). This provides an open and dynamic research and innovation ecosystem involving solution developers, local authorities, policymakers, and user communities (Leminen et al., 2012; Nguyen & Marques, 2022; Vecchio, Elia, Ndou, Secundo & Specchia, 2017). Different actors' participation is necessary because a single organization has limited capacity. Gryszkiewicz et al. (2016) and Tõnurist et al. (2017) reinforce the need for collaboration between agents and the ability to coordinate users' interdisciplinary needs.

In this study, an innovation lab is understood as a platform that provides shared resources and integrates a variety of private and public stakeholders to gather, create, communicate, and deliver new knowledge; validate existing products, services, and processes; and facilitate professional development and social impact (Westerlund, Leminen, & Rajahonka, 2018). Given their definition, labs have several benefits: they help conduct experiments and obtain user feedback, providing a place where co-creation is facilitated (Hyysalo & Hakkarainen, 2016); they can tap tacit knowledge that can be used to translate latent user needs into new products and services, or improve existing ones (Franz, 2015; Leminen et al., 2012); and provide governance and a framework for collecting user insights and filtering problems to support entrepreneurship (Hakkarainen & Hyysalo, 2013; Silva, Vale, & Moutinho, 2021).

Labs produce outcomes: tangible, such as designs, products, prototypes, solutions, and systems; and intangible, such as concepts, ideas, property rights, knowledge, and services (Buhl et al., 2017). These outcomes are based on the labs' ability to facilitate co-creation and improve access to knowledge (Leminen, Nyström, Westerlund & Kortelainen, 2016), which decreases market risk when launching new offerings, increases return on investment, and accelerates the time to put outcomes into operation (Niitamo, Westerlund & Leminen, 2012).

Business Fairs

Business fairs are physical meetings where manufacturers, distributors, and suppliers meet and exhibit their products or describe their services to invited people, including current and potential customers, suppliers, other business partners, and the press (Bonoma, 1983). Sarmento and Simões (2019) write that business fairs are events where participants interact face-to-face or virtually. The context of trade fairs can be: business-to-business (B2B), with actors belonging to the trade, or business-to-consumer (B2C), open to the general public (Palumbo & Herbig, 2002).

Trade fairs can also be temporary and cyclical clusters/ecosystems (Bathelt & Schuldt, 2008; Power & Jansson, 2008; Rinallo, Bathelt & Golfetto, 2017). These temporary platforms allow for vertical interactions with companies belonging to partner or competitor industries; and horizontal interactions with companies in the same industry, which provides interactive learning, knowledge creation, and networking (Bathelt & Schuldt, 2008).

Fairs create the opportunity for information exchange and formal and informal social interaction, which can reduce relational distance and increase trust between business partners (Borghini, Golfetto & Rinallo, 2006; Hansen, 1999; Rinallo, Borghini & Golfetto, 2010; Rosson & Seringhaus, 1995; Sarmento, Farhangmehr & Simões, 2015). Trade fairs allow close contact over a period of time (Bathelt & Schuldt, 2008). Moreover, they have an informal atmosphere (Sarmento et al., 2015) with emotionalized scenarios (Kirchgeorg et al., 2010), full of sensory stimuli (Borghini et al., 2006; Rinallo et al., 2010), which ends up promoting interactions among participants (Sarmento et al., 2015). In this way, they become multidimensional relational spaces (Rinallo et al., 2017).

Trade fairs propagate knowledge and customer engagement, representing privileged communication contexts (Rosson & Seringhaus, 1995; Sarmento et al., 2015). They also provide a favorable environment for developing positive emotions towards the company or the brand (Sarmento & Simões, 2018). Thus, a fair environment is rich in information and learning (Rinallo et al., 2010), generating macro and micro-level effects for participants (Borghini et al., 2006).

Many companies use trade fairs to present their products at different development stages (Kim & Mazumdar, 2016), and visitors search for new products/equipment at them (Westwood, Schofield & Berridge, 2018). Trade fairs that encourage interaction and knowledge exchanges are rich environments for innovation (Sarmento et al., 2015). However, it is still necessary to understand how this knowledge can be shared among the participants to improve innovation practices (at the individual, organizational, and industry levels) and if it occurs only at the fair or before and after the event (Sarmento & Simões, 2018).

Innovation Labs and Business Fairs: Reflections and Possibilities

Considering trade fairs and innovation laboratories, it can be observed that they can act complementarily, stimulating the innovative process. This is because trade fairs are environments full of sensory stimuli (Borghini et al., 2006; Rinallo et al., 2010), which mobilize interactions and relationships among participants (Sarmento et al., 2015). In this way, they are an enabling space to gather, create, communicate, and deliver new knowledge; validate existing products, services, and processes; and facilitate professional development and social impact (Westerlund et al., 2018). In other words, it is a necessary environment for the innovation lab to intensify the exchange of information and knowledge between different actors.

For innovation labs to be implemented in trade fairs, organizers must be interested in promoting one more service to the participants. This would add even more value to the fair and its businesses. Therefore, it is necessary to involve public authorities, the entities related to the fair's focus sector, educational institutions, exhibitors, and visitors. Multi-actor collaboration is essential, as it is one of the factors that has attracted attention to innovation labs (Leminen et al., 2015; McPhee et al., 2016; Leminen et al., 2012) and creates an open and dynamic research and innovation ecosystem (Leminen et al., 2012; Vecchio et al., 2017), which is a fair's function.

The factors demonstrating that innovation laboratories can work in trade fairs are: fairs integrate different actors of the same business sector (Bathelt & Schuldt, 2008), and they enable lab implementation since they require the participation and collaboration of various actors/stakeholders (Asenbaum & Hanusch, 2021; Baccarne et al., 2013; Gryszkiewicz et al., 2016; Leminen et al., 2012; Veeckman et al., 2013).

Laboratories - since they can adapt their action, size, and duration - would be adaptable to the fair formats, which are currently physical or virtual (Sarmento & Simões, 2019), being traditionally temporary and cyclical ecosystems (Bathelt & Schuldt 2008; Power & Jansson, 2008; Rinallo et al., 2017). In addition, laboratories can bring together different stakeholders, allowing information and knowledge exchanges, and enhancing collective learning (Nguyen & Marques, 2022).

Another element that supports innovation laboratory implementation in trade fairs is that they allow face-to-face contact for some time (Bathelt & Schuldt, 2008). This enables the opportunity for information exchange, social interaction, and increased trust among business partners (Borghini et al., 2006; Hansen, 1999; Rinallo et al., 2010; Rosson & Seringhaus, 1995; Sarmento et al., 2015) and disseminates knowledge (Rosson & Seringhaus, 1995; Sarmento et al., 2015) and innovation (Sarmento et al., 2015). Therefore, fairs would be favorable environments for the development of innovation labs (Franz et al., 2015; Pino et al., 2013).

Another facilitating attribute is that laboratories seek to transform user needs into new products and services or improve existing ones (Franz, 2015; Leminen et al., 2012). Many companies use trade fairs to present their products in different development stages (Kim & Mazumdar, 2016), and visitors seek new products/equipment at trade fairs (Westwood et al., 2018). Thus, visitors/users could tell companies their needs and participate in creating a solution during the fair through experimentation, contributing to product improvement, or generating new ideas for future products.

Furthermore, Celuch (2021) states that global emergencies require organizations, regardless of sector, to move beyond the status quo of their current practices and work to meet the Sustainable Development Goals (SDGs) for positive impact. In this regard, the United Nations (2020) already indicates a need to build resilient infrastructure, promote sustainable industrialization, and foster innovation for organizations to survive in the future. However, the absence of public policies and trade fair organizers' and stakeholders' lack of understanding/engagement can inhibit innovation lab implementation at fairs.

Final Considerations

This theoretical study enabled discussions about innovation labs at trade fairs. In the academic field, the debate concluded that innovation labs could be implemented in trade fairs, whether virtual or physical. Business fairs contemplate many of these elements because innovation laboratories need a dynamic collaboration environment to be implemented, facilitating innovation. Moreover, they can gather all of a sector's supply chain during the fair. Innovation laboratories also can easily adapt their functioning to particular demands by using agile methodologies and technological instruments that enhance their results.

Based on the reflections in this work, fair organizers should prepare themselves to articulate with innovation laboratories, which will add value to the event and mobilize participants. If organizers can't see this possibility, the higher education institutions, the innovation promoters, and the government can encourage this action, aiming to bring benefits to all involved and forming partnerships with the different actors.

It is also worth reflecting on why this articulation is not yet a widely developed practice. Or, if it is, why hasn't the academy turned its attention to this phenomenon? This essay may subsidize trade fair organizers and public policymakers with information to implement innovation laboratories in trade fairs. Because of this, this research is the first step to glimpse innovation laboratories operating in fairs and may contribute to information exchange, knowledge expansion about a particular subject, and problem-solving for a sector or customer.

However, this theoretical paper has limitations, mainly because it depends on the involved researchers' point of view, thus having a conceptual bias from their experiences. Furthermore, the material selection may have left out important information. In this sense, it is recommended that future research investigate the findings obtained here through other methodological approaches and an empirical bias.

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Strategic flexibility, intramural R&D, and uncertainties: Understanding their relationship in turbulent times

Abstract ID#254

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Purpose

Environmental turbulence is a great source of uncertainties and managers need to develop strategies to react to unpredictable changes. Strategic Flexibility, as a type of Dynamic Capability, might be a relevant strategy for firms dealing with uncertainties caused by turbulences. Moreover, it is important that firms develop absorptive capacity, and Research and Development (R&D) can contribute to achieving this goal and keep their competitiveness in these periods. Regarding this context, this research aims to deepen the understanding of the relationship between Strategic Flexibility, intramural R&D, and the impact of uncertainties on the introduction of product and process innovation. In other words, the goal is to understand if, in innovative firms, which invest in Strategic Flexibility and intramural R&D, the presence of Strategic Flexibility and intramural R&D can decrease the effect of uncertainties on innovation projects.

Literature Review

Strategic Flexibility is the ability of the firm to adapt to environmental changes (Saeed, 2021), can be understood as organizational flexibility (Aaker & Mascarenhas, 1985) and it has been highlighted as relevant for firms' survival in contexts with high levels of turbulence. One reason for this is that Strategic Flexibility is a type of Dynamic Capability (Zhou & Wu, 2010) whereby managers develop strategies to reconfigure organizational processes and routines (Teece, Pisano, & Shuen., 1997). The literature suggests the relationship between Strategic Flexibility and R&D (e.g. Aaker & Mascarenhas, 1985). Many studies have been carried out regarding Dynamic Capabilities and uncertainties such as market and technological uncertainty. However, there is a need for studies considering Dynamic Capabilities and deep uncertainties (Kano, 2021). From the literature, we developed eight hypotheses regarding if the presence of Strategic Flexibility and in-house R&D can decrease the impact of technological and market uncertainties on product and process innovation. The novelty of this research is to investigate these relationships into different levels of environmental uncertainties, named deep uncertainties, caused by financial turbulence.

Methodological Procedures

This research was carried out using The Community Innovation Survey (CIS) database, (CIS4 – period before the subprime crisis, CIS10 – period during the crisis). Only firms that answer yes for the introduction of innovation were considered. The CIS4 data set is made up of 11 countries and 24,214 observations, CIS2010 is also constituted of 11 countries and 27,389 observations..the method of analysis is logistic regression. Dependent variables: INNOV_PROD and INNOV_PROC were developed from the questions related to the introduction of new products/services and new processes. Independent variables: technological and market uncertainties were measured from questions related to lack of information on the market – INF_UNCERT, and lack of information on technology – TEC_UNCERT (Ramirez et al. 2018). The questions were measured on a four-item scale (no=0, low=1, medium=2, high=3), however, they were transformed into binary variables to better fit this research, that is, high uncertainty (3 and 2) and low uncertainty (0 and 1). Control variables: Internal R&D was operationalized from binary questions if the firm has intramural R&D (RRDIN). Strategic Flexibility is related to organizational flexibility. We created the variable FLEX_FIRM from the questions if the firm introduced or not new business practices, new methods for working and decision making, and for organizing external relations.

Findings

The results (Table 1) confirmed only hypothesis H2a once that in the presence of Strategic Flexibility and intramural R&D the impact of the market and technological uncertainties on product innovation decreases, regarding the period of the high level of turbulence, therefore, deep uncertainty period. Hypotheses H1b and H2b related to the impact of market and technological uncertainties on the process were not confirmed, in the period of a high level of turbulence, with the presence of only Strategic Flexibility or Strategic Flexibility and intramural R&D. To deepen the understanding of the positive effect of uncertainties we carried out a mediating effect analysis, which pointed out the interesting mediating effect of Strategic Flexibility and Strategic Flexibility and intramural R&D into uncertainties (market and technological).

Table 1 – hypotheses results according to the level of turbulence

Level of turbulence	Hypothesis	Results	
high	H1a	product	partial
	H1b	**process**	**Not confirmed**
low	H1c	product	partial
	H1d	process	partial
high	**H2a**	**product**	**confirmed**
	H2b	**process**	**Not confirmed**
low	H2c	product	partial
	H2d	process	partial

Implications

The main implications are related to the relevant role of Strategic Flexibility, as a Dynamic Capability for firms to survive and keep their competitiveness in times of deep uncertainty. We highlight the synergy between R&D and Strategic Flexibility, then R&D projects might be benefited from Strategic Flexibility and both of them might be relevant strategies for the firms to couple with uncertainties. Managers can exploit the positive effect of uncertainties from investment in Strategic Flexibility and/or intramural R&D. This study contributes to the literature by pointing out the effect of Dynamic Capabilities considering the deep uncertainties, and also, regarding the impact of Dynamic Capabilities on those variables generally used as moderating and/or antecedents of Dynamic Capabilities. The database used in this study comprises European countries, then which is a limitation. We suggest studies from different contexts such as countries from Latin America and also, longitudinal and qualitative studies deepening the understanding of DC and deep uncertainties.

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Circular economy and artificial intelligence analysis: An integrative literature review

Abstract ID#309

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Purpose

The digital revolution has brought many challenges and opportunities for businesses. The relationship between the circular economy (CE) and artificial intelligence (AI) are emerging topics that have been gaining deep interest in the academic world yet have been little researched.

Literature Review

The concept of Circular Economy has been gaining momentum since the late 1970s (EMF, 2013). The emergence of the circular economy occurred upon the identification of the linearity of the existing economic model. Little has changed since the advent of the Industrial Revolution in the 18th century, in terms of production and consumption patterns, based on a production-consumption-disposal model.

In the current development conjuncture, the original economic model must change, considered harmful to the ecological system. One of the alternatives for this change is the development of circular actions, putting into practice what the CE proposes (Amui et al., 2016). For Pomponi and Moncaster (2017), the CE emerges as a new paradigm, gaining momentum and promising to overcome the existing contradiction between the economic and the environmental, where they also reinforce the idea that resources should never be turned into waste, but rather kept in the process for as long as possible and with minimal loss of quality.

New directions are set as times move forward; the beginning of AI precedes the very construction of machines. However, questions arise, even to this day, putting the advances in the field of AI in check. There are those who believe that it will be a substitute for humanity and, on the contrary, there are those who propose that AI will coexist with humanity in an environment of mutual interest.

In Genesereth and Nilsson's (2012) understanding, AI is a broad area of research that subdivided into several subareas, each of them adopting different approaches and addressing different problems that, in general, are of high complexity. However, advances in the field of AI seek coexistence, since machines with AI depend on a human to program it, provide data, and give guidelines. Its operation does not fit in a world without human life. Industry 4.0 is a reality and among its enabling technologies, AI, encompassing ML, DL, Big Data and Analytics, Data Mining and Data Literacy for example. A company willing to become circular cannot but consider I4.0 technologies in its value chain. According to Okorie et al., (2018), a company willing to become circular cannot help but consider I4.0 technologies within its value chain.

Methodological Procedures

To conduct this study, a literature review proposed, through an Integrative Literature Review (RIL), the systematic search took place on October 15, 2021, in the Scopus database. The present research has a qualitative, descriptive, and exploratory approach. A research framework to integrate these concepts proves necessary, this study provides a systematic literature review synthesizing conceptual and empirical research demonstrating the CE-IA nexus. By aggregating empirical and theoretical studies, which differs from systematic reviews that limited to the empirical, RIL enhances the ability to implement evidence-based practices (Whittemore & Knafl, 2005).

Cronin, Ryan & Coughlan's (2008) protocol used to provide greater rigor, and the RIL steps followed in this study, filters applied to refine the object of study. Three questions designed to guide the achievement of the study objective: 1) What are the trends and gaps in existing research? 2) What are the relationships between constructs? 3) Identify the main challenges and requirements that must met to implement the principles and strategies of CE and AI.

The originality of this review article is based on the expansion of the knowledge base that the work proposes. The search conducted by the boolean operators "*circular economy*" AND "AI" OR "*artificial intelligence*" OR "*machine learning*" OR "*neural network**" OR "*deep learning*", and after applying the filters, resulted in 348 documents, being the initial research sample. For data analysis we used descriptive analysis, bibliometric analysis with the support of the Vosviewer software. Content analysis was of the thematic categorical type, a fragment of text can give rise to a category of analysis.

Findings

An increase in interest in AI and CE research detected from 2019. With most articles coming from China, followed by the UK and India. The most representative areas are Engineering, Computer Science and Environmental Science. A representative number of articles consider AI to implement Industry 4.0 in the circular economy. Most articles feature AI to improve sustainability. Food and waste also stand out with application areas of AI for CE. In addition to some articles considering AI as a tool to improve CE, others also used AI to perform the review.

Implications

By exploring the applications of AI techniques in improving the adoption and implementation of CE practices, the need for research and expansion of knowledge is evident. This study also discusses research directions, future opportunities for AI applications in CE, for example, an exploratory review can conduct considering other emerging technologies such as blockchain, internet of things, argumentative reality, big data, etc. We proposed a future research framework, implications of the study and study-based conclusion, which could help industrial practitioners and researchers working in this field.

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PARALLEL SESSIONS

Day 3 – May 3rd

10h30h am – 12h30 am

- Industry 4.0 II
- Smart Cities and Regions I
- Strategy and Innovation II
- Research and Technology Transfer II
- Sectoral Innovation III

3h10 pm – 5h pm

- Special Topics on MOT III
- Innovation Capabilities IV
- Innovation Ecosystems III
- Entrepreneurship I
- Technological Innovation I

INDUSTRY 4.0 II

May 3rd: 10h30 am – 12h30 pm

Chair

Marthinus Pretorius (University of Pretoria, South Africa)

Papers

Towards Understanding the Fourth Industrial Revolution (4IR) Ecosystem for the Manufacturing Industries

Steven Zulu, Marthinius Pretrorius and Elma Van Del Linger

A fourth industrial revolution technology adoption framework for a water board

Marthinus Pretorius, Sumeshnee Manickum

Technological risks in industry 4.0: Proposal of a tool for identification

Gian Carlos Medeiros Hackbarth, Luis Mauricio Resende

I4.0: Opportunities for rail passenger transport

Michael Luciano Chaves Franz, Néstor Fabián Ayala

Industry 4.0 and biotechnology: The main trends

Thayline Vaz, Andre Renan Mayer, Fernanda Tavares Treinta

Towards understanding the fourth industrial revolution (4ir) ecosystem for the manufacturing industries

Abstract ID#118

Steven Zulu, Marthinus Pretorius, Elma Van der Lingen (University of Pretoria)

Purpose

There has been an increase of interest in understanding what technology and innovation ecosystems are and how they operate. Due the novelty of the Fourth Industrial Revolution technological phenomenon, the Fourth Industrial Revolution technological innovation ecosystem (factors, actors, complementaries and environment) are not yet well understood, hence the need for a study on the 4IR technological innovation ecosystem in the manufacturing companies. This research paper complements the existing literature of technology and innovation ecosystem by proposing a Fourth Industrial Revolution technological innovation ecosystem for the manufacturing industries.

The main research questions for this study are.

1. What is a Fourth Industrial Revolution technological innovation ecosystem?

2. Why is consideration of ecosystem critical for the adoption and implementation of 4IR technological innovation?

3. What are the key building blocks for a 4IR technological innovation ecosystem?

4. What are main roles of ecosystem members in the 4IR technological innovation?

The main objectives of this research study are.

1. To understand why a 4IR technological innovation ecosystem is critical for understanding and managing adoption and implementation of 4IR technological innovations in the manufacturing industries.

2. To understand the criticality of a 4IR ecosystem as an input into 4IR innovation/ transformation strategies.

3. Understand the factors and actors for the 4IR technological innovation ecosystem.

4. To establish a conceptually and operationally meaningful relationship amongst 4IR ecosystem conditions and actors.

Literature Review

The Fourth Industrial Revolution technologies are characterized, amongst others, by relatively higher levels of integration. Revolutionary technologies are characterized by the appearance of a significant innovation or a series of mutually supporting innovations (Carter, 2012). In addition, 4IR technologies present a different organizational and doctrine challenges to integrate, however, may offer an advantage if integration is successful. The advent of the Fourth Industrial Revolution has caused whole value chains to be objects of restructuring (Matt et al, 2015; Haverkort and Zimmermann, 2017) and it affects people, processes and products/ services (Brynjolfsson and McAfee, 2011).

With the advent of the 4IR technological innovations, new macro and microenvironment dynamics are introduced which will directly affect the success of the focal companies. This means new technological innovation ecosystems are emerging, which require characterization and understanding.

Moreover, it is important to understand the 4IR technological ecosystem as it directly influences the adoption and implementation roadmap of 4IR technologies.

According to Jacobides (2018), ecosystems are interacting organizations, enabled by modularity, not hierarchically managed, bound together. Teece (2007) views an ecosystem as a community of organizations, institutions and individuals that impact the company and company's customer and suppliers. The ecosystem represents an environment that the firm must monitor and react to, which affects its dynamic capabilities and thus its ability to build sustainable competitive advantage.

Methodological Procedures

Owing to the limited published scholarly work relating to Fourth Industrial Revolution technological innovation ecosystems, this research is based on a combination of integrative literature and exploratory research methodologies.

Findings

Understanding of the Fourth Industrial Revolution technological innovation ecosystem has at least the following benefits for the manufacturing companies;

• It helps companies understand which of the ecosystem conditions and actors are carrying higher risks. This aspect is critical for competitive advantage.

• Understanding of the 4IR technological innovation ecosystem is essential for the formulation and implementation of the Fourth Industrial Revolution transformation strategy.

• It also helps companies in aligning the critical path conditions and actors for the 4IR technological projects.

A Fourth Industrial Revolution technological innovation ecosystem model is proposed, considering, conditions, actors and complementaries. The proposed 4IR ecosystem model is based on the structure-conduct-performance (SCP) model used in industrial organization.

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A fourth industrial revolution technology adoption framework for a water board

Abstract ID#134

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Purpose

The water sector in South Africa is plagued with various challenges that include water insecurity, deteriorating water quality through emerging water contaminants, aging infrastructure, rising energy costs as well as increase in demands due to urbanisation. Water management is therefore a necessary requirement to address factors around increases in population sizes, water stresses and the risks surrounding pollution in water abstraction and supply sources. According to Alabi et al (2019), there are challenges associated with aging infrastructure, increased water losses through leaking pipes and infrastructure leaks. The water sector requires effective management through monitoring systems and water reliability control. The delivery of a water supply that is reliable can be achieved with the adoption of technologies capable of monitoring water systems in real time. It is noted by Li (2020) that a Smart Water Management System (SWMS) provides the realisation of real time data and allow monitoring of water systems continuously, monitoring access to a wide range of parameters that include the performance of equipment, the quality and quantity of water, water balancing and other areas of concern for the WB thereby allowing for improved water management systems.

The objective of the research study was to develop a strategic framework for the adoption of Fourth Industrial Revolution (4IR) technologies that will assist the WB in transforming to a SWMS. The research questions therefore included (i) what are the most suitable 4IR technologies for the water boards transition to a smart water management system, (ii) what are the factors that can be integrated in the existing water boards processes for the adoption of 4IR technology and (iii) what are the guidelines for how the identified factors should be integrated in a strategy to manage the water board's shift to a smart water management system?

Literature Review

Cosgrove (2015) identified the typical challenges experienced by the water industry as (i) poor maintenance of assets and aging infrastructure, (ii) environmental and sustainability challenges, (iii) water demand and supply, (iv) water asset operational efficiencies, (v) aging workforce and skills shortages and (vi) electricity costs. According to Kim et al (2020), a SWMS can enable efficient allocation of water, the prediction of future demands and real time response to changes in water quality. The Korean Water Resource Cooperation has defined a SWMS as real-time ICT solutions, such as sensors, monitors, geographic information systems, satellite mapping, and other data sharing tools to provide realtime, automated data to resolve water-related challenges through integrated water resources management. Technologies such as Big Data & Analytics, Internet of Things (IoT) and Cloud technology have been identified to provide opportunities for the water sector. Literature analysed the factors that influence the adoption and acceptance of technology and these theories have been applied traditionally for ICT technology adoptions. The TOE framework identifies the influences of the organisation's adoption decisions framework and provides a holistic approach to technology adoption as it incorporates multiple perspectives.

Methodological Procedures

The proposed framework incorporated the integration of the relevant 4IR smart water technologies, the factors that must be considered to ensure successful adoption of technology and the strategic guidelines that are essential for the development of detailed plans for technology adoption. The study used the Technological– Organisational–Environmental (TOE) Framework to identify the technology adoption factors and is complimented with the Technology Acceptance Model (TAM) to establish the user's acceptance of 4IR technology. A descriptive research design which is cross sectional and uses a mono quantitative methodology was selected. For the research proposed, the relationship between the independent and dependant variables was required to be established for the proposed hypothesis statements. Surveys were selected as the means of data collection with the selected research instrument as questionnaires.

Findings

The findings from the study has confirmed statistically significant relationships amongst the adoption factors and the WBs intention to adopt 4IR technology. Based on the TOE–TAM framework that formed the basis of identifying the influential factors, the study focused on eight factors consisting of technological, organisational and environmental contexts. There was a total of 9 hypothesis statements proposed that was statistically analysed using the Kruskal Wallis H Test. The TOE-TAM factors identified were found to significant in determining the WBs ability to adopt 4IR technology.

Implications

A final model was produced through analysis of the results which can be used by the WB to predict the use of 4IR technology in assisting to address the challenges experienced and allow for the successful management of water services. Therefore, for the WB to embark on its journey to a smart water utility, factors that include technology readiness, perceived benefit and usefulness, top management support, workforce skills and competencies, financial resources, culture and attitude, competitive pressures and government regulations/policy must be integrated in the WB's business structures.

Recommendations for future studies included (i) the inclusion of a broader range of Water Boards in different geographical areas to determine their current challenges with the adoption of smart technologies and determine any additional criteria that must be considered for adoption, (ii) researching and analysing other technological, organisational and environmental factors that has not been covered under this study, (iii) extension of the study to include case studies from developed countries that have implemented a smart water management system successfully and (iv) a study based on qualitative methodology to investigate additional factors that impact on the adoption of new technology at WBs.

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Technological risks in industry 4.0: proposal of a model for identification

Abstract ID#225| Full paper ID#479

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Abstract: This article presents a model for identifying technological risks associated with the transition to Industry 4.0. A systematic literature review was conducted to identify 24 risks that were subsequently classified into five dimensions, including digital, operational, cultural, economic, and social. The Analytic Hierarchy Process methodology was used to measure the importance of each dimension with the help of specialists in the field. The results indicated that the social, operational, economic, and digital dimensions had the greatest impact, while the cultural dimension was deemed less relevant and excluded from the model. Based on these findings, a visual model was proposed, incorporating the four dimensions with the most significant impact on the transition process. This study contributes to the growing body of knowledge on technological risks during the Industry 4.0 transition and provides a model for identifying and managing these risks, potentially benefiting industries, policymakers, and academics.

Keywords: risks, technology, industry 4.0.

Introduction

The world as we know today, with high levels of consumption, is only possible through an industrial sector that can produce products at a compatible speed and volume, which has not always been a reality. As is currently the case with Industry 4.0, other revolutions have radically changed the mode of production that society follows.

First introduced in 2011, the term "Industry 4.0" has become synonymous with the digitization of the industry, integrating complex topics such as the Internet of Things, Big Data, Cloud Computing, and Augmented Reality. Today, the term refers to a paradigm shift in the industry, combining physical and digital factors to digitize the means of production.

The adoption of this new paradigm has caused a mass modernization in the industry, with the use of intelligent systems, many sensors, and highly specialized professionals (Silva et al., 2020; Wang et al., 2020; Elteto, 2021; Isaksson et al., 2018; Freddi, 2017; Luco et al., 2019; Bonnaud, 2019; Sharma et al., 2020; Martins; Simon; Campos, 2020). With consumers' growing need for customized products and the ability to increase their profits, Industry 4.0 uses information and technology to improve production mode.

Every industry at some point in its existence will face challenges, whether due to external factors such as a change in the global market, a pandemic, or an internal crisis in the country, whether due to internal factors such as the change of management of the company or a strike by employees.

One of the exponents of risks for companies, whether small, medium, or large, is the implementation of new strategies in their operations. Despite offering competitive advantages to companies, paradigm changes such as Industry 4.0 raise doubts for the organization due to a lack of certainty about expected returns.

Industry 4.0 brings with it risks of social, economic, and technological dimensions, and added to the fact that it is a new area in society, this process can be problematic if implemented without planning and with realistic expectations.

The use of new technologies to achieve various objectives brings obstacles if they are used erroneously or in the wrong way, which can lead to the misuse of its benefits. With this, the appearance of risks linked to technology is expected in the adoption of Industry 4.0 in the most varied sectors.

This article aims to identify and analyze the technological risks present in the adoption of Industry 4.0 in the industrial sector. For this, a systematized bibliographic review will be developed primarily, Botelho et al. (2011) says it allows "obtaining research results from other authors to theoretically base a given theme".

After carrying out the systematic literature review, a systematization of technological risks present in the adoption of Industry 4.0 will be proposed, to define the susceptibility to technological risks that the company has.

Methodological Procedures

Systematic Literature Review

The systematic review of the literature was based on the proposal of Pagani, Kovaleski, and Resende (2015). The databases used were Scopus and Web of Science due to their relevance, quantity of available articles, and scientific quality. Three research axes "Industry 4.0", "Technology" and "Risks" were used, which were defined by reading articles on the subject, the first research on the databases was realized during May 2022. The list of keywords used in each axis can be seen in Table 1.

Table 1 - Combination of keywords

Axis "Industry 4.0"		Axis "Technology"		Axis "Risks"
'Industry 4.0' OR 'Industrie 4.0' OR 'Advanced Manufacturing' OR 'Industrial Internet' OR 'Smart Manufacturing' OR 'Fourth Industrial Revolution' OR 'Internet of Everything' OR 'Made-in-China 2025'	AND	'Technology' OR 'Technological' OR 'Internet' OR 'Infrastructure' OR 'Digital' OR 'IT' OR 'Automation' OR 'Digital Transformation'	AND	'Risk' OR 'Uncertainty' OR 'Uncertainties' OR 'Challenge' OR 'Barrier' OR 'Danger' OR 'Opportunity' OR 'Opportunities'

As a result, 117 articles were initially obtained, and through the application of the filters proposed by the Methodi Ordinatio methodology, a final portfolio of 51 articles was obtained. The exclusion steps can be seen in Table 2.

Table 2 - Combination of keywords

Stage	No of Excluded Articles	N. of Remaining Articles
Initial portfolio	-	117
Deleting duplicates	27	90
Title and summary deletion	28	62
Deletion by article reading	11	51
Final portfolio		51

The analysis was performed manually, along with the complete reading of the articles, therefore, no specific software or methodologies were used.

Results

With the full reading of the articles of the final portfolio, 26 risks were identified, of which they were grouped into 5 different dimensions, being: the digital dimension, the operational dimension, the economic dimension, the cultural dimension, and the social dimension.

Table 3 brings together all the dimensions grouped into subdimensions and dimensions and their appropriate references.

Table 3 - Dimensions and risks

<table>
<tr><th>Dimension</th><th>Undersize</th><th>Risk</th><th>Author</th></tr>
<tr><td rowspan="5">Digital</td><td rowspan="4">Infrastructure</td><td>Subsystems</td><td>(Fellow et al., 2018; LI et al., 2017)</td></tr>
<tr><td>Data collection and processing</td><td>(Christos et al., 2020; Bonnaud, 2021; Martins; Simon; Campos, 2020; Lall; Torvatn; Seim, 2017)</td></tr>
<tr><td>Delay in processing</td><td>(Li et al., 2017; Sharma et al., 2020, Martins; Simon; Campos, 2020)</td></tr>
<tr><td>Data storage</td><td>(Bonnaud, 2021; Sharma et al., 2020)</td></tr>
<tr><td>Safety</td><td>Data loss</td><td>(Vilkov et al., 2019)</td></tr>
</table>

		Information security	(Isaksson et al., 2018; Luthra et al., 2018; Li et al., 2017; Bonnaud, 2021; Sharma et al., 2020)
Operational	Quality	Drop in quality	(Resinger et al., 2018.; Claeys et al., 2015)
	Planning	Lack of strategies	(Silva et al., 2020; Luthra et al., 2018)
		Unforeseen challenges	(Gabriel et al., 2021; Isaksson et al., 2018; Luthra et al., 2018)
		Implementation	(Sharma et al., 2020; Martins; Simon; Campos, 2020; Sjøbakk, 2018; Lall; Torvatn; Seim, 2017)
	Operation	Sustainability	(Isaksson et al., 2018; Bonnaud, 2021)
		Excess of work	(Resinger et al., 2018)
		Maintenance difficulties	(Roy et al., 2016; Isaksson et al., 2018)
	Consumption	Energy consumption	(Bonnaud, 2019; Bonnaud, 2021; Martins; Simon; Campos, 2020)
	Discard	Electronics disposal	(Martins; Simon; Campos, 2020)
Cultural	Adaption	Uncontrolled transient process	(Kravcik, 2019)
		Development of new strategies	(Silva et al., 2020; Isaksson et al., 2018; Sjøbakk, 2018)
	Human Resources	Cultural resistance	(Kravcik, 2019.; Silva et al., 2020; Luthra et al., 2018; Salimova et al., 2021; Sharma et al., 2020)
Economic	Investment	High cost	(Silva et al., 2020; Elteto, 2021; Isaksson et al., 2018; Lee et al., 2020; Martins; Simon; Campos, 2020)
		Low return	(Silva et al., 2020; Martins; Simon; Campos, 2020)
Social	Labor	Social bubble	(Silva et al., 2020; Freddi, 2017)
		Capable professionals	(Silva et al., 2020; Wang et al., 2020; Elteto, 2021; Isaksson et al., 2018; Freddi, 2017; Luco et al., 2019; Bonnaud, 2019; Sharma et al., 2020; Martins; Simon; Campos, 2020)
	Government	Lack of government policies	(Luthra et al., 2018; Sharma et al., 2020; Martins; Simon; Campos, 2020)
		Patent concentration	(Wang et al., 2020; Isaksson et al., 2018)

Digital Dimension

With the introduction of advanced systems, sensors, and machinery in the production line, there is a need for structures that support this level of scanning, scanning risks refer to failures in the use and/or implementation of these systems. Scanning Risks are all risks arising from the implementation of these systems, whether during implementation or during the maintenance of operations.

Infrastructure Subdimension. Infrastructure risks are characterized by difficulties and/or lack of systems to implement Industry 4.0 strategies. The first risk found was the need for subsystems, ranging from the network that will be used by the company to data processing systems (Fellow et al., 2018., Li et al., 2017), with the systems in operation, data collection, and processing can present a risk if it is performed in an erroneous or poorly planned way (Christos et al., 2020, Bonnaud, 2021, Martins et al., 2020, Lall et al., 2017).

With the great need for sensors, there is a need for systems to operate in real-time, processing a large amount of data. Failure to comply with this need sets precedents for making wrong decisions or even accidents due to the delay in the delivery of information. The massive amount of data being processed is limited to the need to store these large quantities, as defended by Bonnaud (2021) and Sharma et al. (2020).

Subsystems. The subsystem category encompasses the lack of systems for data processing and/or poor sizing of the same, causing a lack of capacity or total inability to work with the amount of data that the company or system manages.

Data collection and processing. The risks of data collection and processing refer to the presence of problems such as overfitting, hyperparameter errors, heterogeneous data, and data that do not reflect the reality of the problem.

Processing delay. With the need for Industry 4.0 to process data in real-time to ensure its operations, Li et al. (2017), Sharma et al. (2020) and Martins et al. (2020), emphasize the risk of processing delay corresponds to the system's lack of capacity to bring this information in real-time.

Data storage. Risk arising from the system's lack of capacity to store large amounts of data.

Security Subdimension. With the integration of digital systems, security becomes an important point and deserves due attention, the authors report the risks related to data loss, when due to invasion, the user or company error, the database is lost or becomes inaccessible (Vilkov et al., 2019), in addition to the risk of systems being hacked (Isaksson et al., 2018, Luthra et al., 2018, Li et al., 2017, Bonnaud, 2021, Sharma et al., 2020). The security sub dimension incorporates the risks arising from the security flaws of the systems used or the loss of customer data.

Data loss. The risk of data loss refers to loss of information, either by hacking systems by external agents, user error in their use or by company failure (such as lack of backups).

Information security. With regard to information security, the risk swerves from the company's lack of capacity to ensure the security of its own systems, being subject to invasion by external agents, who can intervene in the company's operations.

Operation Dimension

During the change in the company's operation to the adoption of Industry 4.0, the operational structure of the company is directly affected, changing the conventional way of operation. The Operational Dimension corresponds to the difficulties of operation of the company under usual conditions, these risks can happen during the implementation of new strategies such as during the normal operation of the company.

Quality Subdimension. Quality problems occur when there is an overload under operators, resulting in a process with compromised quality and a lower production rate, like warned by Resinger et al. (2018). Overloading is the result of the need to meet the demands of the final consumer in products and services that are increasingly personalized or with different characteristics (Claeys et al., 2015).

Fall in quality. The decrease in production quality is observed when there is an overload on the operator, in addition to the loss in the quality of the product produced, also observed the decrease in production productivity.

Subdimension Planning. With the evolution of the fourth industrial revolution, new concepts are integrated, and with this knowledge about the subject is developing. The authors report risks regarding planning for the implementation of new strategies in the means of production, such as the lack of strategies that are already consolidated in the industry, and the wide range of challenges encountered and that becomes increasingly difficult to be predicted, according to Gabriel et al. (2021), Isaksson et al. (2018), Luthra et al. (2018) and Silva et al. (2020).

With the great need for investments, the unpredictability of return and the need for increasingly specialized labor the most affected parts are Small and Medium Enterprises. The authors also report the difficulty of integrating the new systems with existing systems or the formation of new systems, like Sharma et al. (2020), Martins et al. (2020), Sjøbakk (2018), Lall et al. (2017), Salimova et al. (2021), Luca et al. (2019), Elteto (2021), Bonnaud (2019), Freddi (2017), Isaksson et al. (2018), Wang et al. (2020) and Silva et al. (2020).

Lack of strategies. As Industry 4.0 is a revolution still underway, its knowledge is still new and testable. The risk of lack of strategies refers to the lack of consolidated strategies in the industrial sector, preventing the manager from applying knowledge already tested and approved.

Unforeseen challenges. With the uncertainty of the application of knowledge still in development, the challenges of implementing Industry 4.0 are still uncertain and can bring problems for the company.

Implementation. In Industry 4.0 there is the presence of a large number of sensors and actuators, allowing total control of machinery and production. The implementation risk refers to the difficulty in integrating existing machinery in companies with new technologies.

Operating Subdimension. Referring to the risks regarding the functioning of the industry, it is reported the difficulties in maintaining the sustainability of the product after adaptation to industry 4.0, the excessive load on operators and the difficulty in developing and implementing maintenance strategies, many authors like Roy et al. (2016), Isaksson et al. (2018), Bonnaud (2021) and Resinger et al. (2018) referred this dimention.

Sustainability. The risk of sustainability refers to the difficulty in maintaining production at acceptable levels of productivity and may show falls in the level of production.

Overwork. It is noted that after the implementation of Industry 4.0, an overload may occur in the operator. As cited in the risk of a fall in quality, this risk can trigger falls in the quality of the product produced.

Difficulty maintaining. With the implementation of new machinery, technologies and a large number of sensors and actuators, the maintenance sector may face problems in performing the maintenance of the production line, compromising production.

Consumption Sub-dimension. With the use of machinery, sensors, and systems being increasingly present in the industry, energy consumption becomes increasingly a risk when it comes to Industry 4.0, with the exponential increase in consumption, the risk of reaching unsustainable levels must be considered as exemplified by Bonnaud (2019), Bonnaud (2021) and Martins et al. (2020).

Descarte subdimension. With the development of new products, the integration of electronic circuits has become common practice, but the disposal of these circuits is still a problem, representing a risk to the industry when considering the increasing need for electronic circuits according to Martins et al. (2020).

Cultural Dimension

The cultural dimension refers to the resistance to change through the culture of the company and its members, the resistance to change can be characterized by the manifestation of those involved as well as difficulties in adaptation.

Adaptation Sub-dimension. Like the old industrial revolutions, the fourth industrial revolution is characterized by a change in the mode of production, thus the difficulty of adapting to the new paradigms is a risk that must be overcome by managers, the authors report the difficulty in controlling the transitory process of the old paradigm for the new and the complexity of developing new strategies that include Industry 4.0 as cited by Kravcik (2019), Silva et al. (2020), Isaksson et al. (2018) and Sjøbakk (2018).

Uncontrolled from the transient process. During the transition proposed by Industry 4.0, there is the possibility of dyscontrol over the transitory process, both at organizational and technical levels.

Development of new strategies. With the implementation of Industry 4.0, there is a need to develop new strategies that meet demands quickly and effectively.

Human Resources Sub-dimension. As Industry 4.0 is not only characterized by a change in production lines, encompassing the organizational structure of the company as a whole, the risk of cultural resistance is reported by the authors as the resistance to the changes proposed by Industry 4.0, and this resistance is that of both operators and executives and managers of companies, according with Kravcik (2019), Silva et al. (2020), Luthra et al. (2018), Salimova et al. (2021), Sharma et al. (2020).

Economic Dimension

The adaptation to Industry 4.0 demands companies' various investments, such as machinery, labor, training, and hiring of specialists. Thus, the investment required for conversion to Industry 4.0 may represent a risk, since the contribution does not necessarily become a profit for the company as said Silva et al. (2020); Martins et al. (2020).

Investment Sub-dimension. Silva et al. (2020), Elteto. (2021), Isaksson et al. (2018), Lee et al. (2020) and Martins et al. (2020) defends that the need to hire skilled labor and purchase up-to-date machinery, the high level of investment becomes a risk mainly for small and medium-sized enterprises, mainly if accompanied by uncertainty about return and low short-term financial return according to Martins et al. (2020).

High cost. The implementation of new sensors, actuators, or even the replacement of old machinery with new machinery, training of people, hiring of skilled labor, and other costs, become a risk when considering the cost necessary for the transition to Industry 4.0 in certain scenarios.

Low return. Complementary to the risk of high costs, it is observed by Silva et al. (2020), Martins et al. (2020) that investment in modernization may not offer solid financial results, especially in the short term.

Social Dimension

The evolution of Industry 4.0 requires an extremely important resource, people. The Social dimension is understood as any risk arising from the lack or failure of people or organizations of people (such as the government).

Sub-dimension of Labor. Labor risks include the difficulty of maintaining skilled labor as shown by Silva et al. (2020), Wang et al. (2020), Elteto (2021), Isaksson et al. (2018), Freddi (2017), Luco et al. (2019), Bonnaud (2019), Sharma et al. (2020) and Martins et al. (2020). Mainly with the need to develop increasingly specific skills, such as multidisciplinarity, a highly requested skill for professionals who are part of Industry 4.0.

Silva et al. (2020) and Freddi (2017) also report the creation of a "social bubble", which is characterized by the segregation of professionals who do not update themselves to the new demands of the labor market, keeping these professionals unemployed.

Social bubble. The concept of a social bubble refers to the segregation created by professionals who are not able to work in modernized companies, generating a group of people who cannot be employed.

Trained professionals. This risk encompasses the difficulty, or even non-existence, of professionals trained in new technologies and who meet the requirements and profiles that a position requires.

Subdimmension Government. With the rapid development of knowledge about Industry 4.0, Luhtra et al. (2018), Sharma et al. (2020) and Martins et al. (2020) highlight the need for public policies that encompass practices becomes increasingly necessary, and the lack of government policies becomes a risk when the government fails to provide a guide for the modernization of companies.

In addition, like Wang et al. (2020) and Isaksson et al. (2018) reported the high concentration of patents in large companies and developed countries, prevents the development of small and medium-sized companies and less developed countries, since at some point may come across these patents.

Lack of government policies. This category encompasses the lack of government involvement, whether through public policies that encourage companies and sectors to modernize, finance or investments.

The concentration of patents. It is observed in the literature that large companies and developed countries have a higher concentration of patents, in a revolution where it is necessary to use and develop cutting-edge technologies, concentration can become a risk, preventing smaller companies or less developed countries from achieving modernization.

Validation of technological risks in industry 4.0

After identifying the five dimensions that may cause risks in the implementation of Industry 4.0, the next step was to validate the importance of these dimensions, as well as to consider which ones would be more relevant.

Therefore, it was decided to use the AHP method, a mathematical approach created by Saaty (1990), that involves creating a hierarchy of decision criteria and alternatives, assigning weights to each criterion based on their relative importance.

To conduct the consultation with specialists, LinkedIn platforms were used, seeking people who have positions that refer to the transition to Industry 4.0, in addition to direct contact with several companies in the region of Ponta Grossa-PR, due to their proximity to the campus and cooperation in the development of research.

In total, 43 people were consulted, of whom 7 answered the questionnaire in full. The data regarding the respondents can be found in Table 5.

Table 5 - Respondent's date

Enterprise	Area of expertise	Position	Industry Size
1	Services and consulting	Industry 4.0 Specialist	Small
2	Automation and digitization	Automation and Digitization Engineering Manager	Big
3	Technology and automation projects	Master Engineer	Big
4	Automation	Smart Manufacturing Leader	Big
5	Manufacturing Leader	Regional Smart Manufacturing Leader	Big
6	Consultant	Industry 4.0 Corporate Project Consultant	Big
7	Consultant	Industry 4.0 Technical Consultant	Big

Prioritization of Factors

To perform the factor prioritization step, a square matrix n x n was assembled, and the priority vector was calculated, "which is obtained by the sum of each of the lines divided by the number of elements being compared" as defined by Rodrigues (2021).

With the values of each respondent in hand, normalization was performed to find the vector normalized property of each dimension.

Thus, the same operation was performed for all respondents, who were later used to find the overall weight of each dimension through the arithmetic mean of the answers.

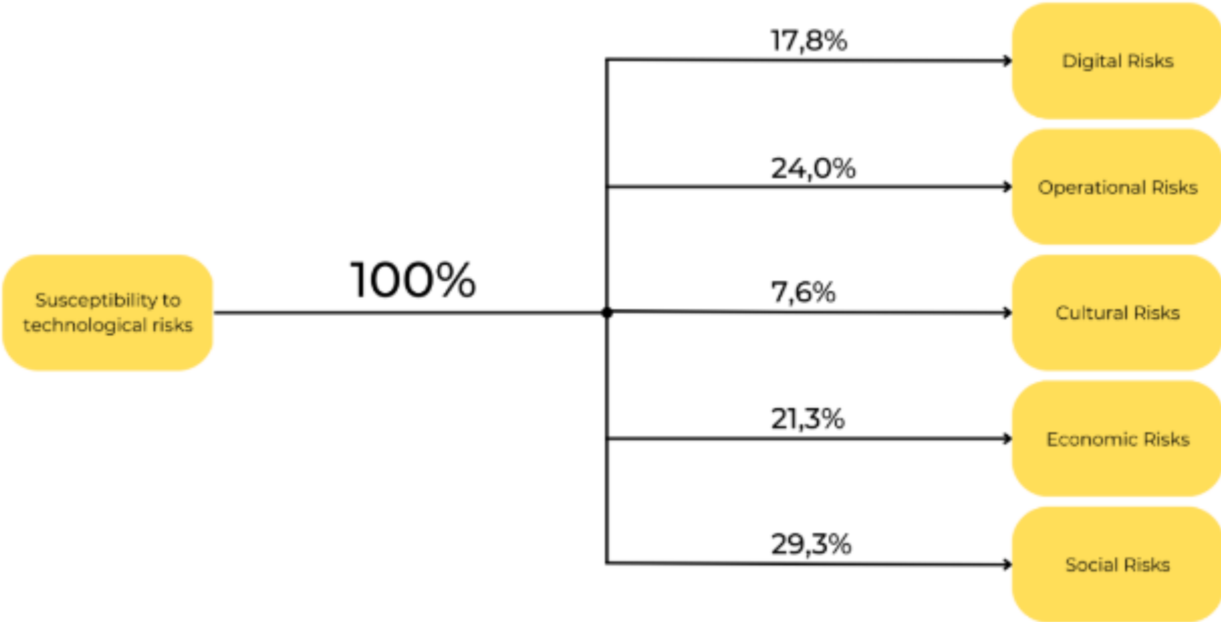
Thus, the result of the mean responses of the property vectors can be seen in Table 8.

Table 8 - Final respondent's date

General	Digital	Operational	Cultural	Economical	Social
Vector P	0,178	0,240	0,076	0,213	0,293

From this, it was possible to calculate the weights by criterion. Figure 1 shows the dimensions next to their values.

Figure 1 - Global weights resulting from peer comparison



The social (29.3%), operational (24%) and economic (21.3%), and digital (17.8%) dimensions were identified with significance for respondents, with relevant weight. However, the cultural dimension (7.6%) showed much less relevance and weight, in the view of these specialties. Thus, it is understood that the final model of technological risks for industry 4.0 should present only the dimensions that proved significant: social, operational, economic, and digital. F igura 2 presents the final risk model for industry 4.0

Figure 2 - Global weights resulting from peer comparison

Conclusions

The study conducted a comprehensive assessment of potential risks associated with the implementation of Industry 4.0. A total of 24 distinct risks were identified and categorized into 5 dimensions, following an analytical approach to ensure optimal organization. Subsequently, the Analytic Hierarchy Process methodology was applied with the help of experts in the field to prioritize the risks based on their relative importance. Surprisingly, the social dimension emerged as the most significant factor, indicating the need for proactive measures to address this aspect. On the other hand, the cultural dimension was found to be less influential, leading to its exclusion from the risk model. These findings provide a useful framework for identifying the most relevant risks that need to be managed during the implementation of Industry 4.0. However, the study also highlights the need for further research to develop a more precise instrument and model for risk planning, which could guide industries in the implementation phase of Industry 4.0 towards more effective risk management.

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Industry 4.0: Opportunities for rail passenger transport

Abstract ID#281

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Purpose

Industry 4.0 (I4.0) has been a growing research topic since this concept coining, following a global trend of developed economies and emerging countries, each with its public policies seeking a prominent position in this new industrial scenario. In the railway sector, few research papers explore the I4.0 benefits, especially regarding demonstrating how to apply the concepts involved systematically. In practice, there are more initiatives of technology applications isolated. Thus, this paper raises an important question: How can the I4.0 concepts be applied to rail passenger transport in a holistic vision? We propose a focal point through the Four Smarts of I4.0 (Frank et al., 2019) to obtain a more comprehensive view of all available opportunities due to advanced technologies. We started from and adapted it to passenger rail transport to answer the research question. Considering the lack of studies with the intended embracing vision, we used an exploratory and qualitative approach and interviewed experts from operators and technology providers in the Brazilian segment. We collected I4.0 application cases from eight operators and four technology providers for the sector, intending to analyze how to organize this kind of company in the context of the Fourth Industrial Revolution.

Literature Review

When companies introduce the base technological level explained by Frank et al. (2019), i.e., IoT, Cloud Services, Big Data, and Analytics, the journey to I4.0 begins through digital transformation (Meindl et al., 2021). Achieved it, there is the foundation to implement the front-end technologies that empower companies in operational needs (Smart Manufacturing and Smart Working internal dimensions) and market requirements (Smart Supply Chain and Smart Products-Services external dimensions). Front-end dimensions consider the support of emerging technologies in the manufacturing activities, productsservices offer, raw-materials provision and products delivery, and workers' performance. Modern railways demand better asset and people safety, operational efficiency, and passenger experience (Li et al., 2017). Hence, the main objective of this study is to holistically estimate how the Fourth Industrial Revolution can continue progress on rail passenger transport based on the Four Smarts of I4.0. We will call the Smart Manufacturing and the Smart ProductsServices dimensions Smart Operation and Smart Services, respectively. It makes more sense for a service provider such as passenger rail transport. The other two front-end smart dimensions remain with the original nomenclature proposed by Frank et al. (2019), Smart Supply Chain and Smart Working, referring to the supply chain and workers' activities.

Methodological Procedures

The present study has an applied purpose which boils down to analyzing how I4.0 can be holistically adopted in passenger rail transport. Considering the scarcity of works with this theme as far as we know, this exploratory research aims to familiarize and clarify the problem. We start from a conceptual framework based on the model proposed by Frank et al. (2019) that suggests the four dimensions of I4.0 and results in a conceptual framework that underpins and guides the investigation (Voss et al., 2002). We proceeded through empirical research with the collection and analysis of qualitative data from cases raised with Brazilian operators and some technology providers in the studied segment, meeting the exploratory objective of the research in an appropriate way (Goffin et al., 2019). In addition, the proposed methodology is suitable as it allows for detailed field information to be obtained for an inductive theoretical construction that aims to understand how a contemporary phenomenon happens (Eisenhardt and Graebner, 2007). We followed the guideline Voss et al. (2002) proposed for case research in operations.

Findings

Our results show that I4.0 can be comprehensively applied to passenger rail in both the internal and external dimensions of the business. The base technologies transform operators, connecting workers, assets, companies, and customers. Big Data is in initial formation as the cases implemented or under study progress, but Analytics still has few applications in the sample studied. The four Smart dimensions proposed in our work made sense in the context of the companies consulted since we found several related front-end technologies. We understand that companies are moving towards an Operation and Maintenance Intelligence Center to implement robust and efficient train timetables, prescriptive maintenance of fixed assets and rolling stock, and improve passenger experience. We propose a final framework showing each Smart dimension for passenger railway, the level of adoption in the sample of companies consulted, and the practical implications.

Implications

The work contributes academically to advance the holistic view of I4.0 as a phenomenon currently taking place, discussing published works and bringing empirical data from companies in the railway sector. The practical contribution of the research is to help rail passenger transport operators plan the I4.0 journey in their segment, both in the design of new subway lines and in the search for more sustainable operating systems. The main limitation of this work lies in the sample of companies consulted, which is restricted to Brazilian operators, a developing country with few state-of-the-art subway lines. As railways from other countries are consulted, or even different modes of transport are the object of research, an expressway of study will open up.

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Industry 4.0 and biotechnology: The main trends
Abstract ID#292

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Purpose

With the development of new technologies according to the pillars of Industry 4.0 applied to the knowledge of Biotechnology, it is expected that both areas will be increasingly integrated. From this context, this article aims to identify the main research themes related to Industry 4.0 and Biotechnology from a Systematic Literature Review.

Literature Review

The industrial sector has undergone several transformations, significantly changing production processes. From the beginning of the 2000s, there was the Fourth Industrial Revolution, characterized by the integration of the Internet in production processes, digitization, the use of sensors, and the use of artificial intelligence applied to machines (SCHWAB, 2017). Regarding technological issues, Rüßman et al. (2015) present the nine main pillars that support Industry 4.0, considering the impact on technical and digital transformation in organizations, namely: big data, autonomous robots, simulation, vertical and horizontal integration, Internet of things, cyber security, cloud, additive manufacturing and augmented reality. In this context, Biotechnology stands out as an area of knowledge that encompasses different natural sciences. It transforms them into several technological applications, thus defining its two aspects: (i) scientific, which encompasses biochemistry, microbiology, genetics, and molecular biology, which is developed in laboratories and universities; and (ii) technological, which transforms science into industrial and commercial applications (SILVA; MASSABNI, 2019). Thus, with the development of new technologies according to the pillars of Industry 4.0 applied to the knowledge field of Biotechnology, it is expected that both areas will be increasingly integrated. The biological transformation will parallel digital transformation, further correlating these two themes (MATT; RAUCH, 2021). In this sense, it stands out from biotechnological innovations. According to the McKinsey Global Institute (2020) report, several advances have been made with the integration of Industry 4.0 technologies and Biotechnology, such as: 3D printing, chemicals produced by microorganisms, and genetic disease prevention products. The bio-machine interface allows it to control electronics, such as editing genes in much faster ways and new techniques. All these advances are evidence of a new era that integrates biology, computing, engineering, and biotechnology.

Methodological Procedures

In this study, a Systematic Literature Review experienced using the PRISMA Method (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to build a portfolio of articles to be analyzed. This method aims to identify, select, evaluate, and synthesize the materials found, making them more transparent and accurate (PAGE et al., 2020). The Research Protocol used in this study sought to ensure documents that covered the two main themes of this work: Industry 4.0 and Biotechnology. With the application of the Prisma Method, 03 main steps are carried out: (i) identification, (ii) screening, and (iii) inclusion. From the final structured portfolio of 65 articles, it was then possible to conduct: (i) a bibliometric and network analysis; and (ii) a content analysis of the portfolio articles supported by MaxQDA software.

Findings

The results of the bibliometric and network analyses enable the identification of the distribution of the paper set per year, the principal authors and their countries, and the keywords network, among other aspects, which provide a better comprehension of the research evolution about Industry 4.0 and Biotechnology. In addition, the content analysis allowed us to identify which are the leading technologies of industry 4.0 that the applied in the area of Biotechnology and how in which stands out artificial intelligence, machine learning, big data and sensors, and the prominent trends identifying the topics that are the most prevalent in this research area, such as: Sustainability, Regulatory Perspectives, Biotechnological Process, Digital Laboratories, and Biopharmaceutical Manufacturing.

Implications

Hence, the findings of this paper contribute to a comprehensive view of the current literature on Industry 4.0 and Biotechnology from a Systematic Literature Review. This research made it possible to map in the literature several applications of Industry 4.0 technologies in the knowledge of Biotechnology. In addition, from the research carried out, it was also possible to identify the main thematic areas in which these applications have evolved. In this sense, the present work has as its main implication a mapping of the current status of a recent topic in the field of scientific research, integrating Industry 4.0 and Biotechnology. It is worth mentioning that even with the concern with the methodological design of this research, it is also subject to limitations. In this sense, there are two aspects related to the portfolio definition: selecting a single database and restricting analyzed document typologies. In addition, it is noteworthy that the results identified in this research used only the literature as a source. It is essential to validate these results with specialists in the area and from the realization of cases. From this research, it was also possible to identify possible topics for a future research agenda since the articles that map the integration of Industry 4.0 and Biotechnology are still limited, as well as the possibility of exploring incipient studies also on Society 5.0 and Biotechnology.

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SMART CITIES AND REGIONS I

May 3rd: 10h30 am – 12h30 pm

Chair

Mauricio Camargo (University of Lorraine, France)

Papers

Schools as actors of innovation ecosystems in the development of smart and sustainable cities

Luciana Maines da Silva, Michele Kremer Sott

Changing the structure and dynamics of incumbet industrial sectors through fosh based demonstrators: The case of the green-fablab

Mauricio Camargo, Hakim Boudaoud, Fabio Cruz-Sanchez, Fedoua Kasmi

A widespread review of smart cities: Identifying dimensions and core components

Michele Kremer Sott, Luciana Maines da Silva, Kadígia Faccin

Development of an integrated business model for smart cities

Fernanda Ignacia Ibarra Fernández, Pedro Palominos Belmar

Metamodel for smart cities and villages: A catalan perspective

Carina Rapetti, Didier Grimaldi, Josep Miquel Piqué

Schools as actors of innovation ecosystems in the development of smart and sustainable cities

Abstract ID#109 | Full paper ID#376

Luciana Maines da Silva, Michele Kremer Sott (University of Vale do Rio dos Sinos)

Abstract: Smart and sustainable cities can be seen as an urban innovation ecosystem with multiple stakeholders seeking economic development and technological innovation (Jackson, 2011) and social and environmental development. Education institutions play a crucial role in generating knowledge in innovative environments; however, the role of basic education schools still needs to be determined. From this context, we identified a gap: schools' role in smart cities' entrepreneurial and innovation development. In this sense, this article analyzes how elementary and high schools' entrepreneurship actions relate to smart and sustainable cities. A meta-synthesis was performed, and 10 articles were composed of the qualitative analysis. The meta-synthesis was chosen once it had a primary purpose of building theory through an exploratory /inductive research design to synthesize primary data collected through case studies. From the analysis of the articles, four propositions were established: (1) smart and sustainable cities leaders can establish policies to integrate different actors of the (innovation/entrepreneurial) ecosystem with schools; (2) students need to be stimulated by hands-on or experiential tools to comprehend the smart/sustainable city context better; (3) schools must increase the application of actions and tools that connect the needs of smart and responsible cities; (4) schools have the knowledge and potential to develop actions and tools and have to be more proactive in strengthening ties with other actors in the ecosystem. Our findings demonstrate that scientific efforts focus on enhancing entrepreneurship skills while other elements of smart cities remain on the sidelines.
Keywords: Schools; Basic education; Smart City; Sustainable City; Innovation ecosystem; Entrepreneurship.

Introduction

Smart city initiatives have revolutionized sustainable urban development (Hollands, 2015), based, among other initiatives, on developing an environment that encourages entrepreneurship (Richter et al., 2015).

Encouraging entrepreneurship and innovation are considered pillars of economic development. In Brazil, in 2019, 53.5 million Brazilians were at the forefront of some entrepreneurial activity, involved in creating a new venture, consolidating a new business, or making efforts (Monitor, 2019). On the other hand, despite the economic acceleration taking place from the development of new products and processes and scientific investment, in Brazil, in 2019, only 6 companies participated in the list of the 2,500 companies that invested the most in research and development (R&D) (IPEA, 2020). Despite the low rate in Brazil, the role of educational institutions, especially universities, is highlighted by João Alberto de Negri, coordinator of studies on financing and investment at IPEA, when he states that “Leading companies and universities are at the heart of a country's ability to accumulate resources and skills to drive and spread technological progress “(IPEA, 2020,).

A competitive country needs competitive smart cities, considered smart when they are composed of smart governance, smart economy, smart people, smart mobility, smart environment, and smart living (Albino et al., 2015).

One key element of a smart city is smart education - the backbone for the successful and ever-growing development of smart city initiatives (Barba-Sánchez et al., 2021). Education, learning, and knowledge are critical elements of the success of smart city initiatives (Leahy et al., 2016).

Education institutions are some of the knowledge-creation institutions that play a fundamental role in smart cities' entrepreneurial and innovation development. While universities have a prominent role as knowledge generators (Mello et al., 2022), schools are still on the sidelines of discussing their contribution to smart cities.

The entrepreneurial and innovation development mentioned above, promoted by cities, also contributes to economic growth, which benefits society from shared responsibility for the growth of local actors such as universities, NGOs, state and municipal governments and civil society, promoting a bottom-up transformation (Coraggio, 2004). On one side, what stands out is that schools are often not cited as one of these local actors (Lombardi et al., 2012; Albino et al., 2015). On the other side, studies such as Barba-Sánchez et al. (2021) proved a positive relationship between the capacity of schools and the resulting entrepreneurial activity of the city.

The authors understand that schools focus on transmitting and creating knowledge, mainly when stimulating entrepreneurship and innovation. From this context, we identified a gap: schools' role in smart cities' entrepreneurial and innovation development. We support our view when considering that smart cities are based on learning (Zulkarnaen et al., 2019). Moreover, schools are preparing the students to be "the adults of the future assuming more successfully and satisfactorily their responsibilities as workers and citizens of environments...". (Barba-Sánchez et al., 2021)

In that way, the main objective of this article is **to analyze how elementary and high schools' entrepreneurship actions relate to smart and sustainable cities**. Specifically, we considered three dimensions: (1) schools relate to the innovation ecosystem; (2) actions and/or tools developed/used to encourage entrepreneurship in students; and, finally, (3) actions/tools that contribute to smart and sustainable cities. It is essential to underline that this study considered that, in the same way a smart city, the concept of a sustainable city has a strong connection with education and inspired schools to develop tools to contribute to this goal.

A meta-synthesis was carried out, analyzing 10 articles, which will be presented below. The concepts of smart and sustainable cities will be presented in the next session.

Theoretical Background

This section will briefly discuss the concepts of smart and sustainable cities and establish the connection between educational institutions and these concepts.

Smart and Sustainable Cities

Countless cities around the world are implementing smart city (SC) projects. In Brazil, Rio de Janeiro, São Paulo, and Porto Alegre, among others, also seek to develop projects to become territories with a high capacity for learning and innovation based on the creativity of its population, its institutions for the creation of knowledge, in its digital infrastructure of communication and knowledge management (Hollands, 2020). Despite being a concept under construction (Hollands, 2020), smart cities can be seen as an urban innovation ecosystem with multiple stakeholders (Mayangsari & Novani, 2015; Camboim et al., 2019). Smart cities are "formed between actors or entities" whose functional objective is to enable technology development and innovation" (Jackson, 2011). Besides, SC are territories with a high capacity for learning, built-in, between others, for the institutions of knowledge creation (Komninos, 2006).

The multiple stakeholder's contributions and knowledge creation highlighted in the SC concept are also connected to sustainable cities (STC). The STC concept overlaps in some way since cities are understood as a set of physical structures. These living entities make up the society of a city and the flow of interactions between them (ISO, 2019). Its sustainable development is based on development that meets the environmental, social, and economic needs of the present without compromising the ability of generations' future to meet their own needs (ISO, 2016a). STC also is a "set of approaches to practically applying the knowledge of urban sustainability and environmental technologies (Bibri & Krogstie, 2017).

In this discussion, knowledge is key in both SC and STC. Education and training at all levels increase knowledge and skills that contribute to sustainable development, intelligence, and resilience (ISO, 2016b).

Methodological Procedures

To meet the objective of this study, the researchers chose to carry out a meta-synthesis. Meta-synthesis is defined as

> An exploratory, inductive research design to synthesize primary qualitative case studies to make contributions beyond those achieved in the original studies (Hoon, 2013, p. 523).

The main objective of choosing the meta-synthesis was to make a more in-depth analysis of empirical studies, aiming to synthesize primary qualitative case studies that were not planned to be analyzed together. The method is based on qualitative case studies, producing a new and integrative interpretation of the findings, more substantial than the results of individual investigations (Silva et al., 2019). The method clarifies concepts, patterns, and results of the theory, ensuring sensitivity to contextual considerations of primary studies (Hoon, 2013).

The method, developed by Hoon (2013), includes eight steps, namely: (1) framing the research question, (2) locating relevant research, (3) inclusion/exclusion criteria, (4) extracting and coding the data, (5) analyzing at a case-specific level, and, finally, (6) synthesis on a crossstudy level, (7) building theory from meta-synthesis, and (8) discussing. All stages proposed by Hoon (2013) were contemplated and are presented in this chapter and the following.

Framing the Research Question

The first stage main to identify theoretical gaps that can be filled later. As presented in the introduction, there needs to be more literature about the role of primary and secondary schools in stimulating entrepreneurship, which contributes to developing smart and sustainable cities.

Finding Relevant Research

Data collection occurred between July 10 and 12, 2022, in the Web of Science, SCOPUS and Ebsco databases. Initially, a search was carried out for the terms "innovation ecosystem", "smart cit*", and "sustainable cit*" and "entrepreneurial education", crossing each of them with the terms "primary education" and "high school." The authors carried out a new search, using the term "entrepreneurial education," also crossing with the terms "primary education" and "high school." The term "entrepreneurial education" (EE) was especially included as EE can improve students' behaviors, mindsets, abilities and skills and, consequently, helps in creating future entrepreneurs (Boateng, 2019). Many of these entrepreneurs are focused on solving the problems faced by smart cities, also called entrepreneurial cities (Kummitha, 2019). In total, we identified 101 articles (Table 1).

Research terms	Web of Science	Scopus	Ebsco	Total
Innovation ecosystem + elementary school	0	0	2	2
Innovation ecosystem +high school	0	5	0	5
Smart cit* + elementary school	6	9	0	15
Smart cit* + high school	6	22	0	28
Sustainable cit* + elementary school	2	3	0	5
Sustainable cit* + high school	2	2	0	4
Entrepreneurial education + elementary school	4	4	3	11
Entrepreneurial education + high school	13	14	4	31
Total	33	61	9	**101**

Table 1. Research results

Inclusion/exclusion Criteria

The next step was the appropriate inclusion of relevant qualitative case studies. Duplicate articles, those that were not available in full, in one other language than English and Portuguese, or even those not related to the purpose of the research were excluded. Finally, 10 articles made up the qualitative analysis. Table 2 illustrates the result of the exclusion criteria:

Total	**101**
(-) Duplicated	(18)
Sub-total	83
(-) Different language (French/Czech)	(2)
(-) Complete proceedings of seminars/conferences	(4)
(-) Purpose not relevant	(48)
(-) Full article not available	(6)
(-) Theoretical studies	(2)
(-) Quantitative studies	(11)
Total for analysis	10

Table 2. Included/excluded articles

Extracting and Encoding the Data

The next step proposed is extracting, coding, and categorizing the studies' evidence.

The empirical studies are the basis for the meta-synthesis. They must highlight the insights of the original researchers through the understanding and interpretation of the data by the meta-synthesis (Hoon, 2013). A reading guide was developed (Table 3).

Section	Observed items
General Data Theoretical framework Context f the research Method	**Verification** Author, title, date, research question Country, sector, place of application Quality of the case study
Analyses and interpretation of the data Discussion Conclusion	**Extraction** Main contributions found, identification of elements or constructs and tools
General evaluation	**Overall article rating** Relevance to the study topic, quality, and reliability of the study

Table 3. Reading guide.

Analysis on a Case-specific Level

The articles were analyzed, and each presented only one case (presented in Table 4) that was explored individually. This analysis disclosed that schools (60% in high school and 40% in elementary school) have several actions that develop entrepreneurial skills outside the innovation ecosystem.

There was a predominance of studies connected to entrepreneurial education and smart cities (4 studies each), comprising 80% of the cases. We highlight that more actions connected to innovation ecosystems and sustainable cities still need to be disclosed.

The following stages synthesize the findings and build theory from meta-synthesis, answering the questions raised in this research, and they both are presented in the discussion. The authors also developed four propositions, considering the findings.

Discussion

This study analyzes how elementary and high schools' entrepreneurship actions relate to smart and sustainable cities. The authors proposed three dimensions of analysis. In addition, based on the findings and the fragility of schools' role, four propositions were presented, recommending that schools have a more protagonist role in smart and sustainable cities.

The first dimension concerns the relationship between schools and the innovation ecosystem (IE). When considering that an IE is a complex system composed of different actors (de Vasconcelos Gomes et al., 2018), universities, governments, corporations, investors, and foundations, among others, stand out as actors (Mello et al., 2022). When analyzing the cases, little connection was noticed with the innovation ecosystem. The studies highlight actors such as a civil association (composed of universities, the private sector, the industrial chamber, the government and the national science and technology council) (de Lourdes Cárcamo-Solís et al., 2017), small and large companies and social institutions (Gomes & de Farias Silva, 2018), research centers (Veety et al., 2018) and universities (Scholten, 2017; Mazocco et al., 2021). A difference was also noticed in the relationship with the actors.

On the one hand, actors such as the civil association and the university use the school as a field, whether for the application of an entrepreneurial education program proposed by the government or applied by the association (de Lourdes Cárcamo-Solís et al., 2017), or to develop a teaching methodology for distributed generation and renewable energies, according to the BNCC (Mazocco et al., 2021), or to explore Geocraft as a tool to involve local people, especially young people, in geospatial issues (Scholten, 2017). On the other hand, the school seeks actors to interact with students through visits (Gomes & de Farias Silva, 2018) or lectures and workshops offered within the school (da Silva Coelho, 2020). There is still the participation of teachers and students in entrepreneurial challenges proposed by the research center, with no direct participation of the school (Veety et al., 2018). Based on these findings, we present the first proposition:

Proposition 1. Smart and sustainable city leaders can establish policies to integrate different actors of the (innovation/entrepreneurial) ecosystem with schools.

The literature and practice of smart and sustainable cities suggest they are ecosystems with multiple stakeholders (Mayangsari & Novani, 2015; Camboim et al., 2019) formed between actors (Jackson, 2011). Policymakers and project leaders must consider that schools and students can contribute to a future generation of citizens, much more adapted and oriented to live and improve the (smart and sustainable) city.

The second dimension concerns the actions and/or tools developed/used to encourage student entrepreneurship. It can be anticipated that the school did not propose or apply some of the actions/tools. Mazocco et al. (2021) present the case of an educational tool for teaching concepts of renewable energy and distributed generation, and Scholten (2017) presents the use of Geocraft. This user-friendly tool facilitates the effective participation and engagement of students. Veety et al. (2018) present the Wearable Device Challenge (WDC), which uses a project-based approach to teach students and teachers to solve real problems. de Lourdes Cárcamo-Solís et al. (2017) present the program "My first enterprise: Entrepreneurship by playing," an educational program that promotes entrepreneurship in elementary schools. Masucci et al. (2020) present a summer educational program for black youth in public high schools that combine digital skills development with urban fieldwork to prototype solutions to age-old urban problems. Finally, Zulkarnaen et al. (2019) present an applied proposal for a science teaching method from the perspective of smart people - the connection between students, teachers and parents. Only two studies present actions organized by schools. Gomes and de Farias Silva (2018) present a proposal for entrepreneurial education in the discipline of Organizational Management for students in an integrated technical high school course. Students must develop a work creating a company or product in the course. In preparation for work, visits are made to small and large companies, lectures by entrepreneurs and visits to social institutions. With a similar proposal, da Silva Coelho (2020) describes a contest for startup ideas. The program features lectures, classes, and workshops using tools such as canvas business model, pitch, and other activities. On the one hand, we highlight that the tools used (Veety et al., 2018; Scholten, 2017; Mazocco et al., 2021) were not developed by the school but by researchers, mostly in universities, that applied it to students.

In the same way, programs like My first enterprise (de Lourdes Cárcamo-Solís et al., 2017) and a summer educational program (Masucci et al., 2020) are developed by institutions, not the school. On the other hand, schools developed and applied actions related to entrepreneurship education, including multiple IE actors, and stimulating students to create new products and companies (Gomes & de Farias Silva, 2018; da Silva Coelho, 2020). Based on the actions/tools presented, we established the second proposition:

Proposition 2. Students need to be stimulated by hands-on or experiential tools to comprehend the smart/sustainable city context better.

Experiential methodologies such as teaching STEM based on the logic of open innovation (Lee & Jung, 2021) or the elaboration of a business plan, creating a product or a service and marketing it (Lizote et al., 2020) make that students perceive the context and seek alternatives, based on the knowledge learned at school.

The third and last dimension concerns the contribution of these actions/tools to smart and sustainable cities. Here, the connection with smart cities was analyzed separately, based on the connection with the development and technological innovation (Jackson, 2011) and with sustainable cities, meeting environmental, social and economic needs (ISO, 2016a).

Applying the engineering design process to solve real-world problems through a project-based approach, in the case of the WDC (Veety et al., 2018), the perspective of smart city-based learning (Rahmayanti et al., 2018) and the use of the logic of smart environment, which became one of the six indicators of smart cities (Rahmayanti et al., 2018), demonstrate some connection with smart cities. A stronger connection is established by using Minecraft to teach geographic and spatial awareness and providing opportunities for citizen participation (Scholten, 2017) by prototyping solutions to long-standing urban problems: the kind of problem that city policies face. Smart people also seek to change (Masucci et al., 2020) and by applying a digital tool developed to support teaching, focusing on renewable energy and distributed generation (Mazocco et al., 2021).

The connection with sustainable cities, in a more intense way, comes from proposals such as the smart garbage bin, which detects garbage based on the garbage group (plastic and metal), and also has the function of education for students (Rahamayanti et al., 2018), the use of Minecraft, based on the challenge of transitioning to renewable energies in a given region (Scholten, 2017) and a digital tool to support teaching, when working with the concepts of renewable energy and generation distributed (Mazocco et al., 2021). In a not-so-direct way, it is the visit to social institutions, intending to develop affective and emotional dimensions in students (Gomes & de Farias Silva, 2018) and the Jumpstart program, which seeks to develop skills in young people to work for the greater good of the society (Morakinyo & Akinsola, 2019).

Besides some tools and actions related to smart and sustainable cities, they were not developed by schools but by universities and civil associations. Table 4 summarizes the actors and actions/tools. Regarding these findings, we established the third proposition:

Proposition 3. Schools must increase the application of actions and tools that connect the needs of smart and responsible cities.

From the actions applied at school, students will understand what a smart and sustainable city is and the potential that can be explored. Schools can develop community-based engagement initiatives by applying the internet of things (IoT), environmental intelligence, and crowdsourcing (Lee & Wong, 2017).

By the end, bringing back the discussion of the minor role of schools in smart and sustainable cities, a last proposition is established:

Proposition 4. Schools have the knowledge and potential to develop actions and tools and must be more proactive in strengthening ties with other actors in the ecosystem.

Criticizing the triple helix literature (Etzkowitz & Zhou, 2017) and innovation ecosystems (Schaeffer et al., 2018), which presents universities and research centers as knowledge generators and schools as transmitters of this knowledge, schools that give attention to the theme must demonstrate the knowledge generated from their actions to stimulate entrepreneurship and innovation. Some examples were presented in the selected studies. Nevertheless, the authors understand that there is still a gap between the actions developed at school and the dissemination to other actors in the (smart and sustainable) city, mainly policymakers.

When analyzing the selected articles and extracting the data, the authors needed to establish a connection scale comprising the factors with no connection, low, medium, and high connection (Table 4). The scale for the relationship between schools and IE actors considers the school's degree of integration and participation in the actions. The connection of actions/tools with smart and sustainable cities is based on the relationship with the concepts already presented.

The next session presents the conclusion.

		Actors of the ecosystem with whom the school relates	Actions/tools used for the stimulating entrepreneurship	Connection to SMART CITY Concept: "... development and technological innovation" (Jackson, 2011, p. 2).	Connection with SUSTAINABLE CITY Concept: "Meet the environmental, social and economic needs of the present without compromising the ability of future generations to meet their own needs." (ISO, 2016a).
1	de Lourdes Cárcamo-Solís et al., 2017	MEDIUM CONNECTION - Civil Association (composed of universities, private sector, industrial chamber, government and the national council of science and technology)	My first enterprise: Entrepreneurship by playing" is a Mexican educational sub-program designed to promote entrepreneurship at the elementary level.	NO CONNECTION - Most mini-companies referred to economic activities of industrial production, jewelry, crafts, and food.	NO CONNECTION - No elements in the article connect the socio-environmental concern.
2	Gomes & de Farias Silva, 2018	MEDIUM CONNECTION - Visit small and large companies and social institutions such as Centro de Dependentes Químicos Agape and the Mons Elderly Shelter. Paulo Herôncio, the House of the Poor, the Association of Parents and Friends of the Exceptional and the Reference Center for Social Assistance.	Visits to small and large companies; lectures by entrepreneurs; visits to social institutions; work of creating new companies/products	NO CONNECTION - No elements in the article connect with technological aspects.	LOW CONNECTION - One activity is visiting social institutions to develop the affective and emotional dimensions.
3	da Silva Coelho, 2020	LOW CONNECTION - Students had a lecture on entrepreneurship, innovation, startup, patents, and fundraising.	Startup ideas contest (program has lectures, classes, and workshops for the use of tools such as Canvas, pitch)	NO CONNECTION - No elements in the article connect with technological aspects.	NO CONNECTION - No elements in the article connect the socio-environmental concern.
4	Morakinyo & Akinsola, 2019	NO CONNECTION - Students participate in the Jumpstart program, but that is not directly linked to schools	Not displayed	NO CONNECTION - No elements in the article connect with technological aspects.	LOW CONNECTION - The Jumpstart program seeks to develop skills in young people to work for the greater good of society.

		Actors of the ecosystem with whom the school relates	Actions/tools used for the stimulating entrepreneurship	Connection to SMART CITY Concept: "... development and technological innovation" (Jackson, 2011, p. 2).	Connection with SUSTAINABLE CITY Concept: "Meet the environmental, social and economic needs of the present without compromising the ability of future generations to meet their own needs." (ISO, 2016a).
5	Veety et al., 2018	LOW CONNECTION - Students and teachers take part in the challenge proposed by the Nanosystems Engineering Research Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST CENTER)	Wearable Device Challenge (WDC) was	MEDIUM CONNECTION - Apply the engineering design process to solve real-world problems through a project-based approach, having the opportunity to explore exciting, cutting-edge applications of science and technology that will inspire them to continue in science, technology, engineering, and mathematics fields.	NO CONNECTION - No elements in the article connect the socio-environmental concern.
6	Zulkarnaen et al., 2019	NO CONNECTION - No elements in the article connect with the innovation ecosystem.	Science teaching method from the look of smart people - the connection between students, teachers, and parents	MEDIUM CONNECTION - Appropriates the Smart city-based learning perspective.	NO CONNECTION - No elements in the article connect the socio-environmental concern.
7	Rahmayanti et al., 2018	NO CONNECTION - No elements in the article connect with the innovation ecosystem.	Not displayed	MEDIUM CONNECTION - Uses intelligent environment logic, which has become one of the six indicators of smart cities.	HIGH CONNECTION - Using a smart recycle bin, which detects garbage based on the garbage group (plastic and metal), also having the function of education for students.
8	Scholten, 2017	LOW CONNECTION – University	Geocraft - Geocraft provides an excellent interactive virtual 3D environment at a well-chosen level of abstraction to visualize, design and explore future scenarios, raising spatial insight and mutual understanding. It is a user-friendly tool to facilitate citizens' effective participation and engagement.	HIGH CONNECTION - Use Minecraft to teach geographical and spatial awareness, al'ém to opportunist citizen participation.	HIGH CONNECTION - One of the proposed projects concerns the transition to renewable energy in a region.
9	Masucci et al., 2020	NO CONNECTION - No elements in the article connect with the innovation ecosystem.	Summer educational program for black youth from public high schools, which combines the development of digital skills with urban fieldwork to prototype solutions to long-standing urban problems	HIGH CONNECTION - Prototyping solutions to long-standing urban problems: the problem that smart city policies seek to change.	NO CONNECTION - No elements in the article connect the socio-environmental concern.
10	Mazocco et al., 2021	LOW CONNECTION – University	An educational tool for teaching renewable energy concepts and distributed generation.	HIGH CONNECTION - a digital tool developed to support teaching.	HIGH CONNECTION - Working with the concepts of renewable energy and distributed generation.

Table 4. Actors, Actions/tools, and concept connections

Conclusions

The authors reviewed case studies exploring the relationship between education and developing smart and sustainable cities. We perform a meta-synthesis to analyze how elementary and high schools' entrepreneurship actions relate to smart and sustainable cities. The study considered three dimensions: (1) schools relate to the innovation ecosystem; (2) actions and/or tools developed/used to encourage entrepreneurship in students; and, finally, (3) actions/tools that contribute to smart and sustainable cities.

We identified that only some innovation ecosystem actors, such as universities and civil associations, interact with schools, developing most actions and tools. In addition, although actions are carried out to teach entrepreneurship, only some actions contribute to the development of smart and sustainable cities. The underused potential of innovation ecosystem actors could help develop the skills and competencies of young people, contribute to the sustainable development of cities, and increase citizens' quality of life.

Schools still have a minor role in innovation ecosystems and sustainable and smart cities. Despite the systematic discourse on the relevant role of the citizen in the construction of smart cities (Petralia, 2020), primary and secondary school students are still neglected. School managers and policymakers also need to build alternatives to expand the role of schools in these contexts.

In this sense, there is an avenue for future studies, mainly empirical studies, that better describes the school's actions. It is also important for future research to focus on the role of different actors in innovation ecosystems in terms of their potential to stimulate and help schools in training young people and reinforce the positive contribution of different innovation ecosystem actors to encourage entrepreneurship in elementary and high schools

By the end, our findings demonstrate that scientific efforts focus on enhancing entrepreneurship skills while other elements of smart and sustainable cities remain on the sidelines. This study has the role of generating insights, and the results have the potential to be considered by researchers in future works.

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Changing the structure and dynamics of incumbet industrial sectors through fosh based demonstrators: the case of the green-fablab

Abstract ID#347

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Today there is more and more evidence showing that the current challenges humankind is facing will constraint the manner we will satisfy our basic needs in the years to come. It means we should completely rethink products but also their associated industrial ecosystems and sectors and so, the technologies and organizational structures of them.

Whitin the present paper we argue that these approaches explore the paradigm of "distributed manufacturing in urban areas" (Hermann, 2020) through the deployment of small manufacturing plants close to new feedstocks sources, namely urban waste. This means that small and distributed production units will be integrated to the urban environment, but in a more sustainable and symbiotic way. This is now a reality for plastics as well as for metals from electronic equipment or even waste from construction. The success of this type of approach is context dependent. In fact, it requires an evaluation of the in-situ conditions that takes into account the technical characteristics of the product and the process, the associated local supply chain and the environmental, economic and social impacts.

Designing open, more robust productive systems using locally available resources requires the integration of new sustainability parameters, allowing the development of resilient design and materialization approaches. The Free Open Source Hardware initiative (FOSH) has proven to be a successful initiative to increase innovation and reduce economic costs in several fields. FOSH refers to “Hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design.”

Nevertheless, this industrial change of paradigm is complex and requires a multidimensional and multiscale vision. To this end, ERPI initiated in 2014 a research program for the implementation of new local closed loop circuit for plastic recycling channels supported by Open-Source 3D-printing technologies (Cruz-Sanchez et al, 2017; Cruz-Sanchez et al, 2020). Within Green FabLab acting as a physical demonstrator and thanks to an iterative process which combines implementing FOSH technologies and applying complex systems modeling techniques, we seek to develop a generic methodology to assist the decision-making process of the stakeholders involved in such a project (Santander, 2020). Through a case study approach, we will describe the process of deploying it, but also drivers and barriers which this type of approaches will contribute to the industrial transition.

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A widespread review of smart cities: identifying dimensions and core components

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Abstract: Smart cities are a new and complex phenomenon anchored by technology, governance, organizations, civil society and government that interacts and innovate to create a sustainable, resilient, and economically prosperous urban ecosystem. For this to happen, several dimensions and urban stakeholders need to cooperate. Despite the undeniable breadth and complexity of the concept, more is needed to know about the dimensions and core components that make cities smarter. With this problem in mind, this study aims to identify and classify the dimensions and components that form smart cities. For this, a systematic review of the literature supported by the PRISMA-P protocol was carried out. The findings show seven dimensions composed of different components that, when interacting, become transformational facilitators of urban spaces. For a city to be smart, these dimensions need to act in a feedback network capable of increasing citizens' quality of life, urban resilience, and sustainable development. This research is a starting point to guide future studies related to urban dimensions and territorial dynamics for the development of smart cities.
Keywords: Smart cities; urban space; urban ecosystem; intelligent cities.

Introduction

Throughout human history, cities have increasingly become centers of production, commerce, mobility, diversity and cultural transformation (Engel et al., 2018). Cities' population density and geographical proximity can generate considerable gains, especially regarding reduced transaction costs, firm productivity, innovation, knowledge production, and quality of life for their inhabitants (Asheim et al., 2011). In this sense, geographical proximity brings urban actors closer together, acting as a facilitating factor for knowledge exchange.

Despite the undeniable opportunities created or enhanced by urban spaces, cities unleash a paradox in their growth. On the one hand, cities are drivers of socioeconomic development. On the other hand, cities face - or foster - numerous challenges related to social inequalities, unemployment, traffic jams, violence, and pollution (Neirotti et al., 2014). As a result of this antagonism, many cities unprepared to deal with growth have stagnated. At the same time, they should be prospering or have declined in the face of the challenges posed by geographical growth and population density (Camboim et al., 2019).

Social, economic, and environmental challenges affect all cities and impact their development. Over time, countless cities have faced development challenges, for example, the first attempt at renewal in Tucson, Arizona, a few decades ago; the lower quality of life for Indian slum dwellers; the decades of decline in Detroit, USA; or the planned mono-industrial cities of Magnitogorsk, Togliatti, and Vorkuta in Russia, with their numerous environmental and social problems (Gomez-Novy & Polyzoides, 2003; Nair & Sharma, 2017).

The transformation of cities over time is a dynamic and complex process involving millions of individuals, governments, and organizations, with multiple political, economic, and cultural factors (Camboim et al., 2019). The complex transformations and rapid expansion of urban environments are gaining ground in scholarly literature to understand the metabolism of cities and the sum of elements, technical resources, and socioeconomic processes that foster cities' growth and sustainable development (Kennedy et al., 2007). Increasingly, urban planners and policymakers join forces to identify parameters that characterize cities and the dimensions and components that can make urban spaces more sustainable, resilient, and smart (Dritsa & Biloria, 2018). However, the dimensions and components that portray smart cities are still scattered in the scientific literature. To the best of the authors' knowledge, until this research was conducted no study has classified all dimensions of smart cities. Many have explored specific dimensions such as economy, environment, and society (Akande et al., 2019), technologies, people, and institutions (Nam & Pardo, 2011), and economy, technology, and mobility (Li et al., 2019). In this sense, this article's objective is to review the literature thoroughly to identify the elements and answer the following research question: *what are the dimensions and core components that transform urban spaces into smart cities?*

We used the PRISMA-P protocol (Moher et al., 2009) to review the literature to achieve our goal and identify the dimensions and core components that make cities smarter. The results show seven main urban dimensions interrelating and feedback to develop cities. The interaction between these dimensions may be critical in developing cities' intelligence.

Theoretical Background

Population density and geographical proximity generate productivity and innovation gains for cities. If, on the one hand, cities are drivers of socioeconomic development, on the other hand, they face immense challenges. Engel et al. (2018) discuss some of the problems faced by cities, such as creating urban centers that can empower and retain talent; developing and make use of technological resources for the benefit of society and sustainability; and creating and maintaining a fair and equitable environment that ensures dignity, equality, and quality of life for the current and future generations.

However, the praxis of smart cities is a challenging task. The new paradigm was born anchored on the creation of value and the search for sustainability, connectivity, accessibility, mobility, collaboration, inclusion, and diversity, which should foster the development of new industries and technologies, new business models and market relations, and a new society (Florida, 2014; Camboim et al., 2019). The complexity and development challenges of cities trigger searches for ways to transform cities into learning regions supported by technology and innovation policies (Balland & Boschma, 2021).

The challenges have aroused great interest in the academic community. In recent years many concepts have emerged in the literature to discuss the evolution of cities. Among these concepts are sustainable cities, digital cities, resilient cities, virtual cities, sensible cities, and many other terms that do not fully explain the complexity and dynamism of cities (Janik et al., 2020).

From this problem, the concept of smart cities emerged, going beyond the other concepts or merging all the previous ones to protect the planet and improve the quality of human life (Benevolo et al., 2015). Despite increasing interest and research on the topic, there is no consensus about the meaning and scope of the concept of "smart cities." It is often confused or used as a synonym for other terms (Janik et al., 2020).

In most studies, the concept of smart cities appears tied solely to using technologies in urban spaces. Several researchers are dedicated to understanding the use of digital technologies such as the Internet of Things (Arasteh et al., 2016; Bellini et al., 2022) and big data (Dogan and Gurcan, 2022; Cavicchioli et al., 2022) to increase the intelligence of urban areas. Fewer researchers understand smart cities as a complex and multifaceted concept. For example, Nam and Pardo (2011a) conceptualize smart cities from three dimensions: technology, people, and institutions. Some researchers analyze smart cities considering other elements, such as governance (Lombardi et al., 2012), environmental protection (Spiliotopoulou & Roseland, 2020), and quality of human life (Benevolo et al., 2015; Engelbert et al., 2019). However, no research gathers all dimensions in a single study and identifies their core components.

Governments, public managers, and researchers use several metrics to measure the degree of intelligence of cities (Patrão et al., 2020), as has been done in Singapore, London, Barcelona, Medellin, and Curitiba, among others (Shamsuzzoha et al., 2021; Bibri & Krogstie, 2020; Smith et al., 2022; Hojda et al., 2019). Despite these efforts, disagreements about what makes cities smarter, and especially the analysis of isolated dimensions and components, anchor regions under different justifications for measuring their intelligence, such as technology, sustainability, or social issues.

Moreover, the different views and metrics on urban intelligence hinder the creation of projects for developing smart cities. At the same time, much research is done to create hyper-connected and sustainable cities (Lim et al., 2018), but few are dedicated to finding solutions to reduce poverty, violence, and inequality found mainly in large metropolises (Seta et al., 2015; Vanolo et al., 2016).

The researchers agree that when a city is smart, its growth is promising, generating income, urban mobility, and access to health and education for all citizens. For all this to happen, it is essential to have multi-stakeholder engagement and a vision oriented toward developing an urban architecture that simultaneously addresses various aspects and elements of cities. However, only a minimal amount of research has devoted efforts to understanding the dimensions and core components of smart cities and creating intervention proposals focused on smart city development.

In the literature review, there became evident that there are divergences in the concept and dimensions of smart cities (Janik et al., 2020; Silva et al., 2018; Firmansyah et al., 2019). The topic unfolds in different fields of study such as architecture, management, technology, and sociology, often fragmenting through researchers' particular views and partial analyses (Oliveira et al., 2019).

As noted, the complexity and breadth of the concept of smart cities highlight its importance. The divergence in the literature highlights that while much research effort is devoted to understanding the topic, more studies are needed to understand its diverse and complex components and dimensions.

To understand the importance of the concept of smart cities and spread it around the world, it is necessary to take a step back to analyze that when an urban space is built and developed, at a certain point, it reaches optimal levels of economic growth, ease of transportation, logistics, access to health and education, leisure, security, and the necessary infrastructure to increase the quality of life of its citizens (Camboim et al., 2019). After this optimal point, however, the quality of life of its inhabitants begins to be impaired by environmental pollution, traffic and congestion, social inequalities, unemployment, disease, and violence. These factors cause cities to quickly lose their gains in density and proximity, harming the quality of life of their inhabitants (Gil-Garcia et al., 2015).

In this sense, smart cities are anchored by technologies, governance, organizations, and policies that interact, innovate, and develop economic processes and infrastructure that differ across different regions and countries (Chourabi et al., 2012). For many years, most of the efforts of researchers were devoted to analyzing possible success cases in developed countries such as Singapore, Hong Kong, and Barcelona (Bakıcı et al., 2013; Gascó-Hernandez, 2018; Kit, 2022). Recently, some cities such as Medellín in Colombia (Camargo et al., 2021), Curitiba in Brazil (Sancino & Hudson, 2020), and Pune in India (Prasad & Alizadeh, 2020) are examples of cities in developing or emerging countries that appear in the academic literature in the quest to transform into smart cities.

Throughout the evolution of urban areas, numerous scientists have devoted efforts to understanding and representing urban systems through discussions of the metabolism of cities (Kennedy et al., 2007) and the formation of urban ecosystems (Alberti et al., 2003). Economist Elinor Ostrom pioneered the study of complex social-ecological systems that consider the urban system's different levels, components, and configurations (Ostrom, 2009; Anderies et al., 2004; McGinnis & Ostrom, 2014). Similarly to Ostrom and Meerow et al. (2016), this study assumes that the urban system forms an interconnected network, where components of each dimension are key factors for urban development and generate different influences on the system over time without assuming a hierarchical structure.

Methodological Procedures

A systematic literature review using the PRISMA-P protocol was carried out (Moher et al., 2009). The PRISMA-P protocol is widely used in literature reviews to ensure research robustness and reproducibility (Furstenau et al., 2022; Khamisy-Farah et al., 2021). PRISMA-P was chosen because it has a robust checklist that aids in research transparency and reproducibility through the steps of identification, screening, eligibility, and inclusion of documents associated with the study objective (Sott et al., 2020; Moher et al., 2015; Sott, Bender & Baum, 2022).

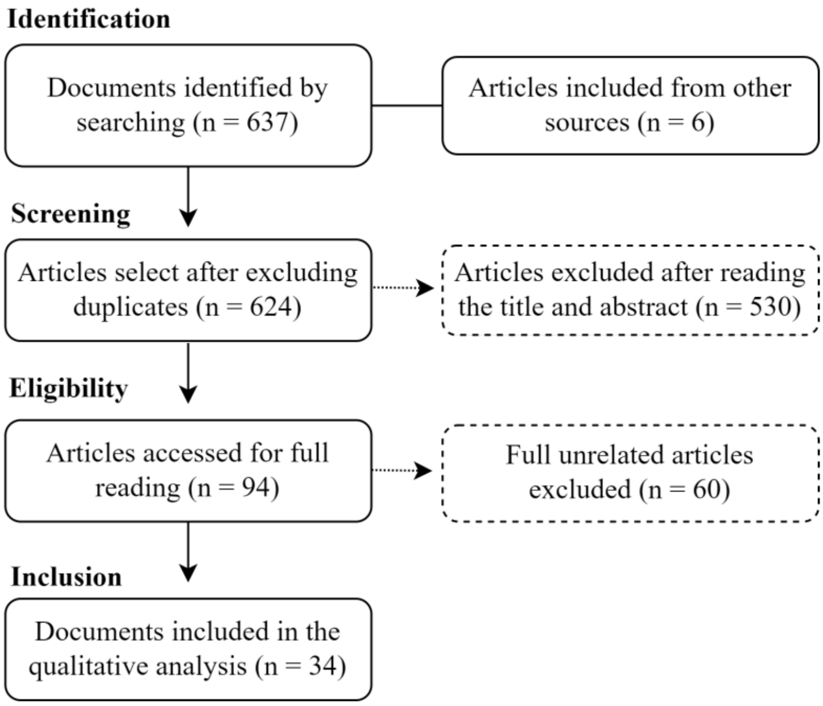
The ISI Web of Science Core Collection (WoS) database was searched for eligible publications. The WoS was chosen because it is one of the indexed databases with the highest volume of quality research and peer-reviewed publications from high-impact journals (Dias et al., 2021; Severo et al., 2021; Furstenau et al., 2023).

The documents were exported on August 17, 2022. The term "smart cit*" was used in the search. Although other terms such as digital cities, sustainable cities, resilient cities, connected cities, and others, present similar characteristics to smart cities, in this study we chose to use only the term smart city, because we understand that this concept is broader and may have the quality of life of urban citizens as its final objective.

Only literature review documents, published in English from 2017 to 2022, with the search term present in the title, abstract, or keywords, were considered. In all, 637 documents were found and tabulated. Due to the number of literature reviews published on the topic, inclusion and exclusion criteria were applied. We selected only papers with methodological robustness that presented smart city components and/or dimensions. The methodological robustness was assessed based on the review protocol used in the analyzed studies, mainly regarding the study's reproducibility and reduction of researcher bias. Articles that clearly identified the dimensions and components of a smart city were selected for analysis. Non-accessible documents were excluded at the eligibility stage.

The snowball approach (Wohlin, 2014) was used to identify other research that characterized smart cities from their dimensions and core components. Finally, 34 documents were selected and included in the qualitative analysis. Figure 1 shows the steps of PRISMA-P.

Figure 1. Phases of the PRISMA protocol



Source: The authors.

Results and Discussion

According to the results, the number of publications in the field of study has grown exponentially over time. Actions are being taken in different parts of the world to develop smart cities, such as Medellin in Colombia, Tokyo in Japan, and Porto Alegre in Brazil. With the rapid growth of cities, numerous aspects need attention. Researchers and practitioners join forces to find ways to develop smarter, more resilient, and more sustainable cities. For the city to thrive, multiple actors must be engaged, and many urban elements must be driven and orchestrated. However, only some previous research has attempted to explain the smart city phenomenon by identifying its elements (Gil-Garcia et al., 2015; Silva et al., 2018; Firmansyah et al., 2019).

Some studies have addressed smart city dimensions, as seen in Albino et al. (2015) and Nam and Pardo (2011a). Nonetheless, to the authors' knowledge, studies have not considered cities as complex systems composed of dimensions and core components that interrelate and feed back into each other. Analyzing urban space as an interacting, feedback-loaded system is significant for understanding smart cities. In addition, despite theoretical and empirical advances, more is needed to know about the elements that make a smart city. According to our findings, well-developed core components can make cities smarter, more sustainable, and more resilient. These core components can be categorized into dimensions.

Our review identified seven general dimensions: the natural environment, urban infrastructure, smart economy, technology and innovation, people, smart governance, and organizations. Each of the dimensions is composed of a cluster of core components. The components represent elements fundamental to economic growth, urban development, and the well-being of urban citizens. By analyzing cities as systems composed of dimensions and core components, all urban aspects become essential, such as maintaining or creating green areas, entrepreneurship, economic flows, and valuing human creativity and knowledge.

Table 1 shows the core components of smart cities identified in the literature and categorizes them into dimensions. The dimension represents a subsystem of the complex system - the city - while the components represent the elements of the dimensions.

Table 1. Dimensions and core components of smart cities

Dimension	Description	Components	Main authors
Natural environment	It refers to the ideal natural conditions necessary for the quality of human life and the prosperity of generations and the planet.	Efficient management of natural resources Renewable energy Green areas Sound, land, water, and air quality Waste management	Lai et al. (2020); Myeong et al. (2022);
Urban Infrastructure	Urban components are indispensable to meet the urban population's locomotion, housing, work, and leisure needs.	Mobility and transportation Convenience and access Smart design Smart buildings Geographic attributes Basic sanitation	Silva et al. (2018); Kasznar et al. (2021)
Smart Economy	It provides opportunities and prosperity for citizens in various areas through interrelationships between civil society, government, and organizations.	Decent quality employment Access to healthcare Quality education Housing Income Encouragement of business Ideal Cost of Living Public Safety	Al Sharif and Pokharel (2021); Silva et al. (2018); Nam and Pardo (2011a);
Technology and Innovation	Encouraging innovation and digital technologies to integrate the urban system and increase the population's quality of life.	Digital Infrastructure Digital and mobile technologies Telecommunications Networks Fostering innovation Emerging technologies	Al Sharif and Pokharel (2021); Myeong et al. (2022); Kasznar et al. (2021)
People	It is concerned with quality social interactions, and their perceptions of public life and should generate a sense of belonging and a life of dignity.	Social Capital Culture, tourism, and leisure Knowledge creation Creativity Collaboration Justice and equality	Chourabi et al. (2012); Al Sharif and Pokharel (2021); Silva et al. (2018); Kasznar et al. (2021)
Smart Governance	It is about the involvement of municipal and state public management in creating public policies and services for citizens.	Public Policies Legislations and guidelines Resilience plan Public services Social programs	Gil-Garcia et al. (2015); Al Sharif and Pokharel (2021); Silva et al. (2018); Myeong et al. (2015); Ruhlandt (2018)
Organizations	It includes private organizations, public organizations, and educational institutions that interrelate with the community.	Research and development Technological education Professional qualification Entrepreneurship	Anttila and Jussila (2018); Dameri et al. (2016); Kummitha (2019); Penco et al. (2021)

Source: The authors.

Each dimension represents a key area for urban development; this is particularly important because it highlights the breadth and complexity of smart cities. It is noticeable that when isolated, each dimension can easily be linked to other city concepts: the natural environment dimension, for example, is directly related to green and sustainable cities; while the technology and innovation dimension guides digital and connected cities; the people dimension, in turn, has a strong relationship with cognitive and knowledge cities.

By analyzing a city from dimensions, we consider its management, policy, and context characteristics as proposed by Nam and Pardo (2011b). Urban dimensions are cut across the routine activities of the urban population and the municipal health, education, and political systems. The multidimensionality and interrelationships of urban spaces make it particularly difficult to measure the intelligence of a city while also making it essential to analyze these dimensions. Although the dimensions have their characteristics, they can be analyzed together. The natural environment dimension is concerned with environmental sustainability and preserving the city's environmental pillar, but this concern is also intrinsically associated with the urban infrastructure dimension. Organizations and people establish stable relationships in the world of work and consumption and are influenced by the governance dimension. Technology and innovation arise in all dimensions and can be used by all. Moreover, all dimensions generate some results in the local economy.

The dimensions prove that a smart urban environment must provide health, education, sanitation, transportation, recreation, safety, and countless other benefits for different groups and populations in the city. Furthermore, a smart city needs to be anchored by solid networks and constant interactions between its internal actors (government, citizens, and organizations) and external ones, such as members of other regions (Ojasalo & Kauppinen, 2016). The ability to develop innovation, foster business and entrepreneurship, strengthen tourism and external relations, and promote equality for its citizens are essential characteristics of a smart city (Nam & Pardo, 2011a).

Due to the complexity of the topic, most research focuses on studying isolated dimensions of smart cities, such as technology (Qian et al., 2019; Bellini et al., 2022; Komninos et al., 2022); governance (Lim & Yigitcanlar, 2022; Golubchikov & Thornbush, 2022); urban infrastructure (Kasznar et al., 2021); people (Calzada, 2021); natural environment (Zhou et al., 2021) and other dimensions identified in this study.

For one strand of literature, a city becomes smarter when it evolves toward a single dimension, potentially becoming more connected (Kummitha, 2020), sustainable (O'Dwyer et al., 2019), or infrastructure-enhanced (Yang & Yamagata, 2019). For another strand of literature, while each dimension individually plays an essential role in the development of cities, the technological and non-technological elements (e.g., demographic attributes, geography, urban context) need to be considered in an integrated manner (Keshavarzi et al., 2021). From this perspective, the degree of technology, urban infrastructure, business ecosystem, or any other component cannot transform urban space into a smart city.

Many disagreements exist in the literature about the development and evolution of cities over space-time to become smart. This study shows that the various parts that shape cities (dimensions and components) remain the same. However, most research continues to focus on specific factors in an attempt to transform cities almost exclusively through technology, sustainability, or economic growth. Thus, this research generates insights to explore smart cities from the elements already known, worrying less about individualized dimensions and more about the feedback between interacting and interdependent parts.

It is important to highlight that there are two essential characteristics of smart cities that, although evidence in the literature, need to be categorized as dimensions in this research: sustainability and resilience. We understand that sustainable development and resilience manifest from the positive result of the interrelationships and feedback of the previously identified dimensions and components. Thus, sustainability and resilience are fundamental outcomes expected from the synergy of the urban system dimensions that orchestrate smart cities. These characteristics have become a global concern through the Sustainable Development Goal (SDG) number 11 of the United Nations (UN) Agenda 2030, which has the mission of making cities and human settlements inclusive, safe, resilient, and sustainable (Vaidya & Chatterji, 2020).

In short, the intelligence of the cities emerges and develops from its elements, which in turn move the agents of transformation (public sector, private sector, educational institutions and organized civil society). It is worth noting that the dimensions of each city have different (and often subjective) levels of development and therefore hinder the process of city transformation, which justifies the pulsating difficulty of measuring the degree of intelligence of cities (Patrão et al., 2020; Sharifi, 2019; Sharifi, 2020; Castanho et al., 2019). This research is the starting point for new insights regarding this theoretical and empirical problem, suggesting an analysis of smart cities as systems to assess the degree of intelligence on the assumption that intelligence derives from the interrelationships between the dimensions we have identified.

Conclusions

This article aimed to explore the dimensions and components of smart cities. Throughout the literature review, there became evident divergences about the concept and dimensions of smart cities, proving that the theoretical reflections are still incipient around these broad, abstract, and complex systems that are the cities. This study also advances by identifying the dimensions and components of smart cities and assuming the need for interrelationship networks, feedback, and cooperation between the dimensions of the system.

This study is not free of limitations. Only literature reviews published in the WoS database were considered. Only research that clearly reported urban dimensions and components was classified for qualitative analysis. In addition, we used only the concept of 'smart city', although we recognize that research with other terms known in the literature has content relevant to the field of study. Future research may fill these gaps.

While early research in the field was primarily devoted to studying the transformation of cities and finding ways to make them smarter, the concern for urban resilience will also increase as the topic reaches maturity. Resilience is an important gap in the literature that needs further study. It is because once cities achieve greater levels of intelligence, they will seek resilience strategies to remain intelligent over time. Urban resilience is essential so that when the goals of sustainability, economic development, and quality of life are achieved, they are maintained over space-time and through constant urban transformations.

In this sense, urban planners and researchers must increasingly dedicate efforts to creating resilient and sustainable smart cities capable of persisting and perpetuating over time while being changeable. In addition to filling a theoretical gap, our research contributes to practice by identifying the core dimensions and components of smart cities. This knowledge is the starting point for exploring the local capabilities of cities and developing solutions for the sustainable growth of urban areas and the well-being of their citizens.

Although the concern and urgency of researchers worldwide to create smart cities are clear, the lack of consensus on the concept's meaning and the lack of tools to measure the intelligence of cities weaken the discussions. Cities in different parts of the world continue to call themselves smart without following standard parameters or criteria about what it takes to be a smart city. This disconformity triggers the need for future research capable of creating tools to measure cities' intelligence levels, considering the local impact of their different components and dimensions. Moreover, future research could explore the complexity of the interrelationships among the dimensions and components of smart cities, their constant transformation processes and their relationships with the external environment.

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Development of an integrated business model for smart cities
Abstract ID#205

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Purpose

Every year, cities are facing greater challenges and problems arising from population growth, accelerated urbanization and resource depletion. In fact, the rapid development of technology, which generates higher expectations in citizens regarding their experiences when using the services provided by cities, expecting them to be satisfactory, easy and fast. Smart cities represent an opportunity in the presence of this type of demands from the population. Since, as observed in various definitions, the term smart city is based on sustainable and collaborative work using information and communication technologies (ICTs), placing citizens at the center (Zhao et al, 2021). Consequently, within smart cities, new services are created that respond to the needs of the community. However, in order to offer these new services, it is necessary, through the execution of business models, to identify which are the key factors that are part of the project and in turn determine the proposal or value creation, which in this framework is based on the welfare of citizens. Thus, the purpose of this research is to propose a business model in a context of smart cities, considering the relationships between the concepts that make up the value creation chain, the digitization of services and new business systems that are generated in a smart city ecosystem, ensuring added value to the community. This research points to how this business model can provide added value to a smart city.

Literature Review

Research on smart cities is clearly on the rise and the creation of smart cities is causing interest in various communities. This can be a clear advantage for society, since these cities use the potential of innovation and ICTs, in addition to other resources, to efficiently achieve improvements in the quality of life of citizens and generate sustainable development. On the other hand, the term business model is defined by Osterwalder, A., & Pigneur, Y. (2011) as the one that describes the basis on which a company creates, provides and captures value. The authors proposed the well-known canvas model, which has been a guide for other research in which it has been modified with the purpose of adapting it to more specific services. Palominos et al, (2020) talk about the value creation chain of a smart city, which describes the phases and activities in which the entities involved develop services to contribute to the transformation of cities; nevertheless, there is little research on the concept of the value creation chain.

Methodological Procedures

The research methodology is composed by the description of the problem covered with respect to the services offered in smart cities and business models. It follows the development of the literature review of the topic studied, with the purpose of identifying and evaluating the information regarding smart cities, business models and the value chain of the services proposed in this context. Based on the above, the necessary components for the development of services in smart cities are analyzed with a proposal of an integrated business model focused on the value chain, and finally the respective conclusions are made.

Findings

The literature shows that there are adaptations of the business model canvas for services implemented in smart cities (Giourka et al, 2019; Timeus et al, 2020) in which concepts such as cost and environmental benefit, risk and social benefit are integrated in order to address the complex changes occurring in the urban environment and at the same time have a sustainable view of the transition to smart urbanism. However, analyses of the relationship between the business model concept and the value creation chain of the services proposed to these cities have not yet been developed. Likewise, there is no business model focused on the services offered by the entities involved in smart cities, which can guarantee the added value to people and thus provide a follow-up over time to ensure not only the correct initial implementation but also that it is beneficial in the long term. Therefore, the research will result in a proposed integrated business model for smart cities in which the concepts mentioned above are related.

Implications

This research provides information to governments and city leaders on a business methodology for the development of services in smart cities, in addition to promoting research in the area of smart economy in smart cities.

The limitations of this study are mainly the restricted information regarding the value creation chain. In addition, no business models have been detected that have a follow-up over time of the implementation of services in the context of smart cities.

As a future challenge, it is expected to conduct several case studies with the proposed model where it is rigorously tested in practice.

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Metamodel for smart cities and villages: A catalan perspective

Abstract ID#126 | Full Paper ID#418

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Abstract: In the urban context, the objective is generally to solve how to handle typical problems of highly populated areas, such as traffic, mobility, waste management, pollution and consumption of energy, among others; all these problems, due to their data-intensive nature, have no direct application in the rural world, where data generation is not so frequent and is much more dispersed and fragmented (Mukti et al., 2022). In the rural context, on the other hand, the effort is focused on solving how to empower citizens and develop the regional economic potential (Maja et al., 2020) to prevent depopulation. Literature is scanty to develop a metamodel, that we define as a model that considers the different dimensions of a city (rural, coastal, size, touristic, industrial, etc.) (Maja et al., 2020). Our paper aims to fill this gap. The methodology is divided into two phases. The first phase is based on a large literature review and a compilation of smart cities models proposed by different authors with their respective dimensions. The second phase takes as input the result of the first phase and is based on the result of a series of workshops held with a team made up of municipal representatives to review, analyze and propose a model of models (metamodel).
Keywords: Smart City, Municipality, Village, Metamodel 1.

Introduction

According to the United Nations report (UN, 2015), most of the world's population is living in urban areas. However, the projections for 2030 indicate that almost half of the population in developing countries is expected to live in rural zones (Mukti et al., 2022). Academics are showing their interest in the research related to the adoption of smartness to improve the quality of life and economic situation (Ramirez et al., 2021). But there is a difference in focus between the adoption of smartness between people living either in urban or in rural areas (Martinez-Gil et al., 2020). In the urban context, the objective is generally to solve how to handle typical problems of highly populated areas, such as traffic (Grimaldi, 2020), mobility, waste management, pollution and consumption of energy, among others (Angelidou, 2015); all these problems, due to their dataintensive nature, have no direct application in the rural world, where data generation is not so frequent and is much more dispersed and fragmented (Mukti et al., 2022). In the rural context, on the other hand, the effort is focused on solving how to empower citizens and develop the regional economic potential (Maja et al., 2020) to prevent depopulation. Various models have been proposed to evaluate smartness with an aim to improve policymakers' actions. Nevertheless, their focus was on urban and big areas, discarding the small or rural zones (Hajek et al., 2022). Moreover, despite efforts and initiatives, the results are below the expectations. The main reason is smartness is evaluated in an aggregated way, while metropolitan areas are very heterogeneous systems. Consequently, literature is scanty to develop a meta-model, that we define as a model that considers the different dimensions of a city (rural, coastal, size, touristic, industrial, etc.) (Maja et al., 2020). The objective of this work is there for twofold, on the one hand, to provide a comprehensive metamodel that is extensive and applicable to any kind of city, it looks to help to have a comprehensive overview of all the elements to be considered in the development of a smart community and to understand how they can be linked in order to establish priorities and achieve greater synergy of the measures to be implemented. And, consistent with the above, the second objective is based on the provision of a framework to analyse the different levels of digital maturity that municipalities must walk in their development journey.

Theoretical background and Methodology

This study reports on an analysis conducted to start filling the knowledge gap generated around the smart and sustainable development of cities and villages and provides insights into the different dimension this ecosystem has from a holistic view, which helps to define what strategic principles cities and villages should consider when approaching the design and implementation of strategies for smart development. The methodology is divided into two phases. The first phase is based on a large literature review and a compilation of smart cities models proposed by different authors with their respective dimensions. The second phase takes as input the result of the first phase and is based on the result of validation held with a list up of experts to review, analyse and propose a model of models (metamodel).

Phase 1: Literature Review

According with the literature review, five main proposals analysing the functions in smart cities and communities were reviewed. From all this research main elements and activities that define a Smart City were included. The articles under analysis are presented below.

- Model 1: Current trends in Smart Cities initiatives. Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014)
- Model 2: Estudio y guía metodológica sobre Ciudades Inteligentes López, M., Martínez, P., & Fernández, S. (2015). DELOITTE CONSULTING para el ONTSI
- Model 3: New forms of entrepreneurship and innovation for developing Smart Cities Grimaldi, D. (2016).
- Model 4: Smart cities as a source for entrepreneurial opportunities: Evidence for Spain Barba-Sánchez, V., Arias-Antúnez, E., & Orozco-Barbosa, L. (2019).
- Model 5: Smart Cities: Definitions, Dimensions, Performance, and Initiatives Albino, V., Berardi, U., & Dangelico, R. M. (2015).

Phase 2: Panel of expert validation

The dimension and functions observed in the previous phase, of literature review, were share with a panel of experts to validate the relevance of the structure proposed. This was developed with five rounds of workshops, refining in each iteration the content of the meta model resulting of this work. The panel of experts was compound by six experts with more than ten years of experience in the fields of: information and communication technologies, innovation, open government and digital technologies, organization and digital policies.

Results

This research was built to stablish a comprehensive metamodel of smart cities and village that was able to increase the current understanding of the development of these areas.

Literature review

The literature review allowed to see the main areas that science propose as fundamentals to the evolution of smart cities and village.

The results will be presented below.

• Model 1: Current trends in Smart Cities Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. Cities, 38, 25-36 The work team of the aforementioned in Model 1 proposes, as can be seen in the figure below (Figure 1), that the domains in which urban development policies are applicable and can be classified into two predominant groups, as to 'hard' or 'soft', in relation to the importance of ICT systems as key enabling technologies. Specifically, the hard domains refer to office and residential buildings, energy networks, natural resources, energy and water management, waste management, environment, transportation, mobility and logistics. In these environments, an improvement in sustainability is based on the deployment of ICT systems, together with the introduction of appropriate policy interventions and urban planning. From the perspective of Model 1, hard domains are the scenarios where the vision of a city that senses and acts can be most applicable, thanks to the use of sensors, wireless technologies and software solutions for manage "big data". Conversely, soft domains include areas such as education, culture, policies that encourage entrepreneurship, innovation and social inclusion, as well as communication between local public administrations and citizens (e-government). In these areas, ICTs play a more limited role and do not necessarily aim to process and integrate information in real time. It is also mentioned in this model that, in the cases of innovation and social inclusion policies, Smart Cities initiatives are not characterized by the deployment of new technologies but by public interventions aimed at creating the appropriate social and institutional conditions (for example, incentives, ad hoc organizational bodies, etc.). In the case of culture, it is expressed that public participation could aim to improve the exploitation and attractiveness of a city's cultural heritage. In the case of policies that foster human capital and innovation capabilities, the role of local policies in creating the appropriate institutional condition could mean, for example, the establishment and support of local incubators for new high-tech companies and their connection to the global world (innovation systems at scale). Areas such as health and public safety can fall somewhere between the hard and soft domains, as Smart Cities interventions in these environments can be characterized by the deployment of sensors and wireless technologies or by the deployment of practices and campaigns aimed at creating social values.

Figure 1:Model 1: Currents trends in Smart Cities – Neirotti, Marco, Cagliano, Mangano & Scorrano. (2014).

• Model 2: Study and methodological guide on Smart Cities. López, M., Martínez, P., & Fernández, S. (2015). Estudio y Guía metodológica sobre Ciudades Inteligentes. Deloitte Consulting para el ONTSI - Observatorio Nacional de las Telecomunicaciones y de la Sociedad de la Información.

The model proposed in the second place is the one that Deloitte has made based on a selection and analysis of various reports, works and perspectives of different entities and public bodies, local administrations, private entities and public-private organizations involved in the development of Smart Cities, with the purpose of conceptualizing the Smart City and defining the functional areas that make it up. Based on this, the areas shown in Figure 2 emerge as a summary, where six large blocks are identified, made up of the following areas and sub-areas.

• Smart Environment, focused on the efficient and sustainable management of the city's resources, and which includes the sub-areas of: Energy, Water, Urban Environment and Waste Management.

• Smart Mobility, focused on improving mobility and transport, and accessibility in the city, and which includes the sub-areas of: Road Infrastructure, Transport and Traffic, Parking, ICT Connectivity and Accessibility.

• Smart Governance, focused on guiding an open and transparent government, and which relies on technology to achieve quality and efficiency in its services and activities, and which includes the sub-areas of: Strategic Planning, Geographic Information of the City, Digital Administration, Transparency and Participation.

• Smart Economy, focused on the economic and competitive development of the city based on innovation, and which frames the sub-fields of: Tourism, Consumption, Commerce and Business, Digital Enterprise, Innovation Ecosystem and Employment and Entrepreneurship.

• Smart People, focused on enhancing the social and human capital of the city, and which takes into account the sub-areas of: Citizen Collaboration and Digital Inclusion.

• Smart Living, focused on increasing the quality of life of the people who are part of the City, and which includes the following sub-areas: Health, Education, Culture and Leisure, Social Affairs, Security and Emergencies, Urbanism and Housing and Infrastructure Public and urban equipment.

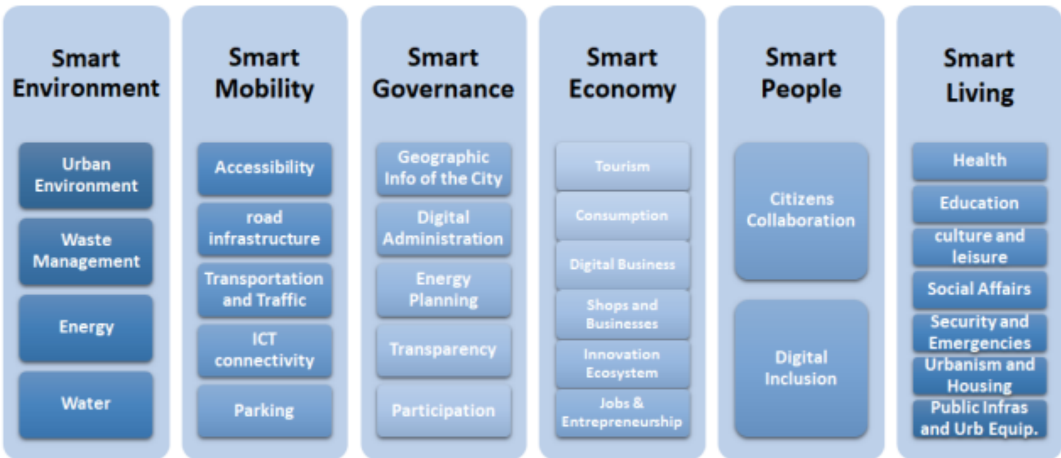

Figure 2: Model 2: Study and methodological guide on Smart Cities - López, M., Martínez, P., & Fernández, S.. - Deloitte Consulting para el ONTSI (2015).

• Model 3: New forms of entrepreneurship and innovation for developing Smart Cities Grimaldi, D. (2016). "New forms of entrepreneurship and innovation for developing Smart Cities", 121 p. Retrieved from http://hdl.handle.net/2117/105833

The analysis proposal number three, is based on what was presented by Didier Grimaldi in 2016, in his work entitled "New forms of entrepreneurship and innovation for developing Smart Cities" which postulates, based on different classifications compiled after studies comprehensive of cities around the world, which domains mainly listed include Energy, Transport, Life, Open Government and Economy.

And at the same time, it shows the tendency to fix the domains and characteristics of a Smart City based on two opposing approaches:

A. TOP-DOWN initiatives, where:

• Urban infrastructure is prioritized, and management is established by the City Council with a unidirectional (top-down) and ICT-oriented approach.

• The high-level domains here are (See Figure 3):

▪ Energy networks, where ICTs allow multiple energy sources to be managed and integrated into the common network.

▪ Environment, where ICTs make it possible to better protect environmental resources and control pollution.

▪ Transport, where ICT provides users with information about traffic and public transport.

▪ Healthcare, where ICTs help prevent and diagnose diseases and reduce healthcare costs.

▪ Public security, where ICTs help protect the integrity of citizens and their belongings by feeding information in real time.

▪ Electronic government and administration where ICTs promote digitized public administration.

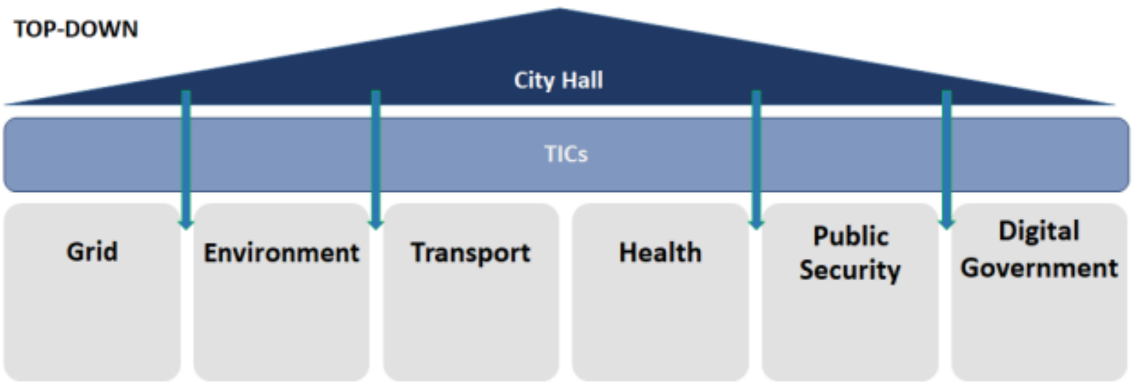

Figure 3: Main Domains of the city according to the Top-Down approach

A. BOTTOM-UP initiatives, one:

• Access to data is encouraged and citizens are allowed to develop their own initiatives.

• The deployment of new technologies is not the main objective, but the cooperation of citizens to eliminate injustice, "return" social rights, mitigate inequalities and help the integration of excluded people, provide assistance to citizens with functional diversity, older or younger people or providing access to culture and education for disadvantaged people.

• Considers that cities are not just a grid of smart sensors and a list of services, but have a unique character that is reflected in the everyday life and culture of citizens.

• Domains are related to education, culture and healthcare.

• Intelligence is people-oriented and ICT plays a limited role.

• Cooperation between citizens can be organized in a place that is usually called Living Laboratories (Living Labs), a shared physical space with the aim of involving users in a creative and collective perspective. (See figure 4):

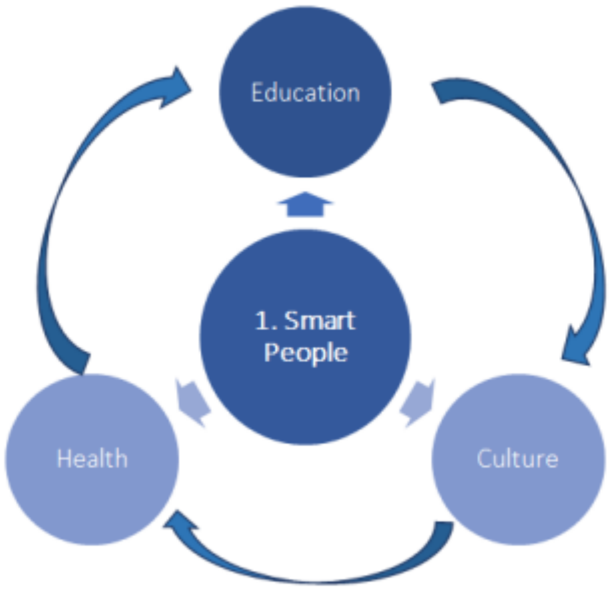

Figure 4: Main Domains of the city according to the Bottom-up approach

• Model 4: Smart cities as a source for entrepreneurial opportunities: Evidence for Spain. Barba-Sánchez, V., Arias-Antúnez, E., & Orozco-Barbosa, L. (2019). Smart cities as a source for entrepreneurial opportunities: Evidence for Spain. Technological Forecasting and Social Change, 148

The proposal made by the researchers of model four, is based on the fact that the intended goals of a Smart City include ensuring security, providing information services and facilitating an environment conducive to the spirit business

It further postulates that the main objective of the Smart City can be approached from two perspectives: as the objective of urban development projects, or as support for specific development policies (as a vehicle to attract investments and attract entrepreneurs and highly skilled labour). He adds that all definitions of Smart City have one element in common and that element is the use of ICT in the implementation and development of the smart city and in all the dimensions involved. However, the concept contains other dimensions such as social or ecological ones that modify this technological scenario, adding social value through innovation and creativity. He concludes his introduction by explaining that the (smart) city is based on three main pillars: planning and management services; infrastructure services; and human services. And that different innovations or emerging technologies of information and communication are called to play a fundamental role in the implementation of the smart city. These technologies include: Internet of Things, Communication Networks, Cloud and Edge Computing, Big Data. Other disruptive technologies that will play an important role in smart cities are robotics (Salvini, 2018), drones (Menouar et al., 2017), autonomous vehicles (Meyer and Shaheen, 2017), blockchain (MarsalLlacuna, 2018), cognitive computing (Williamson, 2017), among others (López, Martínez & Fernández, 2015).

Regarding the environment, waste collection is monitored by sensors not only to improve the cleaning and selective collection services of the cities, but also to comply with the recycling rates imposed by the European Union for 2020. Solutions for energy savings in public lighting, air conditioning and lighting systems in public spaces, smart meters, etc. it raises them as already considerably extended. On the other hand, mobility explains that it benefits from the use of ICT services such as the calculation of optimal routes, traffic consultancy and parking management. Finally, many other applications claim citizen participation as a key element in the smart city concept. (Figure 5)

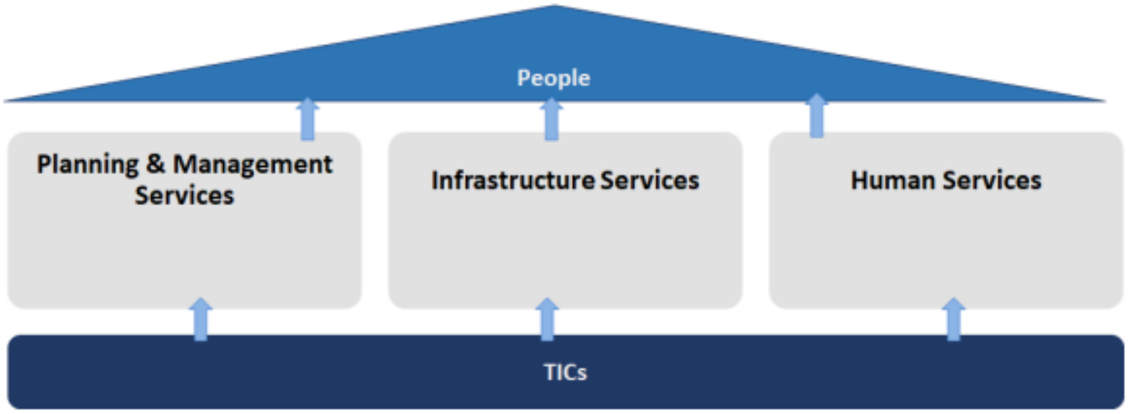

Figure 2: Model 4: Smart cities as a source for entrepreneurial opportunities: Evidence for Spain

• Model 5: Smart Cities: Definitions, Dimensions, Performance, and Initiatives. Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. Journal of urban technology, 22(1), 3-21.

Model 5 seeks, among other aspects, to identify the main dimensions and elements that characterize a smart city, through an approach based on an in-depth bibliographic review of relevant studies, as well as official documents of international institutions. In this sense, it provides that the most common characteristics of smart cities can be summarized in:

• The network infrastructure of a city that allows political efficiency and social and cultural development.

• An emphasis on urban development driven by businesses and creative activities. • The promotion of urban growth, the social inclusion of various urban residents and social capital in urban development.

• The natural environment as a strategic component of the future. Based on what has been explained above, a group of elements is listed without order, which are summarized below:

- Education.
- Infrastructure.
- Economy.
- Life quality.
- Mobility.
- Natural environment.
- People.
- Government.
- Technology.
- Economic Development.
- Labour Growth.
- Interconnection.
- Integration.
- Innovation.
- Human Talent.
- Energy.
- Waste.
- Water.

Panel of Expert Validation

Having exposed the different dimensions proposed by the experts as fundamental in the conception of a smart city, a metamodel of the transformation of municipalities adjusted to the reality of Catalan municipalities has been drawn up, designating key dimensions and components, which are shown and describe below (Figure 6). The aim here is to review all the fundamental aspects that make up a municipality, allowing to present the elements that must be worked on to achieve municipal development and growth from a comprehensive vision.

This final metamodel proposal is the result of five iterations of sessions, with each iteration improving the metamodel's content. Six professionals with more than ten years of experience in the following domains comprised the panel of experts: information and communication technologies, innovation, open government and digital technologies, organisation, and digital policy. The main conclusions of these sessions justify this final structure. The most relevant outcome for practitioners is to provide a metamodel that allows to have a comprehensive view of all the links necessary for the digital transformation of a municipality, and with this facilitate the municipal task in the change pursued. A proposal was made to present this in aggregate form with all of the possible challenges or fields in which action is required, so that municipalities can choose which areas of action to focus their development strategy. For this, five main dimensions or "boxes" have been defined, based on the two in which the municipality has the greatest influence: (1) Digital Administration of the City Hall itself and aspects related to (2) Urban Public services and physical infrastructure of the Municipality. In the upper boxes the services offered to citizens to improve their quality of life (3) Live, (4) People and (5) Economy, which although in some cases are not the direct responsibility of the municipality, can still work together with the other members of the business and social ecosystem, to generate the most favourable context for its development. Also, in line with the conclusions reached in the workshops held, (6) Transversal elements were defined in all dimensions to facilitate their operation and interaction, such as transversal elements of interoperability, connectivity, data governance, knowledge management, cyber security, etc.

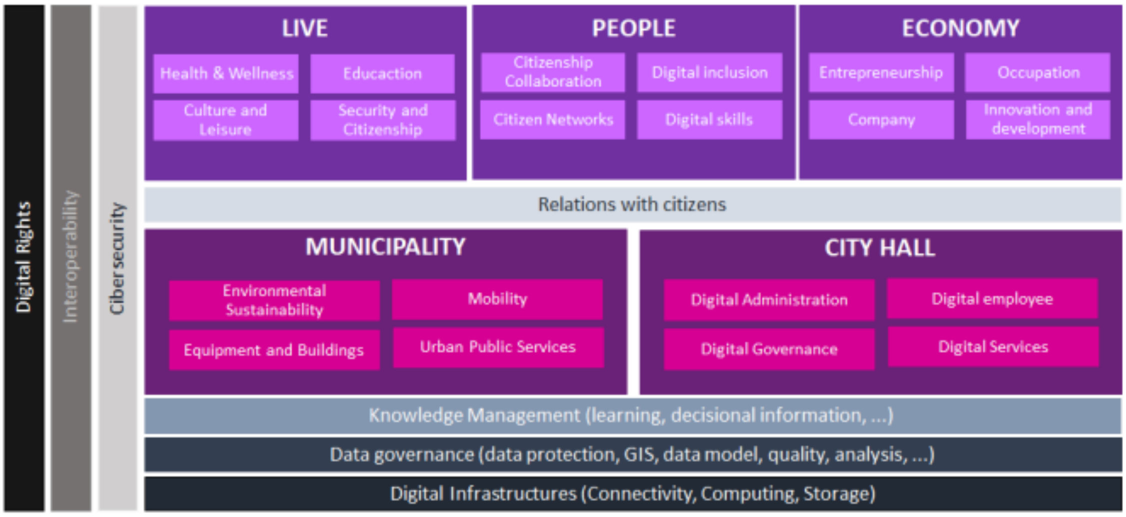

Figure 6: Digital Municipality Transformation Metamodel (Own Development)

The dimensions and sub-elements that make up the Transformation Metamodel are described in this section.

a) DIMENSIONS

- MUNICIPALITY
- CITY HALL
- LIVE
- PEOPLE
- ECONOMY

b) TRANSVERSAL ELEMENTS

- Knowledge Management
- Data Governance
- Digital infrastructures
- Interoperability
- Cybersecurity
- Digital rights
- Relations with Citizens

DIMENSIONS

MUNICIPALITIES

The Municipality block mainly brings together the components of an intelligent city of a more structural nature, which due to their condition fall directly under the municipal field of action. This dimension covers the following sub-areas:

- Environmental Sustainability
- Mobility
- Equipment and Buildings
- Urban Public Services

CITY HALL

The City Hall block involves the incorporation of technology to optimize the benefits and services that the municipality has both for its internal management and for the attention to the needs of citizens. This dimension encompasses the following sub-areas:

- Digital Administration
- Digital Governance
- Digital Workers
- Digital Services

LIVE

This blog aims to work on elements that improve the quality of life of the people who are part of the municipality and contemplate the following sub-areas:

- Health and Well-being
- Education
- Culture and leisure
- Security and Citizenship

PEOPLE

This is a higher level that seeks to enhance the social and human capital of the municipality. This dimension supplies the following sub-areas:

- Digital inclusion
- Citizen Networks
- Digital skills
- Citizen Collaboration

ECONOMY

This blog seeks to contemplate and give visibility to the elements that are oriented towards the economic and competitive development of the municipality, and involves the following subareas:

- Entrepreneurship
- Employment
- Company
- Innovation and Development

TRANSVERSAL ELEMENTS

The category of "Transversal Elements" has been defined to concentrate those functions which, due to their characteristics, affect all the previous elements, that is to say, they are common to all of them, and a global vision and management is necessary.

They are described below:

KNOWLEDGE MANAGEMENT

Work intended to acquire, increase, organize, distribute and share knowledge among all the workers and citizens of the Municipality, includes learning, decision-making information, etc.

DATA GOVERNANCE

Set of processes, functions, policies, rules and measures that guarantee the effective and efficient use of information in order to help the municipality meet its objectives. It allows setting a series of processes and responsibilities that ensure the quality and security of the data used in the society or municipality. Data governance defines who can take action, on what data, in what situations and through what methods. Includes data protection, GIS, data model, quality, analytics, etc.

DIGITAL INFRASTRUCTURES

Basic elements necessary for the development and support of all these technological services. These elements can be servers, fiber optic networks, towers for wireless communications, cloud storage farms, etc. and also other household items such as routers or network connectors. In short, the digital infrastructure is everything that supports these technological services and the information transfers associated with them: connectivity, computing, storage, etc.

INTEROPERABILITY

Possibility to exchange information and use the information exchanged.

CYBERSECURITY

Training and technology in cyber security.

RELATIONS WITH CITIZENS

A bridge between the administration and citizens.

DIGITAL RIGHTS

The extension to the digital environment of already existing human rights

Discussion

When comparing the models presented by the main researchers in the area of Smart Cities (Barba-Sánchez et al. 2019; Grimaldi, 2020; Neirotti et al., 2014), it can be seen that they all include, in one way or another, elements that are increasing their level of sophistication to reach a comprehensive satisfaction of the needs of the citizen. Although there may be variations in the way in which the individual elements proposed are grouped together (Grimaldi, 2016), it can be distinguished that they all include elements of infrastructure, such as connectivity, electricity networks, water, waste, transport and mobility, buildings, etc; that generate the technical and digital base on which the fundamental services are supported (health, education, culture, security, economy, business, employment) that make use of this base to be able to put their functions and solutions into operation in each of their areas, to conclude that the fundamental and central element of all models is the person and their training and training to be able to use these tools and for their personal fulfilment: digital inclusion, digital training, citizen collaboration (Albino, 2015).

The results emphasized that an smart and digital administration is conceived as a fundamental pillar for the impetus of the planned transformation, which takes more weight in small-sized administrations. So, its transformation to digitization as a means to guarantee the full development of citizens becomes the driving force for the rest of the components of the ecosystem at the beginning of the process. Then, once solid bases have already been generated, these same foundations serve as support and empowerment for the remaining (TOP DOWN and BOTTOM-UP strategies applied in a complementary way). The analysed models in the results present a complete and comprehensive view of all the dimensions to be considered in the development of a digital municipality. It is an complete starting point to have a comprehensive vision that contemplates all the aspects to be analysed and allows their prioritization and planning. Although each municipality sets its own strategy and objectives, the reality of the Catalan territory today is that it is made up of a high percentage of municipalities with less than 2,000 inhabitants and with a digital maturity in an initial instance in the majority of the cases (Ramirez et al., 2021). The proposed metamodel is an important step necessary to establish a prioritization regarding which of the elements in the digital transformation will be the ones that will be developed in the first instance and with what level of depth, taking as the main premise the main areas of municipal competence. Once the areas of basic competences are integrated into the digital model, the city can aspire to work on the other dimensions to achieve the efficiency and comprehensive functionality of the municipality for a better quality of life for its inhabitants.

Conclusions

Life in today's society demands constant action and evolution on the part of governments and society as a whole to adapt to the changes that are developing and to provide solutions to the needs that arise. The digital transformation of municipalities is conceived as a way to respond to the goals pursued by the public administrations. It represents a profound change that modifies the way in which all processes are carried out, but which will also allow innovation and guarantee a good service to the population, and above all, improve more and more efficiency, proximity and active listening, based on intelligent management, providing solutions to the new scenarios that arise, balancing for balance and territorial equality, providing opportunities for personal and professional development to all citizens, and working to reduce inequality. Establishing the road map for this development is a fundamental step to get through the entire growth process by having a clear vision of the elements necessary to guarantee the scope of the objectives and make efficient use of all available resources (economic, technological and humans). Establishing a metamodel that shows the key elements allows you to have this comprehensive view of the ecosystem, allowing prioritization and planning in accordance with the reality and ambition of each municipality. With this metamodel, practitioners are able to make a step forward for the digital transformation of the local municipalities, regardless of their size and stage of development. To this end, each municipality will need to develop a road map to be able to respond to urban, economic, social and governance challenges to ensure that its citizens have a fuller life in their personal and professional dimension, where companies and organizations find an optimal ecosystem to develop, where the municipalities have the necessary optimal infrastructures and where the public administration has the satisfaction of promoting a digitally advanced society.

Acknowledgments

This study is a collaborative work with Localret, the local consortium formed by the local administrations of Catalonia. The mission of Localret is to accompany city councils in the process of transforming their town or city into a digital municipality so that their citizens can fully develop there.

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STRATEGY AND INNOVATION II

May 3rd: 10h30 am – 12h30 pm

Chair

Osman Ahmed (Pacific Northwest National Laboratory, United States)

Papers

Alliances for innovation: Paths for the development of vaccines for Covid-19 in Brazil

Marcos Bruno, Rafael Crispim, Ary Plonski

Value creation of in-store digital interfaces, an exploratory study in the grocery retail sector in São Paulo city

Rogerio reis, dimária meirelles

American customer satisfaction index: A case study in a business management systems company in northwest Rio Grande do Sul-Brazil

Kauana Pilatti, Paloma de Mattos Fagundes, Giulia Rios Gualberto, Mariana Juliani dos Santos Portal, Ana Claudia Machado Padilha

Value perception in a business project

Bibiana Riveiro Quintans Sebold, Américo da Costa Ramos Filho, Lucas Werneck Louzada

International alliances for innovation, a social network analysis

Marilia Shocair, Evandro Ribeiro, Marcelo Amaral

Alliances for innovation: paths for the development of vaccines for Covid-19 in Brazil

Abstract ID#350

Marcos Bruno (Bocconi University), Rafael Crispim, Ary Plonski (University of Sao Paulo)

Purpose

Vaccines against SARS-CoV-2, the virus that causes Covid-19, have been developed in record time. Evidently, the dedication of scientists and the mobilization of public and private resources, either at national or international levels, were more intense during the period of production of these medicines due to the urgency that the pandemic caused throughout the world.

Despite the accelerated development and production processes, vaccines for Covid-19 are certainly a recent example of an innovative technology due to its successful global adoption and the effective reduction of death rates derived from complications from the disease, mainly for the population whose vaccination schedule was completed (Lipsitch & Dean, 2020). For instance, by November 2021, more than 3 billion people had been vaccinated, which represents more than 40% of the world's population (Ritchie et al., 2021).

In Brazil, the Institute of Technology in Immunobiologicals (Bio-Manguinhos) of Fundação Oswaldo Cruz (Fiocruz) produces, in two production lines, 900 thousand doses per day of the vaccine in partnership with the pharmacist Astrazeneca and the University of Oxford, both institutions in the United Kingdom. The Butantan Institute, on the other hand, has a daily filling capacity of between 600 thousand and one million doses of the vaccine developed in conjunction with the Chinese pharmacist Sinovac.

In both cases, the two Brazilian research institutes had decisive roles both in the testing stages of vaccine development, and in the production and distribution of those medicines throughout the country. This was only possible thanks to the strategic alliances for innovation structured in order to eradicate the Covid-19 pandemic.

Following Bruno and Vasconcellos (2003) framework, the objective of this study is, therefore, to identify the relevant management factors and best practices adopted in the innovation management process for the two alliances that were established in the development of Covid-19 vaccines in Brazil.

Literature Review

Strategic alliances are precisely the partnerships established by companies to work together, aiming at strategic objectives in common (Harrigan, 1988). Those mechanism of firms' collaboration typically provide expanded access beyond firm boundaries to resources and knowledge, which may be potential sources of competitive advantage for alliance participants (Joshi & Nerkar, 2011).

In this regard, the literature has shown that in the process of technological innovation, partners act as agents in the integration of a unified network of production and use of the scientific and technological knowledge through the alliance (Bruno & Vasconcellos, 2003). This way, the model developed by Bruno and Vasconcellos (2003) identify four dimensions (i.e., institutional, organizational, execution, and value creation) that characterize how strategic alliances for innovation can be structured and managed in an effective way.

It is also relevant to mention that learning and innovation in strategic alliances may take place simultaneously, yet they result from different combinations of partner characteristics, knowledge characteristics, and relational quality (Nielsen and Nielsen, 2009). Therefore, the literature suggests that for the success of strategic alliances for innovation, it is relevant to consider not only the heterogeneity of each firm's intellectual human capital but also the relationship between key innovative activities along the knowledge value chain within the alliance (Hess & Rothaermel, 2011).

Methodological Procedures

This study is structured to adopt a qualitative approach. The method used will be multiple case study (Yin, 2014), and the cases under investigation will be the two main strategic alliances for the development and production of vaccines against Covid-19 in Brazil (i.e., Fiocruz/Oxford/Astrazeneca and Butantan/Sinovac). Data collection will be carried out through semi-structured interviews with representatives of the institutions responsible for the

alliances, in addition to the verification of internal documents, and open access secondary data provided by the Brazilian government about the country's healthcare system. Data analysis will be performed through content analysis of the information collected and will be supported by Nvivo software.

Findings

Expected results are the management factors that influence strategic alliances for the success of innovations in the health sector in conditions of extreme adversity. Also, this study aims to identify common objectives for each strategic alliance under study, which is the qualification of the members in these alliances, the respective roles of each partner, the scope of work for the development and production of vaccines, and the relevant elements for sustaining those alliances on the long run.

Implications

This study has theoretical and practical implication. For scholars, the study provides empirical evidence of strategic alliances for innovation that successfully developed new products, and that rapidly reached the market. In this process, new management practices and different approaches to knowledge sharing had to be implemented. In a practitioner perspective, the study informs policymakers on the incentives to effectively coordinate public research institutes in partnership with private organizations to develop innovation.

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Value creation of in-store digital interfaces, an exploratory study in the grocery retail sector in São Paulo city

Abstract ID#264 | Full paper ID#396

Rogerio Reis, Dimária Meirelles (Mackenzie Presbyterian University)

Abstract: The objective of this study is to analyze and characterize how digital interfaces create value in grocery retail stores in São Paulo city. The theoretical review navigated thru value, retail business model, touchpoints, digital transformation, and technology in retail constructs. This research is qualitative, based on the interpretative paradigm, exploratory and descriptive. Data were collected through direct observation in stores, websites, apps, and interviews. The research results show: (i) digital interfaces create value for customers through reducing purchase time, reducing purchase effort, and increasing purchase benefit while creating value for the retailer by increasing operational efficiency and/or revenue; (ii) how value is co-created between customers and retailers interdependently; (iii) the value co-creation closed cycle process; (iv) customers have cognitive, emotional and social costs to overcome to use digital interfaces, and the retailer has a role in facilitating the learning process. A conceptual model of how digital interfaces create value in grocery retail was developed.

Keywords: Value, business model, innovation, digital transformation, retail

Introduction

Digital transformation is enabling innovations that are changing the way we live, and the way companies do business. The grocery retail industry in Brazil, which answers for 7% of the GDP, is in the early stages of the journey of using technological innovation to improve customers' shopping experience, particularly grocery retail, through increasing shopping convenience in all its dimensions, such as purchase time and effort, purchase transaction itself (i.e., self-checkouts) and the purchase benefit (i.e., the monetary value of the purchase).

Within this context, retailers have some fundamental questions: How can digital innovations create value? Why are certain innovations embraced while others are not? How to make technological innovations financially sustainable?

The purpose of this study is to explain how the usage of digital interfaces creates value, in grocery retail stores. Based on the intertwin of value and customer journey literature, the proposition defended here in this paper is that digital interfaces in grocery retail stores provide the basis for value co-creation.

Customer value parameters, such as include convenience, cost advantages, and purchase decisions, were analyzed in a wide range of digital interfaces. As a result, the paper contributes to identifying and mapping each interface as well as determining the different types of value they add.

Theoretical Background

Value and Customer Experience

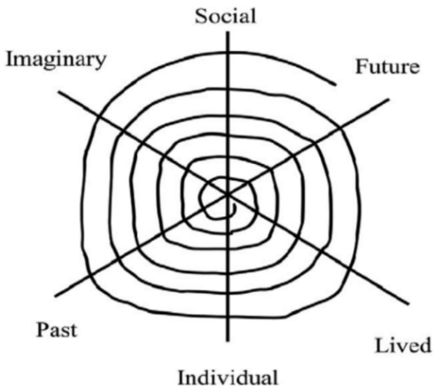
From the consumer's perspective, value is based on the expectations they believe they can receive from a product or service (Woodruff, 1997), expectations that are created before the product is used or the service is provided and are based on the consumer's needs, desires, expectations, and experiences.

The overall value of a product or service relies on the difference between the expectations created and what is received (Zeithaml, 1988). Priem (2007) suggests that the increase in consumer benefit will occur as there is an increase in knowledge or a reduction of the time used in the activities, due to the learning during past consumption experiences.

In retail, customers look to minimize the time and physical effort they dedicate to shopping (Seiders et al., 2005). Berry and Grewal (2002) decomposed convenience by identifying five dimensions: The convenience of decision relates to the time and effort required to decide to buy; the convenience of transaction that involves the tasks related to payment, such as standing in line; the convenience of benefit reflecting the expenditure of resources to obtain the product or service and the post-benefit convenience that refers to the time and effort required to resolve a service failure or additional post-purchase services.

Service customers individually and distinctively attribute value to the experience in an iterative, non-linear way, as the actual value of the experience is built on expectations created by previous understandings and imagined future experiences, embedded in the social context, and comparing the experience received with the expected experience, as described in figure 1 (Helkkula et al., 2012).

Figure 1- The hermeneutic spiral of individual and collective sense-making of value in the experience

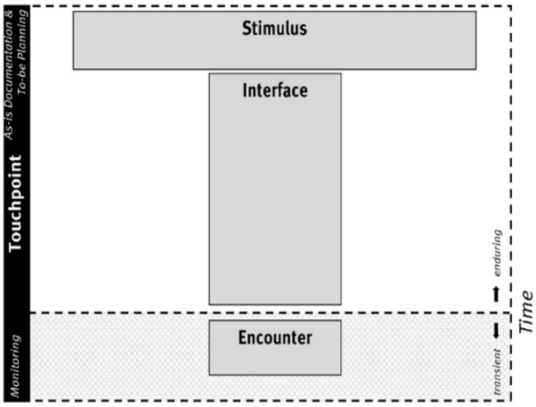


Note: (Helkkula et al., 2012, p. 63)

The customer experience in retail can be analyzed by touchpoints. They are any interactions between the service providers and the customer, physical or non-physical, active, passive, direct or indirect, where service providers offer encounters to customers (Dhebar, 2013; Kronqvist & Leinonen, 2019; Richardson, 2010).

The touchpoints are composed of three constructs: The stimulus, the interface, and the encounter (see Figure 2) (Barann et al., 2022).

Figure 2 - Touchpoint Concept



Note: Barann et al., 2022, p. 3

Customers, when shopping in supermarkets, have needs and expectations, seeking products and experiences. In the store are interfaces planned by the retailer to generate the experience at the touchpoints.

Touchpoints are perceived by any of the human senses (Bascur et al., 2019). It has an interface, which transmits and grants access, to the stimulus, which is mediated by a human, an analog object, or a technology located in a physical or digital sphere.

The customer interface is defined by how retailers structure the exchange process with the customers. The customer chooses a store expecting to find the products and experience he is seeking for. The touchpoint is a stimulus, designed by the retailer, that fulfills a specific function. When encountering a touchpoint, the customer enters in contact with the message from the retailer. Encounters are the exact moment or a time interval in which the customer gets in touch with the interface, that carries the stimulus.

Value Creation and Digital Transformation in Grocery Retail Business

As proposed by Bowman e Ambrosini (2000) value can be modified by increasing the use value or by reducing the exchange value (price). However, the most sustainable way to increase value is to increase the use value by innovation.

Value creation happens in the innovation process, an intentional effort to develop a new product or service that satisfies consumers' needs and desires better than the product or services available in the market (Zott, 2003). However, value is co-created during the interaction between the provider and the customer (Vargo et al., 2004; Vargo & Lusch, 2008), rather than being only added during a separate and non-interactive production and consumption process.

The value co-creation is realized and assessed in the social context of the simultaneous production and consumption process. Value can be also co-destroyed in the interaction between the provider and the customer when it goes in a negative direction (Echeverri & Skålén, 2011); this possibility should not be overlooked (Plé & Cáceres, 2010).

The proposition defended here in this paper is that digital interfaces provide the basis for value co-creation. During the customer journey, the interactions between customers and retailers provoke the customer experience, a personal and multilevel reaction from the customer. When a customer lives an excellent experience, it contributes to value creation (LaSalle & Britton, 2003)

The value expectation implies interdependence between retail format and assortment. Retailers segment customers into target customer groups, creating and developing business models to meet and exceed their needs for products and experiences. The retail format is the combination of elements of the retail mix, such as assortment, pricing strategy, location, and others (Levy et al., 2019). Since customers' needs are different, retailers offer various formats, and customers choose the one that best suits their needs. What differentiates the formats are their location, level of convenience, assortment, price, and shopping experience (Sorescu et al., 2011).

The main functions related to assortment in supermarkets are purchasing, stocking, and moving products. The part that handles the shopping experience has three interdependent dimensions: retail format, customer interface, and governance (Sorescu et al., 2011).

Traditional retailers can develop new services and new interfaces, offering more convenience to customers. The main interface decisions are assortment, price, store atmosphere, and product display, in online and offline stores.

Technological development is a powerful driver for innovation in retail business models (Sorescu et al., 2011). Digital transformation, at the organizational level (Dąbrowska et al., 2022) is about strategy, not technology (Rodgers, 2016). According to (Warner & Wäger, 2019) businesses must identify ways to integrate digital technologies to enable significant business changes, improve customer experience, streamline operations, integrating digital technologies and business processes in a digital economy (Liu et al., 2011).

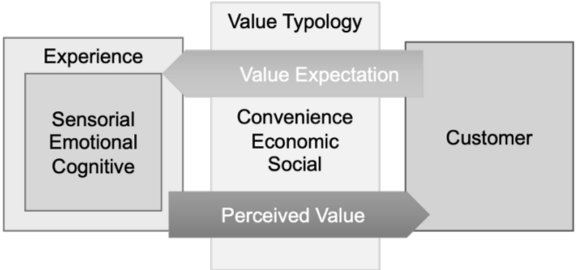
The retail industry has always used technology to generate competitive advantage, but it isn't always the early adopter, due to trying to capitalize on technology trends without appropriate business model evolution is a trap for many companies (Sorescu et al., 2011). Changes in retail have been occurring evolutionarily, in the beginning, technology adoption was focused on the value chain, nowadays, retailers have increased investments in customer experience, from in-store technologies (Grewal e Roggeveen, 2020) such as autonomous technologies (de Bellis & Venkataramani Johar, 2020), autonomous checkouts, virtual assistants, and free Wi-Fi in-store (D. Grewal et al., 2018), and mobile technologies (L. Grewal & Stephen, 2019).

Technology allows the development of digital convenience (Vyt et al., 2022) where digital interfaces, such as click and collect, reduce the time and effort of the traditional customer journey. In this concept, websites and mobile applications become the customer's digital interface with the store.

The integration and coordination between online and offline sales channels have grown in importance with the growth of multichannel and omnichannel retailers (Sorescu et al., 2011).

Technology in retail creates three types of customer value: convenience, allowing the customer to reduce his purchase time and effort; economic, allowing the customer to save money on the purchase and social value, allowing the customer to connect with others before, during, and after the purchase (D. Grewal e Roggeveen, 2020; Willems et al., 2017). Figure 3 represents the value creation process in the experience considering the value typology of technologies in retail.

Figure 3 - Value in the Experience with Digital Interfaces



Note: Grewal and Roggeveen, 2020; Holbrook, 2006; Willems et al., 2017 adapted by the author.

Conceptual Model: Digital Interfaces Value Co-creation Cycle in Grocery Retail

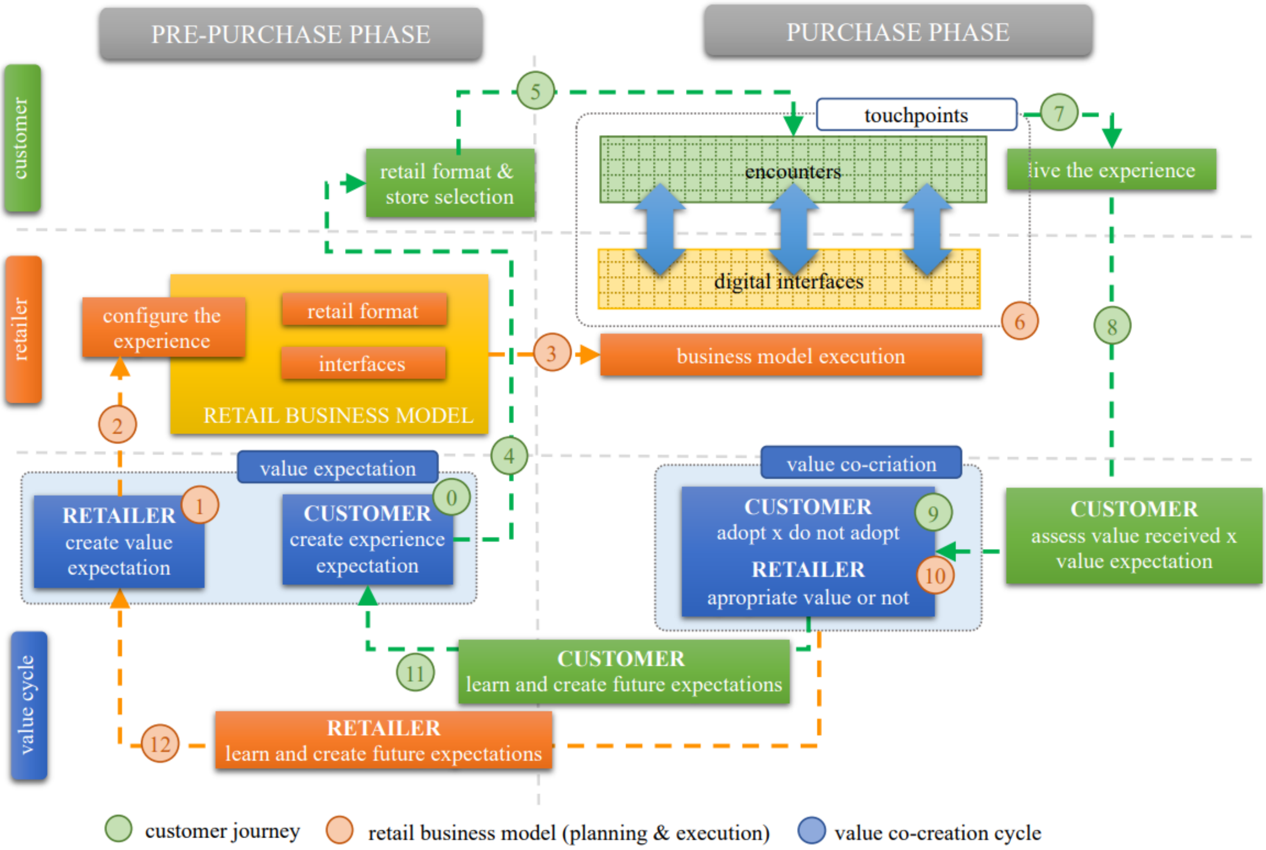
Customer value is in the experience that occurs at all touchpoints along the customer journey. The experience is multidimensional, with cognitive, sensorial, and behavioral aspects. The touchpoint is where customers encounter the interfaces planned and executed by retailers. The experience is cyclical and temporal.

At the customer journey pre-purchase stage, the customer creates his value expectations, based on what he needs to buy and the experiences he expects to have during the journey (0). In this stage, the retailer creates his value expectations (1) and configures the experience the customer is expecting to live, using the retail business model components (retail format, assortment, and interfaces) (2), that are going to be executed in the stores (3).

The customer chooses the format and store he believes would best meet his needs and expectations (4) where he has encounters with the interfaces (5). The interfaces are executed by the retailer in the touchpoints (6). The consumer lives the experience during the encounter (7) and then assesses the value received, comparing it to the value expected (8), and adopts the interface if, the value received is higher than the value expected (9). By adopting the customer gives value to the interface and the retailer appropriates the value created by customer interface adoption (10), in a co-creation process. Both customer (11) and retailer (12) learns from the process and incorporate the learnings into their future expectations, closing the cycle.

The value created by new technologies, as the case of digital interfaces, is measured by their adoption by customers, and the customer's decision to make use of it (Rogers, 2003). Decisions to adopt innovations are individual, being the result of characteristics and perceptions involving the innovation attributes, the learning costs to use the innovation, and the benefits that adopting the innovation provides (Marra et al., 2003). On the other hand, technological advancement enables retailers to capture customer data (i.e., what, how much, when, and how customers shop) (Inman e Nikolova, 2017; Shankar et al., 2011; van Ittersum et al., 2012), providing them access to valuable information to improve their decisions of how and where evolve their business model and personalization of customers experience.

Figure 4 - Digital Interfaces Value Co-Creation Cycle in Grocery Retail Conceptual Model



Methodological Procedures

The objective of this study is to analyze and characterize how digital interfaces create value in grocery retail stores in São Paulo city.

The Nature and Type of Research

This is an exploratory and descriptive research of qualitative nature. Exploratory because the objective is to survey the presence of elements, categorizing them, and descriptive because it seeks to understand the elements, through primary data (observation and interviews) and secondary data (news from the press). The exploratory study is grounded in the subjectivist ontology and constructivist epistemology, indicating the interpretivist research paradigm as the recommended approach to achieve the proposed objective of this study.

Data Collection and Data Analysis Techniques

A sample of 35 retailers operating in São Paulo city, accounting for a total of 1,039 stores was selected. The selection was intentional to cover all retail formats and sizes. To be part of the sample the retailer must have, at least, a website or an app. 47 stores were selected from the sample to be surveyed, an intentional selection to cover all retail formats and regions of the city.

The digital interfaces in stores (47 stores), functionalities in websites (35 websites), and apps (24 apps) were collected using the direct observation method, visiting stores, and navigating through all sites/apps functionalities.

The collected interfaces were evaluated by the dimensions of value, from the customer's and retailer's point of view as well as why customers adopt the digital interfaces. It was used the template analysis technique proposed by (King, 2004) to define the interfaces value dimensions and the cost and benefit of interfaces customer adoption. This is a thematic organization and analysis technique, where it is created an initial categories template, based on a pre-existing model in theory, and the template is developed, adding, eliminating, or reinterpreting categories as the data requires.

Results

The search in stores, websites, and apps revealed the interfaces retailers are using as part of their business model, i.e., a retailer decides to adopt.

Table 01 – digital interface adopted by retailers.

Channel	# digital interfaces
In-store	14
Websites	5
Apps	9 [1]

digital interfaces between the customer and the store.

The interfaces' value creation has been evaluated from the customer's perspective using the convenience template proposed by Berry and Grewal (2002) and Seiders et al. (2005) and from the retailer's perspective using the template proposed by Linzbach et al. (2019) and Willems et al. (2017).

Table 02 - Value creation drivers and definition, from the customer perspective

Customer Purchase Time	time required for a customer to perform an activity in the store.
Customer Purchase Effort	the physical effort required by the customer to perform an activity in the store.
Customer Purchase Benefit	purchase cost reduction, such as the purchase of products on promotion.
Other Customer Benefits [2]	related to benefits that improve customer convenience, not related to purchase time, purchase effort, and purchase benefit (i.e., in-store wi-fi).

Table 03 - Value creation drivers and definition, from the retailer perspective

Retailer Operational Efficiency	operational resources cost efficiency
Retailer Revenue Increase	increase in the retailer's revenues.
Data [2]	related to digital interfaces that allow retailers to collect customer data (i.e., wi-fi in-store wi-fi).

The interfaces were analyzed by the value drivers, based on observation during in-store visits and by experiencing the interfaces in stores, websites, and apps to find out how digital interfaces create value.

Table 04 – How digital interfaces create value.

Customer Perspective	Retail Perspective
• Reduce customer purchase time. • Reduce customer purchase effort. • Increase customer purchase benefit. • Increase other customer benefits.	• Increase retailer operational efficiency. • Increase retailer revenue increase. • Collect, legally, customer data.

The effects on value, from the customer's use of the interfaces, were analyzed by value drivers, deepening the understanding of how value is created (table 05).

Table 05 – Value Creation Customer Digital Interface Adoption Analysis

	Effect of the use of the digital interface on the value driver and on value													
	Customer								Retailer					
Driver =>	Purchase Time		Purchase Effort		Purchase Benefit		Other Benefits		Cost Efficiency		Revenue Increase		Data	
Interface	Effect on Driver	Effect on Value	Effect on Driver	Effect on Value	Effect on Driver	Effect on Value	Effect on Driver	Effect on Value	Effect on Driver	Effect on Value	Effect on Driver	Effect on Value	Effect on Driver	Effect on Value
Self-checkout	reduce	increase	increase	decrease					increase	increase				
Click & Collect	reduce	increase	reduce	increase			increase	increase	reduce	decrease	increase	increase		
QR codes							increase	increase	increase	increase				
Digital price tag									increase	increase				
Bar code reader for price check (store)	reduce	increase	reduce	increase					increase	increase				
Bar code reader for price check (mobile)	reduce	increase	reduce	increase					increase	increase				
Receive store leaflet by WhatsApp / e-mail					increase	increase					increase	increase		
Access store leaflet on site/application	increase	decrease	increase	decrease	increase	increase					increase	increase		
Shopping List	reduce	increase									increase	increase		
Digital payment methods	reduce	increase							increase	increase				
Receive store leaflet by push notification	reduce	increase			increase	increase					increase	increase		
Offers activated on the site/app and received in store	increase	decrease	increase	decrease	increase	increase					increase	increase		
Face-to-face payment	reduce	increase	reduce	increase					increase	increase				
Food purchasing kiosk	reduce	increase	increase	decrease					increase	increase	increase	increase		
Assistant robot	reduce	increase			increase	increase	increase	increase	reduce	decrease	increase	increase		
Scan & Go	reduce	increase	reduce	increase					increase	increase				
Virtual Sommelier	increase	decrease	increase	decrease			increase	increase	increase	increase		increase		
Totem to activate promotions	increase	decrease	increase	decrease	increase	increase					increase	increase		
Totem to retail brand credit card	reduce	increase	reduce	increase			increase	increase	increase	increase				
Totem retail loyalty program	reduce	increase	increase	decrease	increase	increase	increase	increase			increase	increase		
Free Wi-Fi in the store							increase	increase					allow	increase

To understand why customers, adopt digital interfaces it was used the template proposed by Marra et al (2003).

Table 06 - Definition of customer costs and benefits to adopt a digital interface.

Cost Type	Cost Type Definition
Cognitive Costs	customer effort to learn and use the digital interface
Emotional Costs	customer's emotional reactions of learning and using the digital interface
Social Costs	effects on customer social relations of learning and using the digital interface.
Benefits of Use	customer benefits from using the digital interface

Discussion

The purpose of this study is to analyze and characterize how digital interfaces create value in retail grocery stores.

Value co-creation - an overview

Value is co-created between customers and retailers (Vargo et al., 2004; Vargo & Lusch, 2008), and this study confirm that, to be present in a store, a digital interface is creating value for both (see table 05).

From the customer's perspective, value is created in the total experience (Zeithaml, 1988), that is, even if one or more of the drivers decrease (Echeverri & Skålén, 2011; Plé & Cáceres, 2010) the value of the experience the total value of the experience value must be positive.

From the retailer's perspective, value is created when the customer uses the digital interface. To ensure the interface generates sufficient operating cost efficiency (total operating costs with the interface lower than total operating costs without the interface) and/or sufficient revenue to achieve a return on investment, a minimum number of clients using the interface is required.

When a customer utilizes the digital interface, value is created from the retailer's perspective. A minimum number of customers using the interface is necessary to guarantee the adequate generation of operating cost efficiency (total operating costs with the interface are lower than total operating costs without the interface) and/or sufficient revenue to deliver the planned return on investment.

Value Creation - customer's perspective detail

Customers have needs and expectations in their customer journey (Woodruff, 1997) and retailers create digital interfaces to meet them, thus seeking to create value for customers and themselves. The customer has to learn how to use the interface by making cognitive and emotional efforts Marra et al. (2003) and will have to overcome emotional costs (i.e., fear of making a mistake) and social costs (i.e., the shame of making a mistake) when using it. Once the customer has used the interface, experiencing not only the benefits but also the emotional and social aspects (D. Grewal & Roggeveen, 2020; Willems et al., 2017), the customer compares what was received with his expectations and if he considers that he got what he expected or even more (Zeithaml, 1988) he adopts the interface and incorporates the touchpoint into his repertoire of touchpoints in his customer journey and thus creating new expectations for the future (Helkkula et al., 2012). This is the cyclical nature of the value creation of digital interfaces from the customer's perspective.

Value Creation - retailer's perspective detail

The retailer's decision to adopt (incorporate) a digital interface into their business is a strategic decision in defining the retail format (Sorescu et al., 2011). These decisions are made to meet their target customers' needs and expectations (Woodruff, 1997) and to capture value, delivering value to them. The implementation of a new in-store digital interface requires investments in assets (e.g.: wifi antennas), recurring costs (e.g.: employee to accompany the assistant robot), maintenance expenses (e.g.: when some interface breaks and becomes unavailable), staff training (e.g.: employees who know how to operate the self-checkouts and can teach the customer how to operate it).

Once the interface is available in stores, the retailer monitors its adoption (the indicator that customers are valuing the interface) by checking: how customers are using the interface, the number of customers using it, the operational cost reduction, and/or revenue increase. The retailer adjusts and develops the interfaces to continue providing value considering the present and future customers' needs and expectations. This is the cyclical nature of value creation through digital interfaces from the retailer's perspective.

Costs and Benefits of Customer Adoption Analysis

Customers have different needs and expectations in their customer (Woodruff, 1997), which include different expectations on the digital interfaces' value dimensions. For example, some customers value purchase time more than purchase benefit, while others value purchase benefit more than purchase effort. The same customer values a dimension differently depending on their customer journey. These distinct customer needs and expectations motivate them, distinctly, to use a digital interface, since they believe the interface will improve some value dimensions, during the customer journey.

To get the benefits of using a digital interface, the customer must overcome some costs (Marra et al., 2003). The cognitive cost is related to the learning effort because the customer is not familiar with the interface, is not familiar with the technology, and may be inhibited by the machine. The customer faces emotional costs, related to his emotions during the cognitive process, such as the fear of trying or making mistakes. Along with emotional costs come social costs, related to the customer's relationship with others.

The differences in expectations on benefits and how each customer overcomes the costs contribute to the understanding of why some existing interfaces are more adopted than others.

Factors that Increase the Likelihood of a Digital Interface Adoption

The study identified the factors that increase the possibility of an interface being adopted (value creation) by customers and retailers.

Customer Perspective

From the customer perspective, the interfaces that have more possibilities of adoption are the interfaces that:

- Propose to reduce purchase time and effort or increase customer benefits, motivating the customer to consider adopting them.
- Easy to use, designed to minimize errors, thus reducing the customer's cognitive, emotional, and social costs.

Retailer Perspective

From the retailer perspective, the interfaces that have more possibilities of adoption are the interfaces that:

- Increase the retailer's operational efficiency or revenue.
- Designed to be easy and safe to use.
- Have high availability, either in-store or in-store quantity.

Conclusions

The purpose of this study is to analyze and characterize how digital interfaces create value in retail grocery stores. The exploratory research conducted allowed the construction of a model that has theoretical and practical contributions.

Theoretical Contribution

This study fills an identified gap in how digital interfaces create value in grocery retailing by proposing a conceptual model. The conceptual model proposed is processual, which means, is a sequence of individual and collective events, actions, and activities unfolding over time in context (Pettigrew, 1997). The model, as a process, considers the flow of events over time at the customer and retailer level; it considers encounters, where value is co-created or codestroyed, followed by the evaluation of the outcomes of the encounter and thus closing the loop and starting over.

The model also includes how and when, in the process, customers and retailers create their expectations and how and when they access the co-creation or co-destruction of value.

Contributions to Practice

The study identified the factors that increase the possibility of an interface being adopted by customers and retailers, using the value creation drivers and the customer costs of adoption. This is useful to retailers to access the touchpoints, in the customer journey, verifying the touchpoints that are eroding value and why. By doing that retailers can identify potential touchpoints, that can be improved by a digital interface and what to consider when designing the digital interface.

The study extends the view of value creation by incorporating the value drivers for customers and retailers and by incorporating the costs of adoption. This breadth gives retail entrepreneurs a broader view of how to access the value created by adopting technological innovation in their stores, allowing them to incorporate it, as a criterion, in their decision process to adopt a digital interface.

Study Limitations

This is an exploratory study, limited to a few retail companies in São Paulo city and one digital interface supplier. The sample expansion can contribute to the model evolution with new value drivers, new categories, or interfaces not covered by this study.

Suggestions for Future Research

The conceptual model is promising to comprehend the value co-creation process in grocery retailing through the use of digital interfaces. Future research can contribute to the model development such as expanding data collection beyond São Paulo city; evaluating if there is a correlation between retailer size and formats with the adoption of digital interfaces; evaluating if there are variations in the adoption of digital interfaces according to different customer journeys and expand the study to other retail segments.

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American customer satisfaction index: a case study in a business management systems company in Northwest Rio Grande Do Sul-Brazil

Abstract ID#331

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Purpose

With the growth of technologies comes the importance of companies being always up to date to provide the best for their customers. Having a business management system, for an organization is something very important because it is where all the company's information will be stored and will provide support in decision making. With this comes the issue of quality and security of services provided, because all data and information from the company will be gathered in the enterprise management system. The provision of business management system services involves the sale and deployment of the system. After the installation, doubts, errors, updates, and difficulties arise, and to supply this need there needs to be someone to give this support. Therefore, this study aims to analyze the satisfaction of the services provided by a business management system company in the northwest of Rio Grande do Sul. In this sense, the research problem has the following questions: Are consumers satisfied with the services provided by El Informática? How is El Informática's after-sales service?

Literature Review

As a theoretical basis for the research, conceptual approaches were used from the management of services through studies such as Kahtalian et al (2002) and Zeithaml, Bitner and Gremler (2014); also used were studies on service quality by Las Casas (2008) and Kotler and Keller (2018); and finally, highlight to the American Customer Satisfaction Index-ACSI (AMERICAN COSTUMER SATISFACTION INDEX, 2020).

Methodological Procedures

The study is classified as exploratory and descriptive, with a quali-quantitative approach. It is also classified as a case study and as technical procedures it is classified as bibliographic research and survey research. The data collection instrument was a questionnaire adapted from ANGES (2012) composed of 20 questions and applied to 32 client companies of El Informática. Companies in the agribusiness, gas stations and supermarket segments were selected because they were considered essential and remained open during the Covid-19 pandemic.

Findings

The analyses were divided according to the ACSI model which is divided into 3 parts each containing its variables, i.e. antecedents of the core variable, core variable and consequents of the core variable. The results highlighted that most of the customer companies are satisfied with the quality of services provided and the perceived value ratio. However El Informática needs to make some improvements regarding the service time as it was the variable that presented the most dissatisfaction in consumers. The study highlighted that El Informática needs to pay more attention to customer service time and waiting time to resolve complaints. However, it was also identified that most customers are satisfied with the company. During the research it was also possible to analyze the company's after-sales and reinforce the importance of this practice to make customers increasingly satisfied, because without the receipt of complaints and feedbacks consumers have no opportunity to present their expectations and frustrations, as well as suggestions for changes and improvements.

Implications

With the survey's relevance, El Informática will be able to offer more quality in its services as well as better service throughout the region. It also has practical relevance since the company does not use any standard tool to evaluate the quality of services offered, factors that can cause great impact on a company in this industry, since today's consumers seek quality not only at the time of sale. In addition, this study can help other companies that provide services and create business management system software.

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Value perception in a business project

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Abstract: Innovation has assumed an increasingly important role within organizations. Companies must remain innovative to stay competitive. This paper seeks to understand how an entrepreneurial accelerator program impacts company strategy and how it develops intrapreneurship. For this, besides a bibliographical study on the topics open innovation; entrepreneurship and intrapreneurship; strategy; startup and corporate accelerators, a questionnaire was applied, answered by six members of the top management of the company Souza Cruz, in which this study was conducted in its corporate accelerator program, Transforma Souza Cruz. It was possible to analyze, from the perspective of a company's top management, what the reasons are for developing an entrepreneurial accelerator program in a traditional company like the one analyzed and how this affects the company's strategy, as well as to understand whether it develops concepts such as intrapreneurship in the company

Keywords: Innovation, Startup, Accelerators, Entrepreneurship, Intrapreneurship

Introduction

In the business environment, more and more companies are changing and becoming more competitive. This is influenced by several factors such as globalization, culture, increased market competitiveness and more demanding consumers. Innovation is the central axis of an organization's strategy that seeks to overcome the obstacles caused by the speed generated by technological development. A company that does not innovate ends up becoming obsolete very quickly.

According to Chesbrough (2006), there are two ways to seek innovation: through closed and open innovation. In closed innovation, companies seek solutions within their own structure by investing in Research and Development. This type of investment is costly and there is no certainty of return, since a large company has established processes and standards and a more rigid structure.

In the open innovation model, on the other hand, the company searches, through inputs and outputs external to the organization, for new market solutions. This usually happens through startups that connect with companies through business acceleration programs within organizations.

Taborda (apud Signori et al. 2014) defines a startup as "a company in its infancy, usually in the process of implementing and organizing its operations. It may not yet have started marketing its products or services, but it is already up and running or at least in the final process of creation." This mode of business is expanding in Brazil and worldwide in recent years. The new methodologies proposed for entrepreneurship show the paradigm shift that has occurred in the last decade in business activity, in addition to how the new methods work beyond the validation of hypotheses that influence the business model.

With all this growing importance, inside and outside organizations, an innovation ecosystem is emerging that seeks to attract start-ups, to offer growth conditions in exchange for innovative, and often quick, solutions to problems that the corporation cannot solve, or that would take too long to research how to do.

This ecosystem should be concerned with the development of entrepreneurship and intrapreneurship. According to Dornelas (2016), "entrepreneurship is the involvement of people and processes that together lead to the transformation of ideas into opportunities." Intrapreneurship, according to Stevenson and Jarillo (1990), is the practice of entrepreneurship within the company, that is, the employee acting as the "business owner" and developing innovative ideas, even if not in their scope of work. It is increasingly common to see startup accelerator programs within organizations.

Considering that the alignment between entrepreneurial and strategic orientation becomes an element of value for the relationship between companies and start-ups, the main question that this paper seeks to answer is: how does a corporate accelerator program impact the company's strategy and how does it develop intrapreneurship?

The main immediate result of this relationship was the improvement of communication within the organization, beyond the solutions already developed and to be implemented in this first acceleration cycle. As a long-term result, we can cite the beginning of the implementation of a culture of innovation, open to error, and the development and strengthening of the concept of intrapreneurship. In addition, organizations are increasingly concerned about staying current and innovative, since traditional and archaic structures no longer correspond to the reality of the increasingly competitive business environment. Not innovating means missing business opportunities, or even worse, going bankrupt.

Theoretical Background

Open Innovation

The theme of innovation is constantly discussed in organizations. In a world driven by novelties, not innovating means losing business opportunities, competitive advantage, and consequently, money. For Bessant and Tidd (2009), the need for innovation is clear in corporate mission statements and strategy documents.

The study considered is called Global Competitiveness Report, produced by the World Economic Forum (WEF) and based on the GCI index (Global Competitiveness Index), which includes 12 dimensions that evaluate the institutions, factors and policies for economic prosperity.

According to this report, Brazil ranked 80th in 2017. Analyzing the data on innovation, we can observe a significant improvement in innovation capacity (19 positions), improvement in the quality of scientific research institutions (9 positions), companies' spending on Research and Development (12 positions). These variables are evaluated by the interviewed executives, so they are a subjective perception of the data. As such, this analysis reflects more optimism and willingness to invest in innovation.

Innovating in an open way requires implementation processes. For Gassmann and Enkel (2004), there are three ways to put this process into practice. The first is called "outside-in". In this process, the company develops new technologies through integration between suppliers, customers, partners, thus facilitating the creation and flow of knowledge. It is generally used in companies with low technological capacity that have to resort to other companies to license patents and develop technologies. Thus, with this integration, the company is able to add value to its product.

The second process is called "inside-out", the exact opposite of the first process. In it, the company develops the technology and gains from the value of the intellectual property. It is a process most commonly used in technology industries that are able to patent their technologies and license them to companies that are interested in them.

The third process is called "coupled", that is, it is a combination of the two ways of innovating.

In this context, as mentioned earlier, there are two ways to innovate, through open innovation and closed innovation. For Chesbrough (2006), open innovation is the antithesis of closed, traditional, and vertical innovation. In it, ideas can come from inside or outside the organization and can go to the internal or external market.

Ideas come not only from within the company, but also from the external market. Competitive companies are not proud to say that a technology was completely developed within their business environment, because, the results obtained with open innovation tend to be much better (BURCHARTH. 2015).

Entrepreneurship and Intrapreneurship

Currently, the term entrepreneurship has been discussed much more frequently, and the global trend of fewer jobs is noticeable, generating an urgency to create new jobs, as well as a workforce ready to readapt to every change. It can be said that innovation is the key to the functioning of large companies. For Said (2013), society is moving from the second wave of the industrial revolution to the third wave, which is based on the information revolution. In it, there is the supremacy of knowledge which is shown as the main asset.

In Brazil, entrepreneurship presents a specific characteristic. According to Natsume (2004), entrepreneurship is often generated out of necessity. The above-mentioned worldwide trend towards reduction of jobs makes self-employment a viable alternative to ensure the family's subsistence, but the lack of planning and the urgency to receive profits can generate non-lasting businesses.

Opportunity entrepreneurship, on the other hand, occurs when the entrepreneur decides to undertake the business despite the fact that there are other sources of income available. Since he is not dependent on the immediate profits of the company, he can think about his business more calmly and has more resources to create and conduct the business.

For Bessant & Tidd (2009) and Dornelas (2016), entrepreneurship happens at different stages, and it can be applied in startups, with small structures and in early stages of development, but it can also be applied in large and established companies, which have to look for ways to update the way they create and deliver value to their customer. For this reason, defining the term is a difficult task, as there are different approaches. Dornelas (2016) states that entrepreneurship is to do something new, different, to change the current situation and seek new business opportunities with a focus on innovation and value creation.

In addition, Said (2013) argues that the entrepreneur needs to overcome external obstacles, such as lack of resources, changes in the economy, and lack of support from others. Intra-entrepreneurial challenges are more related to internal barriers, such as bureaucracy, traditional management, and lack of openness to change.

The first definition of the term intrapreneurship was given by Pinchot (1989), which is understood as all activities in the organization, including administrative functions that are not connected to the business. Prior to his studies, it was believed that an individual could only be an entrepreneur if he was outside the formal structure of a company.

Such a viewpoint resulted, according to Said (2013), from the economic dynamics itself that ended up limiting this viewpoint. Companies increasingly base their operation on the concept of Enterprise Management, being the main factor of innovation within these structures.

In intrapreneurship, the employee is expected to act as an owner of the company, seeking innovative solutions even if these are outside his or her scope of work. For Said (2013), an intrapreneurial organization is "(...) an organization that recovers the entrepreneurial spirit that reigns in the company in its infancy, when it is more creative, dynamic, audacious (...)", that is, that keeps alive the entrepreneurial spirit within an already established company

Strategy

Adcock (2000) proposes that "strategy can be described as a link between the objective and the implementation necessary to achieve those objectives." Thus, the objective is the definition of what the company wants to achieve and the strategy is how these objectives will be achieved.

The moment when the school of strategic thinking achieved the greatest importance was in the year 1970. In this school, strategy is based on the analysis of internal and external environments, seeking efficiency and effectiveness. Nowadays, with the increase in competitiveness, it is not enough just to develop a strategy, but also to closely monitor its execution, adjusting it if necessary. The inputs are the inputs of strategic management. The core of the system is based on the Administration pillars: planning, coordination, organization and control. The outputs are the results obtained from the implementation of this strategy. It is therefore up to the company to establish its main guidelines, such as mission, vision and values, since it is through them that opportunities will be identified and actions taken to achieve the objectives.

A wrong strategy cannot be corrected by a well-executed tactic and operation. Once you have a reliable strategy, tactics and operation are the elements that must be modified most often.

Startup

It is a very broad concept that can be defined in different ways. Taborda (2006) proposes that it is a company in the initial phase of implementation and organization of its operations. Blank and Dorf (2012) propose that it is a temporary organization, seeking a repeatable and expandable business model. According to Ries (2012), it is a company made up of people, acting in various fields of activity, focused on creating a new product or service that makes a major impact on the market and operating in a scenario of extreme uncertainty.

Thus, the main points that define a startup are: being formed by people with common interests; having the goal of creating an innovative product or service; acting in an environment of extreme uncertainty.

Business Accelerator

The concept of business accelerator is directly linked to that of open innovation, discussed earlier, which states that the company starts looking for innovation outside its structure. The role of accelerators is to attract and select companies with great potential for impact and, through a well-structured support program, enable and assist in the search for value generation. (CAMPOS apud ABREU E CAMPOS NETO. 2016)

According to Abreu and Campos Neto (2016), the function of accelerators is to help startups obtain resources, financial and human; build their initial product; and identify the customer segment. Generally, these acceleration programs have an average duration of three months and rely on the guidance of specialized personnel. In addition to being coached by this resource, the owners of the startups also network with people on the ground.

For the present study, the most important thing is to understand the concept of a corporate accelerator. According to Kotler (2016), corporate accelerators are limited-duration corporate-backed programs that support cohorts of startups during the new venture process through mentorship, education, and company-specific resources. They generally share the following characteristics: An open application process; A focus on small teams rather than individual founders; Time-limited support, including company interactions and mentoring; and Cohorts of start-ups rather than individual companies. Furthermore, according to Kohler apud Travers and Teixeira (2017), this category of accelerators is characterized by being supported by companies. Through this interaction, the company can, through the business accelerator, select startups that offer solutions to problems experienced by the company.

Methodological Procedures

This research is exploratory with the use of literature search and data collection with people who had practical experience with the problem (KAUARK et al, 2010).

The procedures were the literature review previously presented and a case study which, according to Yin (2001) allows an investigation to preserve the holistic and significant characteristics of real life events - such as individual life cycles, organizational and administrative processes, changes in urban regions, international relations, and the maturation of certain industries. The company chosen was Souza Cruz. A questionnaire was applied based on it, answered by six members of the management of the company Souza Cruz. The application of the questionnaires was done online, through Google Forms and the participants chosen were people from the management with some relation to the development and implementation of the program.

The main objective of the questionnaire was to understand the effectiveness of the Program and how it related to the main aspects of this theoretical framework: strategy and open innovation. This was based on Table 1: Summary of the Theoretical Framework and structured in six questions:

i. What was the motivation for creating the Transform Program at Souza Cruz?
ii. How is the Programme aligned and linked to the company's strategy?
iii. Entrepreneurship expects employees to act as entrepreneurs, seeking innovative solutions even when these are outside their scope of work. Do you believe that the program strengthens and stimulates employees to develop this behavior? In what way?
iv. Closed innovation is developed inside the company, while open innovation seeks innovations outside the company structure, for example through startups. Do you believe that this Program was effective for this purpose?
v. What results were observed in the interaction between startups and Souza Cruz?
vi. General comments and considerations.

The questions were structured in order to understand first the stimuli for the creation of the program and what problems were observed by the members of the company to motivate this action. Then we tried to understand how these actions would be linked to the company's strategy and how they would generate value for the organizational structure. Furthermore, we tried to understand if there was a strengthening of the entrepreneurial spirit and if, in the respondents' opinion, there was a strengthening of the demand for open innovation within the organization. Finally, respondents were free to make comments related to the program.

For data processing, according to Teixeira (2003), the researcher theorizes the data and confronts the theoretical approach with the data obtained in the field, correlating the results. One of the obstacles of this type of research is, according to Minayo apud Teixeira (2003), the researcher's illusion before the conclusions, that is, thinking that the data are clear from the beginning, causing the data to be simplified and the conclusions to be superficial.

Results and Discussion

In its first edition in 2019, the Transform Souza Cruz Programme received 243 applications from start-ups for the development of a Minimum Viable Product and a Proof of Concept. Of these 243, five were selected and for four months they were accompanied by 30 company executives and underwent more than 20 mentoring sessions.

The following answers were taken from the questionnaire applied inside Souza Cruz, answered by six members of the top management. No names or positions will be mentioned in order to preserve the identity of the respondents.

The answers are from people directly involved with the Program, either in its conception or as mentors in the process.

The presentation and analysis of the results will be done as follows: first, a compilation of the answers to the question presented will be made, and then a consolidation of what was commented will be presented.

Question 1: What was the main motivation for setting up the Transform Souza Cruz Programme?

For the respondents, the Programme arose from a business need based on a number of different factors.

The first of these was to challenge the status quo of the company, in other words, to think of new ways of doing the same thing. A company like Souza Cruz, with a history of 116 years of operational excellence, needs to reinvent itself and seek new ways of generating value for its customers through solutions focused on them, improving consumer experiences and ensuring the success and sustainability of its business.

The second is related to the first because it is linked to the need to create an innovative environment and to develop this culture within the company. Traditional organizations tend, over the years, to focus only on the execution of their tasks, not challenging their employees to think differently. The interaction between the startup and the company causes a new way of thinking to be developed and strengthened within the company.

The third factor is related to the previous one, making it possible, with the establishment of this relationship, to keep the organization abreast of technological innovations in a faster and uncomplicated way.

The fourth factor is the search for solutions to critical and immediate problems. With this lack of innovation culture and focused only on execution, the company ends up facing very specific problems that are difficult to solve. Startups appear as a more agile way to solve this, because, for the most part, they have reduced structures and focus on specific problems. Thus, this interaction seems to offer solutions to problems that previously could not be so easily solved.

The fifth factor is to develop a faster and more agile way of working, based on the innovative structures of startups. Traditional companies with rigid and defined processes can be an obstacle to innovation, because until an idea is developed it has to go through different approvals.

Thus, the main motivation for setting up the Programme was the quest for innovation which, as mentioned earlier, is the central axis of corporate survival, for without it, the company loses its competitiveness to its competitors.

This innovation was the main motivation for the development of the Transform Souza Cruz Programme, seeking both to develop the organizational structure, in order to obtain a more updated and competitive model, and innovations outside the company.

Question 2: How is the Program aligned and connected with the company's strategy?

The company states on its website (www.souzacruz.com.br) that to ensure its longterm and sustainable growth it is necessary that the entire production chain is developed together. Therefore, it is the company's duty to generate shared value for its stakeholders. For the respondents, the generation of shared value is done both locally and globally, through different mechanisms.

Locally, the company develops within its structure a programme called Souza Cruz Attendance, which is designed to establish goals and objectives for business development. This establishes an innovation pillar that fits in perfectly with the Transform Souza Cruz Programme.

In addition, the company is undergoing a process of transforming its internal organisation and its human capital development strategies. In addition to introducing innovative solutions for the way in which Souza Cruz works, the Transform Souza Cruz Programme is important for strengthening intrapreneurship and the development of new skills for its employees, which are essential for today's working environment.

Globally, it is aligned with the strategy of its holding company, British American Tobacco (BAT), which has encouraged the search for disruptive solutions and the simplification of processes made possible by the development of this program. In addition, BAT recently created its business acceleration area, in order to facilitate the collaboration and acquisition of startups.

Abdalla et al. (2019) defines that strategy is the link between the goal and the implementation needed to achieve it. The Program is aligned with the business strategy locally and globally. This is because it seeks to encourage the development of interpersonal skills of its employees, defined as key concepts for business development in its strategy, as well as greater interaction between innovative structures, talking to its strategy of creating an area that has this function within its global structure.

Question 3: Intrapreneurship expects the employee to act as the owner of the business, seeking innovative solutions even if these are outside their scope of work. Do you believe that the program strengthens and encourages employees to develop this behavior? In what way?

All respondents agreed that the Program strengthened intrapreneurship within the organization and that this happened in different ways.

First, the program showed that there is room for innovation, even in a mature company like the one that was analyzed. It is possible to implement new ways of working and incorporate new technologies into the process, as well as seeking a less bureaucratic and faster decision making process, as in the case of startups.

In addition, the solutions brought by startups in the Program are not limited to traditional departmental structures, forcing employees to work beyond the boundaries of their duties to enable the development and implementation of initiatives. This makes the employee feel much more like the owner of the action, reinforcing their intrapreneurial spirit.

The Program also generates a curiosity factor that, according to one of the respondents, provokes the feeling of: "we've been trying this for years...how did they do it in two months?", cultivating the feeling of making it happen and seeking the renewal of the organizational structure, as mentioned earlier, to eliminate procedural barriers of the large corporation. This curiosity factor was also pointed out as a reason for change even outside the Transform Souza Cruz Programme, as it motivated the curiosity of other areas to seek alternative solutions and partners in order to develop simpler solutions that are less costly for the organization.

Said (2013) argues that stimulating intrapreneurship is related to the entrepreneurial spirit, which was the same at the beginning of the organization, making its structures more creative, dynamic and audacious.

Analyzing the answers, we can conclude that this Program played an important role in the development of this concept within the organization, stimulating, mainly through the implementation, albeit initial, of an environment and culture of innovation, instigating experimentation, and eventually error and leaving a little aside the rigid and departmental structures of a traditional structure.

Question 4: Closed innovation is developed within the company, while open innovation seeks innovations outside the company structure, through startups, for example. Do you believe that this Program was effective for this purpose?

According to Chesbrough (2006), open innovation is the opposite of closed and traditional innovation. Through it, ideas come from inside or outside the organization, ensuring the dynamism of the process and contact with new ways of thinking. This dynamism reduces costs with the process, in addition to reducing the time invested in such action.

Classifying the Transforma Souza Cruz Program, by the model of Gassmann and Enkel (2004), that the process used was the "from outside to inside". In it, new technologies are developed through the integration of agents external to the organization, in this case represented by the startup. For the interviewees, the program reached its ultimate goal of promoting this category of innovation within the company and brought results that would not be achieved in the traditional way, due to time and competitive costs. In addition, it has developed skills and capabilities, while providing rapidly tested solutions with proven implementation effectiveness to the business.

Question 5: What are the results observed in the interaction between startup and Souza Cruz?

For the respondents, one of the main outputs of this interaction was that when it comes to open innovation and corporate acceleration, the company must have maturity, seriousness and commitment. First, because a review of your bureaucratic processes and flows is necessary in order to allow projects to flow more quickly. This also concerns the involvement of the company's board of directors directly in decisions, so that projects can be implemented more quickly, following the model of startups. In addition, innovation must be disconnected from Key Performance Indicators (KPIs), and from bonuses, such as profit sharing, for example. This makes innovation stop being a step to be accomplished in order to gain these benefits or achieve goals and become a mindset of the organization.

A key factor pointed out to the company by almost all respondents and with immediate observation within the communication. Because startups have a fast and fast process structuring, the structuring of processes ends up being a traditional structure of the company. Therefore, the company needs to review its processes, as previously mentioned, and adapt the way of communication and operation of these structures.

Considering that startups have a fast and uncomplicated structure, the main result of this interaction was the adaptation of the communication of a traditional and rigid company to a simpler and cruder model. It is also noteworthy that an open innovation implementation strategy needs attention and commitment from the organizational structure to achieve its ultimate goals.

Question 6: General comments and considerations

This question was opened to the participants so that they could make comments if they believed to be relevant to the subject.

For the respondents, the responses to the Program were very positive and generated learning for all those involved in terms of the company. The Program activated as initial editions and new initiatives and initiatives within a similar model are already under discussion.

In addition, the corporate delivery program is linked directly with the company's Transformation Program and is important to the company's transformation of strategic plans.

Conclusions

The present study sought to understand, based on a project in a specific company, how the value of interaction between companies and startups is perceived, whether through strategic alignment or entrepreneurial orientation. In other words, and more specifically, how the Souza Cruz Corporate Acceleration Program was able to leverage entrepreneurship and intrapreneurship within the organizational structure.

To this end, the theoretical background was conducted addressing the topics innovation; entrepreneurship and intrapreneurship; strategy; startup and business accelerator. In addition, the study also included a questionnaire applied to six members of the company's top management, responsible for the conception and execution of the program.

The answers to the questionnaire showed that the company's decision to develop the corporate accelerator program arose from the need to innovate and to update its organizational strategy to keep the organization competitive, in view of the numerous technological innovations and the growing competition.

Due to the maturity of the organization, it was necessary to challenge its current way of working, creating a culture of innovation among its employees and renewing the organizational structure to make it increasingly agile. Because it is inserted in a traditional context, with its 116 years of operation, many of its processes end up becoming bureaucratic. Hence the diagnosis that these processes no longer met the company's requirements and should be updated to reflect the current innovative and competitive environment.

These bureaucratic processes tend to hinder entrepreneurial attitudes within the organization, especially employee initiatives. With the strengthening of the relationship between company and startup it becomes much more evident to develop the concept of intrapreneurship, which generates a lot of value for the organization, but also generates value for the employee, since it is an expected competence in today's organizations. The development of this culture of innovation generates a win-win relationship for both the company and the employee.

Thus, the objective of the study, which was to define how the value of the interaction between company and startup is perceived, was achieved, according to the answers to the questionnaires presented above. The main immediate result of this relationship was the improvement of communication within the organization, beyond the solutions already developed and to be implemented in this first acceleration cycle. As a long-term result, we can cite the beginning of the implementation of a culture of innovation, open to error, and the development and strengthening of the concept of intrapreneurship. intrapreneurship.

Business acceleration continues to be a topic and, when analyzing the respondents' speech and the bibliography studied, it is clear that programs of this type generate much added value for the company and should continue to be studied and developed. This becomes an area of opportunity, both in the academic and organizational sphere, which should seek to develop this topic, as it tends to increase in importance as the years go by.

For the Transforma Souza Cruz Programme, the quantitative results on the success rate of the implementation of the proposals were not analyzed, since the programme was not yet finalized. Another important point would be to obtain more information about the lessons learned from the processes and understand the improvements that could be made, in the opinion of the respondents.

However, despite not being based on quantitative data, as informed by the respondents themselves, the Program was already considered a great success within the organization and a second round of business acceleration is already planned, proving that the company identified added value in the initiative. Another area of opportunity would be to carry out a new work about the program, encompassing the learnings of the first round and with quantitative analysis on the subject.

In view of everything discussed in this paper, we can conclude that organizations are increasingly concerned about staying current and innovative, since traditional and archaic structures no longer correspond to the reality of the increasingly competitive business environment. Not innovating means losing business chances, or even worse, going bankruptcy.

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International alliances for innovation, a social network analysis
Abstract ID#117

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Purpose

This study aims to understand the evolution of research interests and the consequent publication of structured papers on the topic of international alliances for innovation, using social network analysis (SNA) as an analytical tool.

Literature Review

For Chen, Zhang and Fu (2019), collaborative research alliances can be considered a driving force for obtaining a competitive advantage in innovation at the global level. From the 1950s onwards, the work whose core is to identify or even map the evolution of this theme has multiplied, aiming to shed light on gaps and problems not yet seen, using the most diverse methodologies.

Among the methodologies used to understand the evolution of a theme, it is common to find statistical analyzes of the volume of the structured publication with the aid of tools such as Microsoft Excel and SPSS (Agostini and Nosella, 2019; Khaldi and Prado-Gascó, 2021); bibliometrics structured from data analyzed with the support of Bibliometrix/RStudio (Wang et al., 2022); and others based on social network analysis (SNA) (Tsai, 2002; Faraj et al., 2022).

Inspired by graph theory, an SNA is structured as a grouping of connected actors (people, companies, patents, countries, etc.), whose graphic structure depicts their interrelationships (Kurt & Kurt, 2020). Network-based science results from an interdisciplinary effort to represent structures and behaviors capable of signaling trends (Lewis, 2020).

Methodological Procedures

The SNA technique was applied with the software CiteSpace, based on the Web of Science collection data. A total of 813 articles published between 1993 and 2022 in indexed journals were part of the analysis conducted in June 2022.

Findings

As a result of this research, it was possible to verify that this is a network divided into two large groups. One, which is equivalent to 48% of the nodes (about 510 authors), is composed of small, totally disconnected networks. Although in some points movement is observed, no prominent clusters were identified in this grouping. The second large group is composed of 52% of the nodes, or approximately 552 authors, who are considered to have representativeness within the network and make up the giant component of the network.

There is at least two possibilities: a) the themes dealt with in these works may be being applied to specific contexts, which are difficult to reproduce globally, being restricted to small groups, which explains the smaller grouping; and/or b) these themes may be considered by the actors in the giant component as dated or outdated. This second assumption, if it is real, can count on the reinforcement of the characteristics of modularity and silhouette that the global network has – as seen, they are clusters with low coupling and almost perfect separation.

The numerical data obtained made it possible to characterize the authors' network as of low density, whose clusters present low coupling and high content separation between them. A similar movement was also observed when analyzing the theme's evolution from the perspective of countries of publication, which present weak relationships, low density, and an important separation of contents from each other.

The publication by Grant and Baden-Fuller (2004) stands out for having the highest degree (28), sigma (1.60), and PageRank (4.02). Such results indicate that this work has the highest number of links, degree of novelty, and importance.

However, in an overview of the data presented so far, it is observed that the work of Dyer, Singh and Hesterly (2018) stands out. This article is the most current among the main nodes of the network. It belongs to the #2 knowledge acquisition cluster – the largest in size and which is still in movement (2021 – now). It has a degree equal to 18, a centrality of 0.02, a sigma of 1.09, PageRank of 2.17, and a burstness of 3.91 starting in 2020 to date. These characteristics, when combined, allow us to infer that this may be the main work of the network or the work with the greatest potential for prominence and influence.

Implications

The studies by the network of authors that are based on the theme "international alliances for innovation" tend to absorb debates on socio-environmental demands, the understanding of the impacts of Covid-19 on these relationships, as well as the incorporation of the proposals made by the United Nations to sustainable development, in addition to associating themes such as absorption capacity and entrepreneurial skills as central observation points within a relationship of alliance and innovation.

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RESEARCH AND TECHNOLOGY TRANSFER II

May 3rd: 10h30 am – 12h30 pm

Chair

Bibiana Martins (Unisinos, Brazil)

Papers

A model design for an integrated approach to research contracts management in the university context

Cornelia Malherbe, Cornelius, S.L. Schutte

The Effect of PIPE on the Development of Technology-Based Ventures

Edivan Alexandre Ferreira, Tiago Paz Lasmar, Ana Paula Paes Leme Barbosa

The university-industry interaction in Brazil: Characterization of the actors, object of the contract and relational aspects

Mayara Maria de Jesus Almeida, Mauro Catharino Vieira da Luz, Jair Sampaio Soares Junior, Rogério Hermida Quintella

Barriers and enabling mechanisms for the achievement of results in R&D and technological innovation ventures in partnership between universities, scientific institutions and companies

Klaus de Geus, Walter Tadahiro Shima

Transaction costs of university-industry interaction in Brazil: A study from collaborative projects financed by public funding

Mayara Maria de Jesus Almeida, Mauro Catharino Vieira da Luz, Jair Sampaio Soares Júnior, Rogério Hermida Quintella

A model framework for an integrated approach to research contracts management in the university context

Abstract ID#131 | Full paper ID#443

Cornelia Malherbe, Cornelius S.L. Schutte (Stellenbosch University)

Abstract: Purpose: Universities experience the challenge of building on their research endeavors, whilst facing ever declining funding. Partnerships with external organisations are essential for survival and formalized through research contracts. This study delves into the complexity of research contracts management, within the governance-, compliance- and risk management frameworks throughout the contract lifecycle. In the absence of an integrated monitoring-, management- and reporting approach, universities are severely exposed to significant risks, which could otherwise be pro-actively identified, managed, and mitigated. This leads to the Model framework for an integrated approach for research contracts, verified and validated through experts in the field. Design: The Soft Systems Methodology combined with supporting methodologies, literature, interviews, and case studies leads to a credible Model framework. Findings: The Model framework allows universities to make incremental improvements and provides a comprehensive set of requirements to benchmark current practices. All universities raised concerns regarding monitoring capabilities, which is addressed in the Model framework. Limitations and implications: Limited literature is available, therefore interviews and available (limited) benchmark studies form the basis. This Model framework adds significantly to the limited body of knowledge. The practical and social implications are that this research highlights problematic areas and provides a pragmatic approach to incremental improvements, with a specific focus on universities in survival mode. Originality / Value: A requirements list and practical proposals on implementation strategies are made through the Model framework, which can benefit all universities. Paper Type: Research Paper

Keywords: research, contracts, risks, integrated, monitoring, strategic

Introduction

As the knowledge economy drives and requires a growth in the need for universities, the reality is that globally universities' budgets are declining, in some countries more drastically than in others (Faust, 2010)(Myklebust, 2019)(African News Agency, 2016). Universities experience the challenge of building on their research endeavors, whilst facing ever declining funding, which is even more aggravated by the Covid-19 pandemic (O'Malley, 2020)(Independent.ie, 2020)(Lillian, 2021). Partnerships with external organizations are essential for survival (Makoni, 2022)(Department of Science and Technology, 2019)(Mkhonta, 2020) and often formalized through research contracts.

With more external funding from the private sector and other funding organizations, universities are subject to, and accountable, as well as regulated not only by government, but also by the private sector and external funders. This phenomenon results in universities evolving towards a new type of Public-Private Sector hybrid. This poses several challenges to universities who need to balance their public and private interests. The private sector is strictly governed by legislation and corporate governance principles, whereas governments are strictly governed by legislation and regulations prioritizing the best interest of the public (taxpayers). Funding sources from other jurisdictions brings additional complications when legislations from different countries are not aligned with the local legislation (Deloitte LLP and affiliated entities, no date).

Within the above context, research contracts are drafted to ensure that relevant legislations under applicable jurisdictions are complied with. The contract will specify exact expectations in terms of the parties' requirements and policies regarding financial-, ethical-, confidentiality-, intellectual property (IP) etc. The permutations and combinations of legislative- and funder requirements are infinite.

It is reported in an international benchmark study with thirty participating United Kingdom (UK) and Australian universities, that contract complexity has increased significantly and factors driving this complexity includes international- and multi-partner collaborations (with compliance, due diligence requirements and different legislative frameworks at the core), industry negotiations (especially around IP ownership) and publications. A further concern is that a significant number of organizations in developing countries, don't have the needed expertise and capacity to engage in research contracts negotiations, and don't have the required contractual- and institutional compliance oversight and abilities (Johnson et al., 2018), as also reported through the interviews with South African universities.

These concerns are echoed in a Report, which serves as guidance on fairer research contracts negotiations for low- and medium income countries (LMIC), which highlights core constrains such as the lack of access to legal expertise and contract management ability, financial know-how, and managerial and administrative structures (Marais et al., 2013).

Although most organizations realize that managing contractual risks are increasingly important, corporate risk management structures do not address managing contractual risks by using a systematic approach (ProSidian Consulting, 2011).

In a benchmark study undertaken by the Aberdeen Group in 2011, top pressure points for managing contracts are identified. Although this benchmark study is focused on companies and Procurement Contract Management specifically, the underlying principles and challenges are applicable to other fields of Contract Management. Over 130 companies participated in the study and the top pressures for managing contracts were determined, which includes the need to establish better controls on deliverables and expenditures; the need to improve the current poor insight and oversight in the contractual agreements and commitments; the need to reduce risks on supply of services as well as on the supplier; to improve contract compliance capabilities; and to improve the poor insight and oversight on the performance on contracts by the supplier (Limberakis, 2011).

Limited literature and benchmark studies are available in the context of Research Contracts Management (RCM), apart from literature on Industry-University Collaboration (IUC). In the case of IUC, literature reports specific hurdles which relate to contractual aspects and IP negotiations, however there are no solutions provided. Hence this study will substantially contribute to the body of knowledge and scientific publications in this field as it draws on the author's 20 years of RCM experience, and experience of participants in this study from nineteen universities, fourteen industry partners and twelve senior researchers.

Therefore, the **problem statement** for this study is: *In the absence of an integrated monitoring-, management- and reporting approach for research contracts, universities are severely exposed and vulnerable to significant risks from several sources, which could otherwise be pro-actively identified, managed and/or mitigated.*

The contract lifecycle is significant in comprehending otherwise complex procedures and policies required to manage the contract throughout its entire duration (ConductScience, 2020). Several gaps in the state-of-the-art contract lifecycle management are identified. It is argued that there is more to consider in terms of the contract lifecycle and therefore one of the key contributions of this study is to ***enhance*** the contract lifecycle by including two additional phases discussed in section 4.

This study explores foundational requirements for effective RCM, governance, compliance and risk management (GCR) (Tallyfy, 2014)), and draws attention to institutional management practices, and how it relates to external pressures.

This study uses a system engineering approach to RCM, where the Model framework exist of the enhanced contract lifecycle and the risk management approach as the process considerations. All the requirements from universities, researchers and industry are compiled, verified, and validated within the Model framework, which makes it a unique compact framework for any university to improve on their current approach.

The key research objective is a RCM approach capable of fulfilling the requirements placed on a university to comply with external- and institutional requirements and each contract's terms and conditions within the *enhanced* contract lifecycle. This includes the integrated ability to monitor, manage and report on each contract, and a contract portfolio with the added value to enhance strategic decision making based on management information obtained through this approach. This objective relates to considering the contract itself as a complex system together with the RCM practices as a complex system. These two complex systems are considered right through the *enhanced* contract lifecycle (for the individual contract and the portfolio of contracts) which in itself is a complex system. The soft issues related to relationship management forms part of the integrated approach.

This Model framework adds significantly to the limited body of knowledge. The practical and social implications are that this research highlights problematic areas as identified by universities, industry, and researchers, and provides a pragmatic approach for RCM practitioners in the university context to benchmark their current approach and systematically improve on their approach through the identification of desirable changes and the ease and benefits of implementing changes. A further significant contribution is the focus on, not only universities already experienced in RCM, but also those in survival mode, as the mentioned benchmark studies and reports indicate that universities in the LMICs struggle severely to demonstrate evidence of sufficient RCM to be regarded equal partners in research collaborations.

Methodological Procedures

Systems Thinking Philosophies are considered to find the most suitable high-level methodology. It takes the holistic view and acknowledge that several different theories can be incorporated in finding suitable solutions, whilst understanding that each methodology can have its own purpose and value and operate within different contexts. The end goal is that these different methodologies can work together in a holistic approach to solve a complex problem. As this study relies heavily on qualitative data, and understanding the relationships and perceptions, it falls within the so-called Second Wave of Systems Thinking (Soft) (Van Rooyen and Labuschagne, 2016).

Various methodologies fall within the Second Wave, some are considered for this study and summarized in Table 1 below.

Table 1: Overview of considered Systems Thinking (Soft) methodologies

Criteria	7 Step Soft Systems Methodology (SSM)	Inquiring Systems Design	Strategic options development and analysis (SODA)
Purpose of methodology	SSM is a widely used applied Systems Engineering approach designed to solve complex management- and business problems, also described as “soft ill-defined” problems (Mobach, Van Der Werf and Tromp, no date). It assists in tackling messy situations in an organised way in the real world, through the ability to highly define and describe a situation whilst having the flexibility in use and covers a broad scope (Checkland and Scholes, 1990).	Inquiry is defined as an activity that produces knowledge. It involves a process that search for the truth (meaning, facts, information, and knowledge). The basis of inquiry systems is grounded in general systems theory (Linden, Richardson and Adams, 2007).	Colin Eden and Fran Ackermann developed the Strategic Options Development and Analysis (SODA) and approach to help consultants working on complex problems where social processes are involved (Reynolds and Holwell, 2010).
Purposeful application to this study	This methodology is developed based on a practical and pragmatic approach where these so called “soft ill-designed” problems are identified and followed by an appropriate solution design. It also allows for the use of several supporting methodologies during the high-level approach (Mobach, Van Der Werf and Tromp, no date). A fundamental point is taking a broad approach to examining a problematic situation where decisions on action can be made where both the “what” is needed and “how” to address it, are uncertain (Checkland and Scholes, 1990).	Concerns were raised regarding the lack of agreement on fundamental concepts in the theory and a lack of identity as a discipline (Linden, Richardson and Adams, 2007).	SODA is suitable where the problems are likely to be of a qualitative and quantitative nature (Reynolds and Holwell, 2010).
Reason for use / not use	Widely used and applicable and compatible with other supporting methodologies as used.	Concerned about the lack of agreement on fundamental concepts, therefore not used.	Considered as suitable, however for this specific study most of the data is of a qualitative nature, and SODA is more appropriate where both qualitative and quantitative information are concerned. Therefore, not selected.

High-level Methodology

It is concluded that the 7 Step Soft Systems Methodology (SSM) is the most appropriate as a **high-level methodology** to design the Model framework, supported by other methodologies and case studies to improve understanding of the data and ensure credibility of the Model. This article will focus mainly on the high-level methodology, with brief mentioning of supporting methodologies where applicable.

An overview of the seven steps of SSM combined with the supporting methodologies, is illustrated in Figure 1.

SSM Step 1: Enter the problematic situation:

Gathering of information and perspectives about the problem in the real world. The assumption is that there is room for improvement and more information on the key stakeholders, the current state of the art and concerns are obtained (Checkland and Scholes, 1990)(Mobach, Van Der Werf and Tromp, no date).

SSM Step 2: Express the problematic situation:

With acceptance that the real world is “messy”, various views on the specific problem situation are captured. Themes are identified for further analysis in the systems thinking world, and assist in identifying the relevant systems taken into the systems world (Checkland and Scholes, 1990)(Burge, 2015).

SSM Step 3: Formulate the root definitions of relevant systems:

Entering the systems thinking world, the root definition is formulated to capture the essence of the relevant systems, taking into consideration the holistic view, including constraints (Checkland and Scholes, 1990)(Burge, 2015).

SSM Step 4: Build conceptual Model:

In the systems thinking world, the conceptual Model is built based on the requirements and root definitions as per SSM 3. Defensible logic is provided to motivate the steps and structure (Checkland and Scholes, 1990)(Burge, 2015).

SSM Step 5: Compare the Model with the real world:

By returning to the real world the Model is compared with reality through a verification and validation process (Checkland and Scholes, 1990)(Burge, 2015).

SSM Step 6: Define desirable and feasible changes:

Proposed improvements are defined (real world), taking cognizance of the desirability and feasibility (Checkland and Scholes, 1990)(Burge, 2015).

SSM Step 7: Improve the considered problem:

In the real world, the identified changes from SSM 6, are implemented (Checkland and Scholes, 1990) (Burge, 2015).

The intent of this study is to design a credible Model framework for improved RCM based on the SSM approach. This study thus completes step 5 and enters step 6 where recommendations are made on an approach to identify desirable changes, presented as possible scenarios depending on the university’s current state of the art. However, this is where the practical application of this Model framework will have to start within a university.

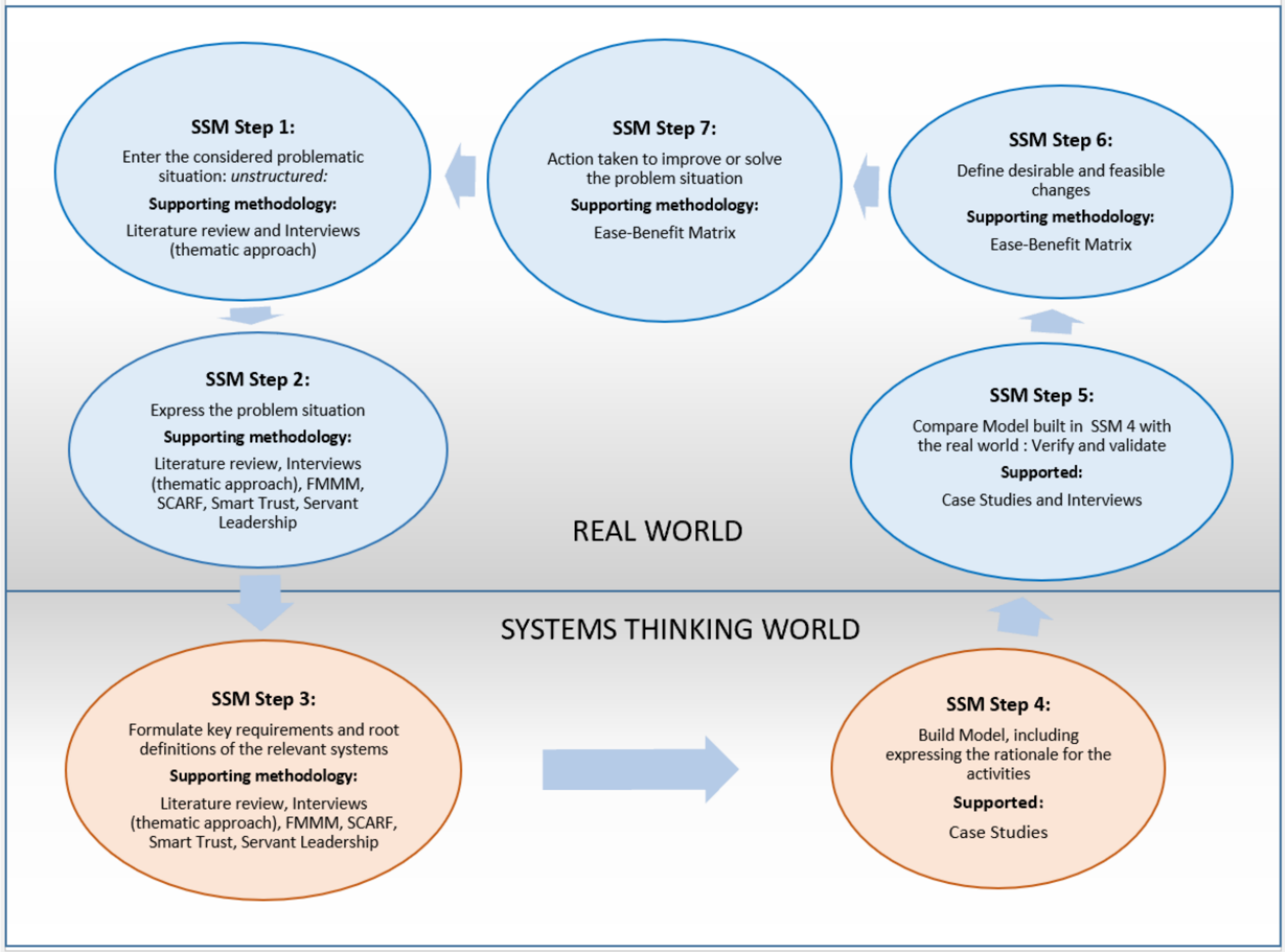

Figure 1: The 7 Step SSM (Adapted by authors from (Burge, 2015))

Supporting methodologies

Literature review

A literature review is conducted on several themes related to RCM, and includes aspects such as:

- Economic-, research funding-, and legislative landscape in the international university context
- RCM practices
- Governance, compliance, and risk management (GCR) frameworks
- Industry-University Collaboration (IUC) and partnerships

Interviews

Interviews with nineteen **universities** from South Africa, Ireland, England, and Scotland are conducted to receive input in the requirements set for Model framework, and a selected group is used for the validation process. Interviews are conducted with Senior Managers (such as Directorates of Research Division/ Technology Transfer Office's (TTO)/ Finances/ Legal Services) responsible for management of all research-related contracts. For more information on the selection criteria, please refer to the Supplementary_Material_Appendix_1.

Interviews with fourteen **industry partners** in the high-technology industry with an international footprint, experienced in IUC, are conducted to receive input in the requirements set for Model framework, and a selected group is used for the validation process. Interviews are conducted with Senior R&D managers, CEO's and contract lead specialists. It is ensured that the industry partners have experience with several universities in South Africa and international, as to ensure the study is not biased towards the authors' home university.

Twelve senior **researchers** from the authors' home university participated in interviews reflecting on a real-life case study, providing input in the requirements for a Model framework, and a selected group is used for the validation process. These researchers are selected based on their seniority and experience with the RCM practices in the university spanning a period of 16 years.

Ethics clearance, informed consent and gatekeeper permission are obtained. The interview questionnaires are available in Supplementary_Material_Appendix_2.

Through the interviews and literature review, a requirements set is compiled (Available in Supplementary_Material_Appendix_3), which informs the Model framework. A thorough verification (Available in Supplementary_Material_Appendix_3) and validation process of the Model is conducted to ensure the credibility of the framework. The main findings from the literature and interviews which impact on the Model framework, are briefly mentioned in this article.

A thematic approach is used for the data analysis of the qualitative data obtained through interviews as described in Figure 2 below.

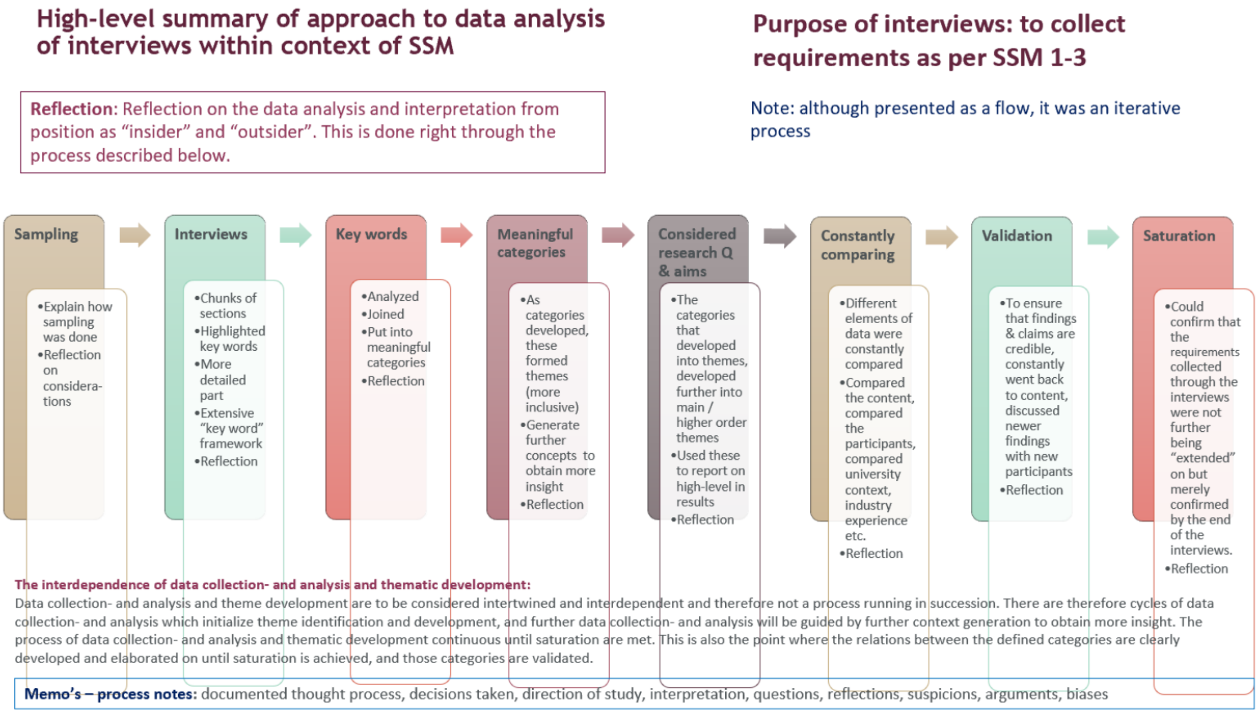

Figure 2: The approach to qualitative data analysis (author's contribution)

Other supporting methodologies

In Figure 1 an indication is provided where other supporting methodologies are used throughout the SSM. As this article intends to present the Model framework, it will only focus on the high-level methodology and report the main findings supporting the Model framework with brief mentioning of the supporting methodologies.

Background and requirements collection

Through literature review and interviews, the state of the art of RCM is determined (SSM Step 1 in *Real World*) and confirmed (SSM Step 2 in *Real World*). The problem situation is expressed by identifying key challenges (SSM Step 2 in *Real World*). By entering the *Systems Thinking World* in SSM Step 3, the key requirements for an integrated approach are identified and considered within the relevant systems.

The relevant systems identified include considering the contract itself as a complex system (***relevant system 1)*** together with the RCM practices (***relevant system 2***) as a complex system. These two complex systems are considered right through the *enhanced* contract lifecycle (***relevant system 3***) (for the individual contract and the portfolio of contracts) which in itself is also a complex system. The soft issues related to relationship management forms part of the integrated approach.

The **root definitions** are formulated as follows:

- For relevant system 1: The external and institutional environment influences the scope and nature of a research contract.
- For relevant system 2: RCM consists of systems of processes and practices that must be responsive to external and institutional pressures. These processes and practices exist within the complexity of other relevant systems.
- For relevant system 3: Research contracts can be individual contracts or a portfolio of contracts, and each of these have a similar life cycle.

Within this context, a research contract is a "legally binding agreement that sets out the rights and obligations of the parties concerned and forms the basis of a relationship around a particular research programme, exchange of information or materials, or other collaboration (Research Consulting, 2013)." Examples includes Clinical trials-, IP Rights- Analytical- and Consultancy-; Material/Data Transfer-, Confidentiality-; Research Grants, Consortium-, and Industry Sponsored Agreements etc. (Johnson et al., 2018).

Six broad themes are identified and further investigated through literature review (albeit limited in availability) and interviews.

Theme 1: Principal drivers for effective research contracts management (RCM):

Governance, compliance, and risk management (GCR) are considered as the principal drivers for an effective organization and are interrelated (Kenton, 2019).

Governance

Governance is defined as: "The system of rules, practices, and processes by which an entity is directed and controlled. …… essentially involves balancing the interests of the many stakeholders in an entity…" (Kenton, 2019). Good governance is all about the manner in which decisions are made and business is conducted, and rests on the principles of fairness, accountability, responsibility and transparency (King, 2016).

Compliance

Compliance is the measures and controls to ensure conformance to legislation, regulations, policies, rules, and processes and whether they have been adhered to or not. An organization that merely focus on the compliance activity, will lose opportunities to improve excellence, if they are not also striving for performance improvement whilst complying (Bridgman, 2007).

Risk management

Risk management refers to a systematic approach to identify potential risks in advance, to understand, evaluate and analyze these risks and addressing them through precautionary steps to reduce/ mitigate the risks (Kenton, 2019).

Any organization that experiences that its compliance systems fail will only be in crisis-management mode and cannot focus on performance and governance. Performance is more than compliance, as it relates to the strategic value embedded in the compliance and performance data, and the proposed direction within a contextual framework. In a complex domain expertise is not enough. Judgement and the exercise of discretion are required to govern well in the face of complexity. Therefore, for any organization to function in a healthy mode, governance, compliance, and risk management must be the principal drivers and operate effectively together, which requires an understanding and acknowledgement of the complexity and context, and the many interactions that can influence the outcome (Bridgman, 2007).

Theme 2: Considering the three dimensions impacting effective research contracts management:

The management of any research contract can be viewed in three dimensions (each with its GCR drivers), considered within the specific contract lifecycle phase (more detail in section 3.3).

External dimension

This covers the external landscape which impacts on any research contract such as relevant national and international legislation and regulatory requirements, permits, exchange control approvals, funder's requirements etc (Marais et al., 2013)(Johnson et al., 2018).

Institutional dimension

This refers to institutional compliance with external and internal requirements, to ensure effective management processes and accountability. These requirements can be in the form of a response to a funder's requirements in terms of their policies, or a response to legislative requirements, or a university's internal policies (including procedures and audit controls) to ensure good governance (Marais et al., 2013)(Johnson et al., 2018).

Terms and conditions of a specific contract:

This considers the reporting- and audit requirements, financial considerations. deliverables, management of confidentiality requirements, data management, intellectual property management etc., as set out in the contractual terms and conditions (Johnson et al., 2018).

Theme 3: Contract lifecycle:

With the general research contract lifecycle, the three dimensions (section 3.2) with its primary drivers (GCR) (section 3.1) are considered.

Pre-contractual phase

The input consideration is where a researcher applies for funding from an external organization for research, or where an external organization approaches a university with a specific request to solve a problem, vice versa. The output is a research project submitted to funders or collaborators (ConductScience, 2020).

Contractual phase

Instructions are issued for a suitable legal contract to be drafted and negotiated (input for this phase) which will address the relevant considerations identified in the pre-contractual phase, as well as aspects such as: the relevant legislative frameworks and jurisdictions (Johnson et al., 2018), compliance matters related to external legislative frameworks and university policies (ConductScience, 2020)(National Institutes of Health (NIH), no date) project specific considerations, approval considerations and legal authorization (Naughter, 2022).

The output of this phase is a successful negotiation and signed research contract.

Post-contractual phase

The risk exposure for any organization is very high in the post-contractual phase as the oversight and monitoring abilities are usually much weaker than in the first two phases (Naughter, 2022). The specific requirements as set out by the contract and applicable legislation need to be adhered to. The input for this phase is the kick-off of the research contract.

The output of this phase is a successful completion of the research contract and compliance with all the contractual- and legislative requirements as per the signed contract.

Theme 4: Research contracts management (RCM):

In general, contracts management is defined as "the execution and monitoring of a contract for the purpose of maximizing financial and operational performance while minimizing risks" (Limberakis, 2011). Most organizations acknowledge that contractual management is a specialized field due to its complexity, and not merely an administrative function, however corporate risk management structures do not address managing contractual risks by using a systematic approach (ProSidian Consulting, 2011).

From a benchmark study undertaken by the Aberdeen Group in 2011, top pressure points for managing contracts are determined to include the need to establish better controls, poor insight and oversight (including risk oversight) in the contractual agreements and commitments, and improve contract compliance (Limberakis, 2011).

It is further established that centralized functions for contracts management creates consistent contract drafting, negotiation and interpretation practices and increases efficiency and enhances "oversight" into contractual commitments and agreements. Consistency in contract management allows organizations to identify weak areas where policies and procedures are needed to improve audited contractual systems and processes (Limberakis, 2011).

Management can be challenged in distinguishing between managing contractual risks for a specific situation versus managing risks embedded in all contracts through processes. Inefficiency in the system, overarching contractual oversight problems, inadequate controls and audit processes, inaccurate forecasts are all symptoms of a lack of clarity into contractual risks (ProSidian Consulting, 2011).

Universities experience a significant increase in research contracts with resulting research income. New and/or amendments to regulatory and legislative requirements significantly adds to the complexity of managing research contracts (Johnson et al., 2018). Due to the pressure of compliance with the relevant legislative framework, universities must take further steps to ensure that collaborators are able to comply with legislative frameworks beyond their own jurisdiction. Subsequently more focus is placed on performing due diligence on organizations (Hicks, 2021)(Johnson et al., 2018)(Marais et al., 2013).

In the next sections, certain themes are further explored to distil the requirements set for the design of the Model framework for an integrated approach to RCM.

Organisational structure and mandates

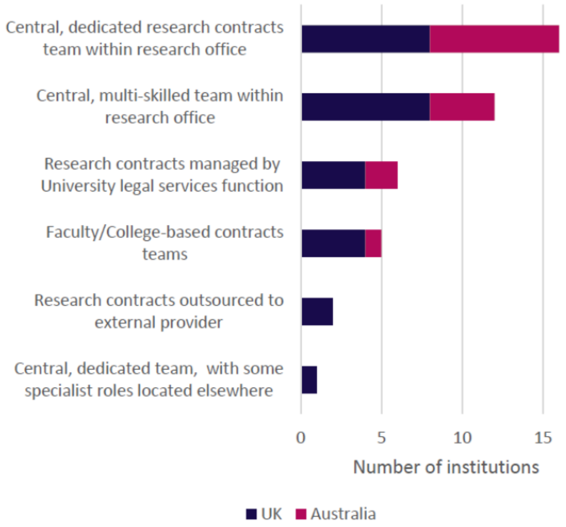

Figure 3: Organisational structures (Johnson *et al.*, 2018).

The purpose is to establish whether the organizational structure and the mandates for RCM are "fit for purpose" [3]. Consideration is also given to the close working relationships between the research contracts team and the pre-award- and technology transfer (TT) teams.

It is reported that dedicated research contracts teams within the research support offices are more typical in universities with a larger research income (higher research-intensive). It is further reported that those universities with smaller research incomes (lower research-intensive), typically reports that the central legal services function of the university managed research contracts or outsourced. It is further notable that higher research-intensive universities have legal expertise in the research contracts team, and reports a narrower remit for the research contracts function with a separate Technology Transfer Office (TTO) to deal with specific commercialization activities (Johnson et al., 2018). Figure 3 gives an overview of the findings from this international benchmark study in terms of the organizational structures of 30 participating universities.

From the above information and the interviews conducted with the 19 universities, it is reported that universities considered as research-intensive, or want to become more research-intensive, focus on a dedicated research contracts team within the research office (considered as **current state of the art**). Whether the TT-function is part of the same team or research support division, or a separate division, the success in managing the research contracts is dependent on clear mandates for both the research contracts- and TT-functions. The remits of the types of research contracts will also depend on these mandates. It is notable that 60% of these internationally recognized research-intensive universities incorporated their TT-function in the research office with the research contracts teams (considered **desired improvement on current state of the art**) (Johnson et al., 2018), as also confirmed during the interviews.

Universities with no dedicated research contracts function and mandates are slow to adapt to best practices. Concerns reported includes: the under-prioritization of research contracts; insufficient specialized knowledge to negotiate optimal transactions; insufficient oversight risks and opportunities (Johnson et al., 2018) as also confirmed during the interviews.

Research contracts management (RCM) approach

The purpose is to establish whether the RCM approach optimally supports its purpose, which can include aspects such as contract registration-, review-, negotiations, and sign-off arrangements. It also refers to the needed policies and procedures. More importantly it refers to the overall oversight (*footnote* 1) and/or insight (*footnote* 2) in the full research contracts portfolio (which includes the risk *oversight* and risk management practices). For this study, focus is placed on insight and oversight abilities, including the risk oversight and -management practices.

Capabilities to use information to predict or respond to a threat, referring to the needed insight in the research contracts portfolio, is reported in an article which embeds this section (Authors, 2021). Organizational structure with a dedicated research contracts function and mandate, is an important contributing factor to a higher level of insight into potential threats or opportunities as well as oversight of the research contracts portfolio, as confirmed during the interviews.

For *oversight* (including *risk oversight*), the needed policies are set and implemented, with an overlay of management information and expertise to utilize such. From the international benchmark study in 2018, a key finding was the need to better assess which contracts are to be considered as "high risk". The anecdotal evidence suggested that the risk oversight and -management practices are varied and emerging across universities and the concerns raised by universities indicated "a lack of clarity about acceptable risk" and the responsible decision-makers on risk-based issues. What is considered as risk judgements criteria was reported either purely the financial value or the international nature of an agreement (Johnson et al., 2018).

The greatest concerns reported through the interviews revolves around risks related to reputation, compliance (legislative and funder requirements), lack of understanding by researchers on what the required compliance requirements entails, insufficient capacity, and insufficient oversight of the contracts portfolio.

Research contracts information

The purpose is to establish whether the available information and the systems that are used could support accessing accurate information for monitoring, management, and reporting purposes. Three specific subthemes are identified, and this section will delve deeper into these based on information from literature (albeit limited) and interviews with universities. Capabilities to use RCM information to improve strategic decision-making, is reported in an article which embeds this section (Authors, 2021).

RESEARCH CONTRACTS METRICS FOR WORKFLOW MANAGEMENT

From the international benchmark study in 2018, it is reported that most universities are not able to optimally support the research contracts workflow. One of the main reasons is the absence of dedicated systems to effectively manage research contracts. In most cases parts of information systems are used supplemented by spreadsheets to capture contract specific information (Johnson et al., 2018).

Some universities share their frustrations during the interviews regarding several divisions in the university working on research related contracts and using different systems, hence no single system is available to search across the university. The interviews highlight how important the integrated approach across the organizational structures is, and the importance of interpretation of the data. Limited examples (apart from one university in Scotland) are found of improved use of information derived from research contracts data as metrics to measure the research contracts team's performance and workflow.

INFORMATION FOR MONITORING- AND MANAGEMENT OF RESEARCH CONTRACTS

The purpose is to establish whether the available information and the risk management practices support assessing and mitigating its contractual, legislative, and financial risks.

An example is a variety of funding that comes from various international sources with specific regulatory requirements. Asking universities whether they keep track of these requirements and have a quick overview of which contracts are subject to a specific regulatory-, contractual- or financial-compliance requirements, all the universities interviewed (except for one) confirm that they do not capture specific information on a contract system. They highlight these risks to the researcher in a formal contract memo and keep it on record. However, none can extract reports to obtain insight into a specific regulatory- or compliance risk across their research contract portfolio when needed. The interviews confirm this as a desired improvement for the Model.

INFORMATION FOR REPORTING- AND STRATEGIC DECISION-MAKING

The purpose is to establish the management practices to support the strategic decision-making capabilities needed to respond with agility when faced with a threat. In a Research Office (RO) survey done in the UK in 2020, it is reported that there are different levels of involvement in the provision of information to executives to drive the institutional research strategy (summarized in Figure 4) (Bales et al., 2020). The typical reporting requirements are indicated in subsections below.

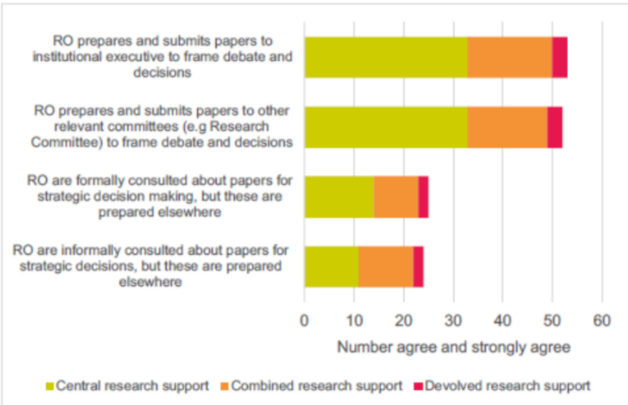

Figure 4: Reporting strategic information (Bales *et al.*, 2020).

General reporting on research contracts portfolio:

In general, all the international and medium-high research-intensive South African universities, have the capability to compile general reports on their research contracts portfolio. Typical information includes contracting partners, contract amount, contract type, faculties/colleges, researchers, linked contracts to the main agreement, etc. The lower-medium research intensive South African universities reported severe challenges in this regard due to their organizational structures.

Reporting on research contracts income and expenditures to government:

All universities interviewed are required to submit annual reports to their governments where information on their research contracts income, - expenditure, etc. are reported. Research offices are in general responsible for providing such institutional information (Bales et al., 2020).

In the South African context, a sub-study is conducted by using a financial management maturity model (FMMM) as supporting methodology, to determine the financial maturity of these universities. The findings indicate the lower-medium research-intensive universities experiencing a lack of collaboration between divisions, very limited data is available and inaccurate data interpretation is prevalent. The only accurate information is available from the Finance Division, and is only finance-focused, with a very low level of analysis of data. No operational information to enrich the context or to inform strategic decision-making is available, with no accurate insight into the research contracts offering as confirmed during the interviews. For the medium-high research-intensive universities in South Africa, a medium-high maturity level is reported with shortcomings regarding the inability to forecast and lack of integration across business sectors within the institution.

Information on ip transactions concluded on research contracts:

None of the international universities interviewed captures specific information on the type of IP transactions negotiated and signed-off, such as non-exclusive royalty free license, IP assignment, joint ownership etc. The international universities in general register a desire to do so. On the other hand, the South African universities attempts to keep track of such transactions, for reporting such to the National Intellectual Property Management Office (NIPMO) to ensure compliance to the IP legislation (Department of Science and Technology (DST), 2008).

Information on forecasted income from research contracts:

From the interviews it is reported that one South African university has actively worked towards the ability to forecast research contract income based on the research contract portfolio. The other high research-intensive universities stated their desire to have forecasting capabilities, but the lack of robust technology is a barrier in developing these capabilities.

From the interviews with the international universities, the universities in Ireland confirmed that they don't have forecasting capabilities. On the other hand, all the UK universities does have the capability of forecasting, and this is due to the full economic costing requirements of the UK government (University of Cambridge, 2022).

Theme 5: Building a trust foundation

By using the authors' home university as a case study, researchers reflect on their experience to describe a worst-case scenario vs what they determine as a state-of-the-art approach to RCM over more than a decade, with a focus to understand the impact on researchers when changes in legislation, policies, and RCM practices are enforced. The way the impact is managed, and the changes enforced through communication, relationship management and the building of trust, are critical considerations to the overall success of an RCM approach at any university.

For this part of the study, several supporting theories are used, such as the Smart TrustTM Matrix (Covey, 2019), Servant leadership theory (Greenleaf, 1970) and the SCARF model (Rock, no date). Although the details are not shared in this publication, it is confirmed that building trust and attending to the soft issues in the RCM context, is critical for success.

Theme 6: Contract structuring and negotiations

Industry-university collaboration (IUC) is considered as important and beneficial to both industry and universities, but not without its challenges (Ramos-Vielba and Fernández-Esquinas, 2012)(Scandura, 2016)(Wright et al., 2008). Within this study, academic engagement and commercialization are of particular interest. Academic engagement is considered by industry to be significantly more valuable than commercialization. Universities' income derived from academic engagement is further reported as significantly higher than through commercialization (Perkmann et al., 2013).

Academic engagement is defined as "*knowledge related collaboration by academic researchers with non-academic organizations [and] include formal activities such as collaborative research, contract research, and consulting, [as well as] informal activities like providing ad hoc advice and networking…*" (Perkmann et al., 2013), whereas commercialisation refers to "*the patenting and licensing of inventions as well as academic entrepreneurship* (Perkmann et al., 2013)" and focuses on the "generation of patents and the creation of spin-off firms stemming from research projects (Ramos-Vielba and Fernández-Esquinas, 2012)".

Available literature studies highlight the motivations and characteristics for IUC and stretches from gender, geographical locations, seniority, scientific fields to funding (Perkmann et al., 2021). Frameworks for improved IUC are proposed with consideration of the institutional context, national policy and the academic engagement aspects (Perkmann et al., 2013)(University of Cambridge, 2022)(Awasthy et al., 2020).

However, the literature and proposed frameworks highlight the challenges, but do not specifically provide pragmatic proposals to address them. This study investigates these challenges, designs proposals to address them, and verify and validate such during industry and universities interviews.

From the interviews with companies, it is evident that the following are critical for conducive industry-university collaboration (IUC):

- Fair and transparent contracting and negotiation principles (including costing- and pricing)
- Different IP ownership options
- Fair valuation of IP
- Reasonable time frames for negotiations and execution of projects
- Maturity and experience of the university contracts teams
- Contractual compliance, especially with regards to industry confidential/sensitive information

More detailed results on IUC are published as part of this study (Authors, 2021).

Conclusion on the requirements set

An extensive requirements set (available in Supplementary_Material_Appendix_3) (SSM 3) for the Model is compiled based on the needs identified through literature and interviews. These requirements are considered and compiled in a referenced framework and give directions for the design framework presented in section 4.

Results presented in model framework

By entering the *Systems Thinking World* in SSM Step 4, the key requirements identified in SSM 3 (available in Supplementary_Material_Appendix_3), are used to build the Model. SSM steps 5-7 are considered for the verification- and validation process and identifying desirable changes for actioning in the real world.

Formation of the high-level design framework:

From a process context, an input will be expressed as the required output after undergoing a ***transformation process***. The input (**I**) would be the consolidated requirements (section 3) to transform the current RCM approach to a desirable output (O) via the **Process Considerations (A-E)** (= Transformation (T)).

By considering the problem statement (in section 1), the steps of a systematic risk management approach (section 3.1.3) are used as the ***Process Considerations (transformation process)*** and forms the **y-axis** for this Model:

- **A:** Identification (Screen + identify)
- **B:** Analysis (Requirements Evaluate)
- **C:** Respond (Mitigate + implement + engage)
- **D:** Agreement (Authorisation)
- **E:** Monitor/report

The ***contract lifecycle*** (numbers **L1-L3**) forms the **x-axis** as presented in section 3.3. It is argued that this general contract lifecycle is insufficient to reach the desired outcome, and therefore the ***enhanced research contract lifecycle*** is presented (with inclusion of numbers **L4** and **L5** and illustrated in green) in Figure 7 below. Each of these phases utilize information from and provides information to other phases. The introduction of **L4** and **L5** are considered as unique contributions in itself:

L4: Post-contract execution phase:

Attention is drawn to the operational mechanisms- and legal compliance requirements beyond the contract's duration, for instance where confidential information is required to be kept secret for decades after contract conclusion. Having an insight and overview of the types of contracts and the specific legal- and funder requirements is addressed in **L4.**

L5: Unlocking strategic value phase:

With dispersed information across a university, and insufficient overview and insight of available data, the inability to utilize information to influence strategic decisions can prevent an institution from reaching maturity in efficiency (addressed in **L5**).

The ***enhanced research contract*** lifecycle is established on a solid ***foundation*** **(F)** (second **x-axis**), deducted from requirements set out in section 3:

- **F1:** Organisational structures to support dedicated RCM roles and centralised approach
- **F2:** Oversight (including risk oversight) and insight in the contract portfolio and the contractual compliance requirements
- **F3:** Appropriate RCM practices that include the needed policies and processes
- **F4:** Utilisation of research contract information derived from data, and the technology in support thereof
- **F5:** Soft issues

The GCR-drivers (section 3.1) and three dimensions (external, institutional and contract specific) (section 3.2) and their interplay create the needed context (X) to reach the desired outcome. Figure 5 illustrates the formation of the design of the Model framework.

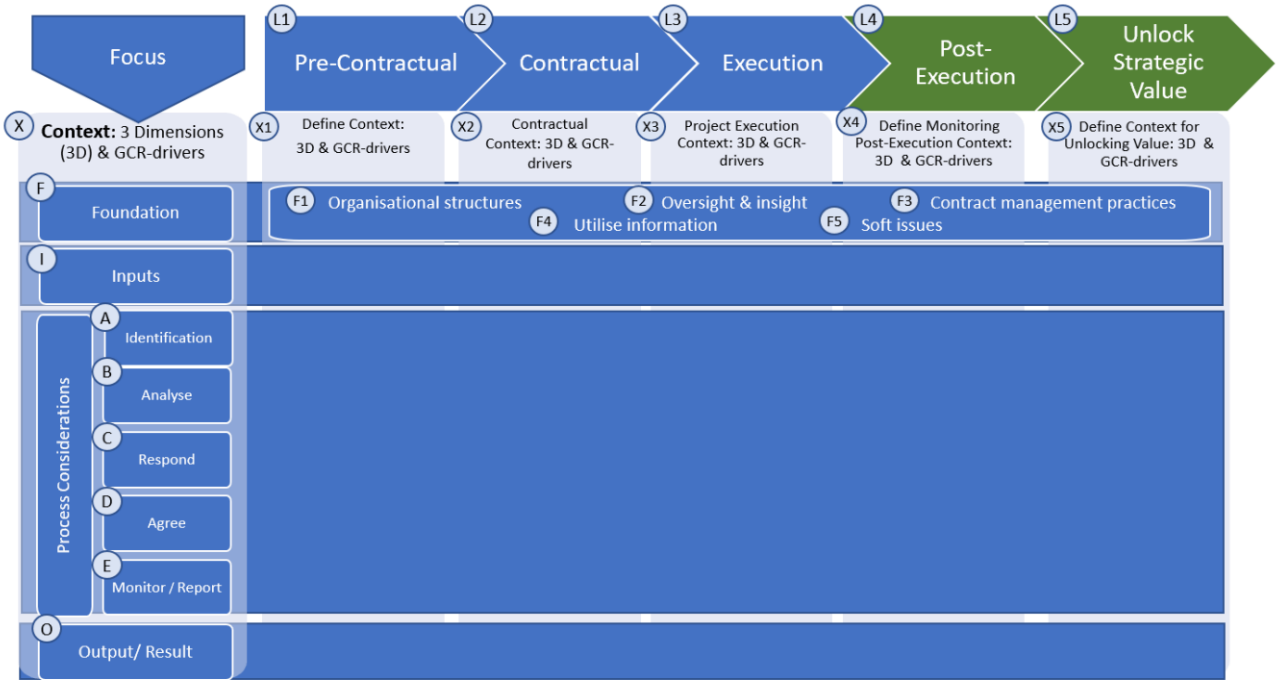

Figure 5: Formation of the Model Framework (author's contribution)

Figure 6 illustrates the completed Model framework (as per SSM 4) for an integrated approach to monitoring, management, and reporting on research contracts after describing all the lower-level processes within the enhanced research contracts lifecycle, done by using case studies and the requirements set.

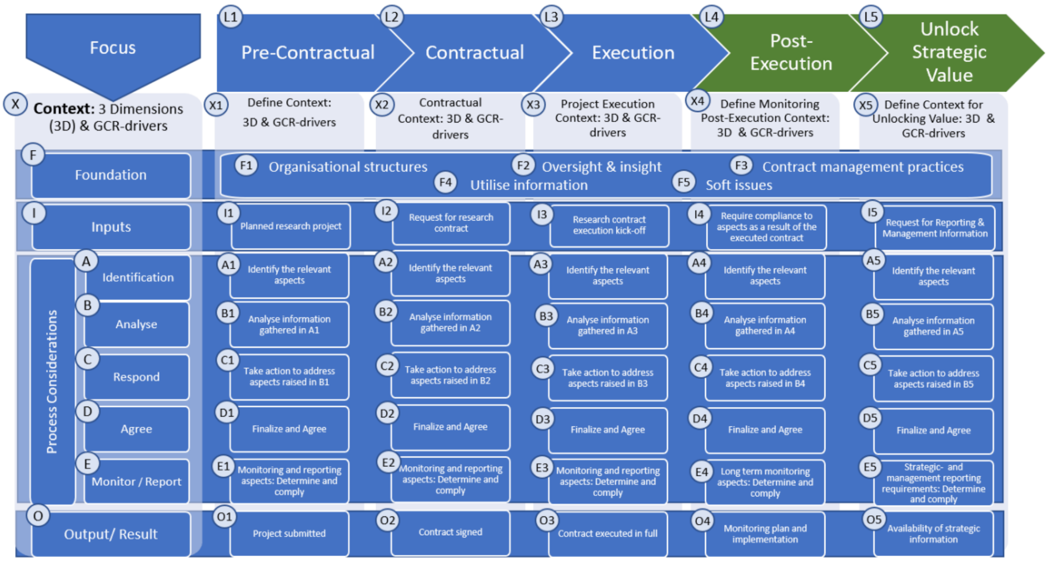

Figure 6: Model framework for an integrated research contract management approach
(author's contribution)

Verification of the Model framework:

Moving from the *Systems Thinking World* (in SSM Step 4) to the *Real World* in SSM 5, the Model is verified on a theoretical basis by using case studies. Each requirement is considered within the process considerations of the Model and each process number from the Model that satisfies the specific requirement is recorded with notes to provide an audit trail (available in Supplementary_Material_Appendix_3).

Validation (SSM 5) and Desirable Improvements (SSM 6 & 7):

The Model built in the *Systems Thinking Worl*d is verified (section 4.2), and now validated in the *Real World* (*SSM* Step 5). Desirable and feasible changes are defined in the *Real World* in *SSM* 6, and actionable steps identified to improve the problem (*SSM* 7 in *Real World*).

The validation process is illustrated in Figure 7 below and is actioned through reflection on the key research objective and refer to expert opinions on whether this Model is credible and serves its purpose.

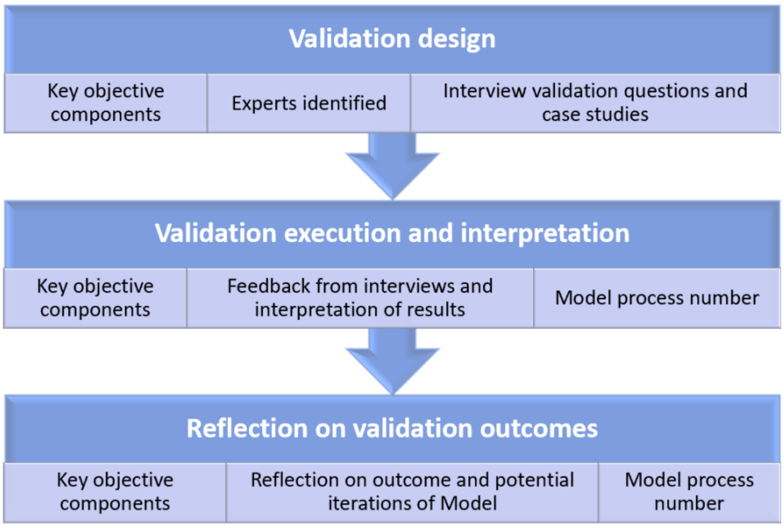

Figure 7: Validation process (author's contribution)

During the validation design, components of the key research objective are identified. During the interviews with experts, specific questions are asked within context of case studies and the high-level components and processes of the Model. Feedback from these experts is obtained and summarised with relevant process numbers of the Model.

Once validation (*SSM* 5) is completed, desired improvements are identified (*SSM* 6) and actioned (*SSM* 7). An Ease-Benefit matrix can assist in tabling desirable improvements and assign a priority to each and indicate the ease of implementation versus the benefit it will bring, providing guidance on which actions to prioritise (*SSM* 7) (Investors in Excellence, 2013). This is illustrated in Figure 8.

ID	Applicable lifecycle phase	Desired improvement – high-level
	L1: process E1	**Desired improvement – high-level**
DI-01		University does not have a strong pre-award/pre-contractual function or a strong research compliance team which covers all aspects from finance, ethics, compliance requirements to other legislations etc. Although it is sufficient and in line with the current state of the art compared to several other national and international universities, a desired improvement would be to extend the capacity and remit of the research compliance and monitoring-function to pro-actively flag certain compliance requirements and pull it through the rest of the contract lifecycle. This will also mean an integrated process to share information between different teams and a feedback loop between other lifecycle phases and L1.
		Granular components of the desired improvement
GC-01	Financial:	Expand the pre-award financial team and build capacity and expertise in managing various national and international funding programmes
GC-02		Implement a policy for pre-award budgeting to be compulsory on the University's full cost template
GC-03		Capture all budgets in the financial system – if the financial system doesn't make provision for it, then the necessary system amendments should be developed
GC-04		More training of researchers to ensure they understand the financial compliance requirements of their research contracts and the importance of longer-term strategic information based on each individual contract
GC-05	Non-financial:	Identify the most regular compliance requirements for the current research contracts portfolio
GC-06		Make provision to flag these specific compliance requirements on the contract system pro-actively. If there is not a specific functionality for it, then the necessary system amendments should be developed
GC-07		Expand the contracts team at the University to make provision for the necessary capacity to be more involved in the pre-award side and pro-actively high-light the compliance requirements
GC-08		More training of researchers to ensure they understand the financial compliance requirements of their research contracts and the importance of longer-term monitoring requirements based on each individual contract

Through the validation process, it is confirmed that the Model addresses the requirements for a credible Model.

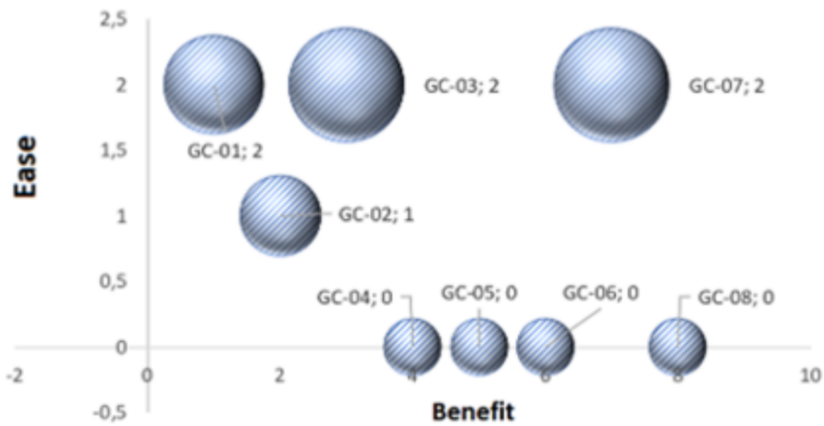

Figure 8: Identify desirable changes to act on (author's contribution)

Conclusions

Through this study and confirmation through interviews, it is reiterated that in the absence of an integrated monitoring-, management- and reporting approach, universities are severely exposed to significant risks, which could otherwise be pro-actively identified, managed, and mitigated. The *Model framework* for an integrated approach for research contracts, verified and validated through experts in the field, provides a pragmatic approach to assist universities to pro-actively identify, manage and mitigate risks.

This study leads to several contributions in the field of RCM. One contribution is the *enhanced* contract lifecycle with the addition of lifecycles L4 and L5, assisting the orderly and systematic consideration and improvement of monitoring- and strategic decision-making capabilities. It further combines the contract lifecycle with a systematic risk management approach. As contracts management is inherently concerned with mitigating risks, it is a suitable process consideration for each contract lifecycle. Each process consideration in the Model framework (L1-O5) is carefully verified and validated and provides a complete set of process considerations and requirements for RCM.

These unique contributions lead to a credible Model framework for an integrated approach to assist a university to comply with external- and institutional requirements as well as the contractual terms within the *enhanced* contract lifecycle. This includes the integrated ability to monitor, manage and report on each contract, and the portfolio of contracts with the added value to enhance strategic decision making based on management information obtained through this contract management approach.

As this Model framework is designed, verified and validated based on the input from practitioners and experts in the field of RCM, the Model framework can be regarded as a pragmatic and useful approach for universities to apply to their own RCM approaches.

The intent of this study is to design a credible Model framework for improved RCM based on the SSM approach, which will hopefully have an uptake in the university sector. This study thus completed step 5 and entered step 6 where desirable changes are identified and presented as possible scenarios depending on the university's current state of the art. However, this is where the practical application of this Model framework will have to start within a university. The author of this study is currently applying the Model framework in the university context as a practitioner and hopes to present a case study on steps 6 and 7 in the future.

Future work will also focus on the concerns raised by universities and industry regarding the compliance and monitoring structures and capabilities, and there is considerable potential to develop maturity models for universities' RCM approaches.

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The effect of PIPE on the development of technology-based ventures

Abstract ID#178

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Purpose

This study aims to understand how government support impacts the development of technology-based ventures (TBV). Beyond exploring the impact of financial support, we investigated how funding agencies collaborate in the organizational value-creation process. Knowing that innovation is a challenging journey, especially for research-based projects, government support is vital in fostering the development of uncertain projects. However, the support is usually described in terms of financial matters. Despite that, some funding agencies embrace other activities to foster the TBVs of their portfolio. Consequently, from the entrepreneurs` perspective, we would like to understand how initial support by governmental agencies impacts their development. We studied the Pipe/ Fapesp Program.

Literature Review

TBVs are companies usually created by scientists or engineers based on research projects. The role of TBV in economic development, through job creation and local innovation, received attention from researchers and government sectors (Mustar et al., 2006) since by supporting the development of such companies, a country can generate employment, knowledge, and innovation.

Developing a research-based product is complex and full of challenges, involving several uncertainties. The initial stages are especially challenging due to the difficulties in providing data for investors' analysis. For example, VC (venture capital) is scarce for this stage of high uncertainty and lack of information on return on investment. Additionally, the lack of technical knowledge from venture capitalists about the project affects their confidence and willingness to invest. In this context, Lee et al. (2001) state that government agencies certify innovation, which contributes to the development of investors' confidence.

Therefore, government support benefits surpass direct financial support. It prepares the path to venture capital investments by building credibility for the TBVs funded (Söderblom et al., 2015). However, it lacks a deeper understanding of how government support affects TBVs, which we expect to provide in this study from the perspective of entrepreneurs.

Methodological Procedures

We used a qualitative approach based on grounded theory that uses detailed and deep discussions to develop concepts (Glaser & Strauss, 1967). Data were analyzed following an open-coding approach (Strauss & Corbin, 2008) using Nvivo software. Later, the Gioia data structure was adopted (Gioia et al., 2013) to help make sense of the data. This way of organizing and structuring qualitative data contributes to the construction and justification of the findings. The research was carried out with TBVs supported by Fapesp (The São Paulo Research Foundation), a Brazilian funding agency, through the Pipe Program (Innovative Research in Small Business) to support TBVs. We studied 16 companies from different businesses and maturity.

These companies were chosen among a universe of 1,500 with the help of two experienced consultants from the Agency. Data were collected through semi-structured interviews with the entrepreneurs (approximately 1 hour each) and by secondary data from news and company websites. All interviews were digitally recorded and transcribed, which resulted in 180 pages. Following Gioia, interviews were coded (1st order codes), and these codes were synthesized into second and third-order codes to reach theoretical explanations.

Findings

We provide a more fine-grained understanding. Our analysis presents the perceived impact of the Pipe support by the entrepreneurs, which surpasses the financial matters as literature identified in a broader sense. Among the main contributions of Pipe support are the development of managerial skills, professionalization of the organization, support in obtaining qualified labor, and acquisition of equipment and services from third parties. Additionally, the study reinforced the importance of the Agency's role in helping build the credibility of the TBV, which may leverage the next stages of the company development through the attraction of private capital and diffusion in the media.

Implications

The study contributes to the discussion of resourcing and leveraging high-uncertainty projects in the context of TBVs. Governmental programs going beyond funding can increase the success of TBVs. With a focus on the success of developing new technologies, government agencies provide the support needed in the early stages to overcome the valley of death.

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The university-industry interaction in Brazil: Characterization of the actors, object of the contract and relational aspects

Abstract ID#303 | Full paper ID#522

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Abstract: This work addresses the historical characteristics of university-industry interactions in Brazil for the development of technologies. Based on a sample of 389 survey contracts funded by Funding Authority for Studies and Projects (FINEP) selected between the years of the 2000- 2010, this research aims to qualify the actors, the contract and the relationship between university and industry in Brazil. From the statistical analysis, we observed that interactions were concentrated in specific areas of knowledge and linked to the experience of the project coordinator; concept and consolidation of graduate programs and characterized by the proximity between partners. Firms that cooperated with Brazilian universities were essentially large and familiar with the R, D & I process, judging by the number of patents filed. Furthermore, the study revealed that although the FINEP has tried to apply a policy of decentralization of resources, most of the universities participating in the collaboration were located in only two regions of the country. Hence, this research contributes to understand the characterization of IU collaborative projects financed throughout the national territory, which can be help define effectives innovation policies.

Keywords: Contracts; Funding; University-Industry interaction; Brazil

Introduction

The term industry-university (IU) is used to describe many possible forms of relationship, which may involve joint R&D, technology transfer and provision of technical services (Perkmann et al., 2013). In addition to the different forms of relationship between universities and industries, the intensity and nature of IU show significant variations in different economic environments (Suzingan & Albuquerque, 2011). In developed countries, for example, the authors observed the existence of deep interactions as has suggested in Triple Helix and Open Innovation approaches. While in developing countries, these initiatives generally tend to be punctual, short-term, with a flow of knowledge unidirectional (Rapini, 2018).

Given the importance of IU to enhance the innovation, this subject has become the object of public policies and interest of researchers (Abramo & D'Angelo; 2021; Da Silva & Sartori, 2022). Forms of collaboration or transfer channels, motivations and enabling factors for successful collaboration, as well as its barriers figure as main subjects studied (Ankrah & Al-Tabbaa, 2015; Kleiner-Schaefer & Schaefer, 2022; Nsanzumuhire & Groot, 2020).

The literature on this topic in Brazil indicates important findings in understanding the reasons and forms of IU (Gomes, Gonçalo, Pereira & Vargas, 2014; Lemos & Cario, 2017; Rapini, Oliveira & Silva Neto, 2014); facilitators and barriers of these processes in Brazil (Cunico, Cirani & Teixeira, 2015; Puffal, Rufoni, & Schaeffer, 2012); and the IU relationship with the elements of the innovation system and their results (Closs, Ferreira, Sampaio & Perin, 2012; Lemos & Cario, 2017; Sousa, Zambalde, Souki & Veroneze, 2018; Viana, Jabour, Ramirez & Cruz, 2018).

However, we also observe important incompleteness in the literature and a research gap in developing countries (Nsanzumuhire& Groot, 2020). When mapping publications about IU in Brazilian scientific journals of Administration, the cooperation process has low participation among the studied subjects and the case study was the most used research strategy since the 2000s. Thus, we still know relatively little about the characteristics of the cooperation agreements, in particular, those Brazilian universities.

The present work aims to qualify the actors, the contractual object and university-industry relationship in Brazil from the collaborative projects selected between the years of the 2000-2010 obtained through the Access to Information Law-LAI (Law No. 12.527 of 2011). This time frame is justified because access to data from ongoing or recently completed projects would hardly be allowed due to confidentiality terms. This research accessed consolidated collaborative projects financed by FINEP, an important federal institution for fostering innovation in Brazil (Silva, 2015; Thielmann, 2014).

It also is important highlight that the Federal Innovation Law was enacted in 2005, when the Intellectual Property Rights (IPR) Policy and the Technological Innovation Centers (NITs) became mandatory for federal universities in Brazil. Regarding the sample studied, it was observed that, in the period 2000-2010, 37% of the Brazilian universities did not have an institutionalized NIT at the beginning of the IU; 29% had one for less than 5 years; only 19% had one for more than 10 years. Concerning the institutionalization of the IP Policy, the incidence was even lower, this policy was non-existent in 46% of the Brazilian universities. In that period, the country had an increase in Science and Technology (S&T) investments, which was not observed in posterior decade. De Negri (2021) presents that federal budget in S&T distribution from 2000 was growing until 2013. After this year, investments decreased until 2020, and the value was lower than that one observed in 2009.

This scenario makes it possible to analyze the actors, the nature and the relational aspects of collaborative research and development projects for innovation in a relevant period, when Brazil had more public financial support but, a small time of constitution of the NIT and institutionalization of the IP Policy.

Differently from other studies that have been carried from secondary information (national surveys, patent analysis), this work used data source of contractual documents of consolidated institutional partnerships of development projects with an empirical-quantitative approach. This way, it overcomes some barriers faced other studies about the IU, with regard to accessing data, pointed out by Perkmann et al. (2013). Moreover, this study makes it possible to increase knowledge of the characteristics of interactions in national territory.

In addition to this introduction, this work has a section that addresses the determinants of university-industry interaction. In section 3, the methodological procedures of the research are described. Subsequently, the results found are presented. And, finally, section 5 brings together the conclusions.

Drivers of university-industry interaction

The IU represents a collective effort to sharing of costs and risks in the sense of developing new technological knowledge that will serve to expand the scientific one and to develop and improve products (Segatto-Mendes; Mendes, 2006). Given the distinct institutional nature of the parties, establishing and maintaining partnerships is not a trivial process (Da Silva & Sartori, 2022). In this sense, the factors that influence IU and its results have been explored in several studies.

With regard to the characteristics of the IU actors, the quality of academic research and previous experience in collaborative projects by institutions and researchers are relevant factors that stimulate cooperation (Hong & Su, 2013).

The researcher's academic status then works as a driver of the IU, insofar as those with higher degrees, high productivity in publications and patent filing, and experience in projects are more likely to raise funds in public calls and attract business partners. (Belkhodja & Landry, 2007; Franco, Haase & Fernandes, 2014).

Studies also point out that previous experience in collaborative projects is relevant for IU. The argument is that the acquired learning enables, in addition to knowledge of operational procedures, greater flexibility for dialogue with the partner (Abramo & D'Angelo, 2021; Bercovitz & Feldman, 2007; Bruneel, D'este & Salter, 2010; Closs et al., 2012). In addition, previous positive experiences end up encouraging new attempts at cooperation (Hemmert, Bstieler & Okamuro, 2014). On the contrary, Tartari, Salter and D'Este (2012) found evidence that the researcher's lack of experience makes them perceive the interaction process as major barriers, which increases the difficulty of dialogue with the different administrative divisions of the university.

From this perspective, firms that have internal R&D are more likely to collaborate and succeed in interaction projects with universities. Familiarity with the research process helps identifying and selecting partners, negotiating, and establishing contractual clauses, understanding the uncertainties inherent to activities, flexibility for adjustments and greater capacity to absorb technology (Bodas Freitas; Geuna & Rossi, 2013). On the other hand, the lack of experience of firms in absorbing embryonic technologies acts as an obstacle (Desidério & Zilber, 2016).

The size of the firms has also been relevant. Nelson and Winter (1982) state that larger firms can incorporate and generate new technologies faster than smaller competitors. In addition to greater availability of resources (human, physical and financial), these organizations have greater specialization and division of labor, consumer market and, therefore, greater possibility of investment in R&D and innovative posture (Belluci & Pennachio, 2016). This proposition is also considered valid for universities. Larger departments tend to have more human, physical and financial resources available for research, in addition to a greater stock of knowledge and skills for interaction (Araújo, Mascarani, Santos & Costa, 2015).

Institutional policies and knowledge of procedures for managing aspects related to intellectual property and technology transfer also influence the IU, as they facilitate the solution of bureaucratic issues (Closs et al., 2012), considered as one of the major barriers to cooperation initiatives (Bruneel et al., 2010; Perkmann et al., 2011; Stal & Fugino; 2014;). Furthermore, according to Bstieler, Hemmert & Barczac (2015), when universities IP policies are not clear and transparent, there is a high risk of conflicts over intellectual property or the dissemination of interaction results.

In this sense, the performance of the Technological Innovation Centers (Nsanzumuhire & Groot, 2020; UNCTAD, 2014), which have the function of managing the innovation policy in scientific and technological institutions, is relevant. These centers, called Innovation Agency in some institutions, or even Technology Transfer Offices (TTO's), provide legal guidance regarding Intellectual Property Rights (IPR) and their negotiation. In addition, they had their mandatory institutionalization in Brazil from the Innovation Law of 2004.

González-Pernía, Kuechle and Peña-Legazkue (2013) and Tartari et al., (2012) showed that the low performance of universities' technology transfer offices constitutes a difficulty for IU. In Brazil, investigators reported lack of information on protection of invention by patents.

Regarding the characteristics of the research object for which the interaction was constituted, some studies point out that projects in more applied technological fields tend to have faster results than those in other areas. For Metcalfe (2003), the nature of the areas of knowledge and their specific forms of variation differ according to the different disciplines. The areas of Engineering and applied technologies are more associated with the transmission of knowledge in the "trial and error" type and are treated for problem solving. (Araújo et al., 2015).

In addition, given the uncertainty involved in the innovative process, firms tend to invest in those projects they believe to have a greater probability of return. According to Bruneel, D'Este and Salter (2016), investment in uncertain and long-term activities with university partners is carried out by firms when they are protected from financial slack; thus, it is possible to infer that projects with greater volume of resources are associated with greater risk.

Corroborating this idea, Rapini et al. (2014) found that the objectives of industry collaboration with universities are influenced by the nature of funding (private or public). According to the authors, public and private financing were more linked to projects with higher risks and costs, while projects financed exclusively with private resources were more focused on results of interest to the industry. In this context, the research budget is also an influence factor for the IU. Belkhodja and Landry (2007) concluded that, although the predictors vary among different fields of study, in general, the probability of researchers collaborating with the industry and public institutions grows with the increase of the research budget.

With regard to the relational aspects, Rossi (2010) points out that the proximity (geographical, cognitive, cultural, social) has also been identified as an important factor for the result of the IU, given the tacit character that involves the transfer of knowledge among different agents (Bruneel et al., 2016; Hong & Su, 2013).

Maietta (2015) investigated collaborations with universities from firms in lowtechnology sectors and concluded that the geographical proximity is a determining factor for product innovation. In this line, based on Storper and Venables (2004) and Duranton and Puga (2001), Araújo et al., (2015) argue that university groups located in denser urban regions can benefit from greater possibilities of interaction. Thus, the IU would be influenced by the level of urbanization, industrial structure and qualification of the workforce in the region where the partners are located (Araújo et al., 2015). On the other hand, according to Muscio and Pozzali (2013), the location of universities in sub-industrialized areas reduces opportunities for interaction and fundraising.

Geographical distance, in turn, can be considered a barrier to collaboration since it increases the cost of face-to-face communication and would decrease the sharing of knowledge and instruction, especially in the case of R&D alliances, in which tasks are highly complex and interdependent (Dyer, Powell, Sakakibara & Wang, 2007; Hong & Su, 2013).

However, this is a controversial point in the literature. Investigating the role that technological and relational attributes have on IU, Petruzzelli (2011) found that geographic distance would not have to be considered as a restriction on IU, when the university has high prestige because it tends to be attractive to geographically distant partners. Hong and Su (2013) observed that the negative effect of long distances between partners can be minimized by the trust built in previous collaborations.

Thus, the existence of previous collaborations is presented as a relevant factor for IU (Abramo & D'Angelo, 2021; Petruzzelli, 2011). This is because it promotes the development of relational routines and an initial base of trust between partners (Bruneel et al., 2010). In other words, the intensification of relationships, due to the greater number of meetings, informal dialogues, and knowledge exchange between the parties help in the development of trust and common language collaborating for the resolution of conflicts.

Moreover, the entrepreneurial orientation of the university and the researchers' experience in private projects tend to make them more understanding in relation to the industry's needs. The industry's familiarity with the research process can help it identify and select partners in negotiating and establishing contractual clauses, understanding the interference inherent in activities, flexibilization for adjustments and greater capacity to absorb technology (Bellucci & Pennacchio, 2016).

Even when analyzing collaborative projects among firms, Dyer et al. (2007) showed that the number of people involved in the teams may be relevant. According to the authors, the process of negotiating collaboration goals, protecting intellectual property, controlling and owning research results, sharing knowledge and collaborating in R&D can be hampered by the need to reconcile the interests of a larger number of partners. Furthermore, while adding resources and expertise, an alliance with additional partners can also increase the costs of coordinating research activities.

Methodological Procedures

Information in the contractual documents of projects of scientific and technological development carried out by Brazilian universities in cooperation with industries constituted the main secondary source of data of the documentary research. These projects were selected by invitation letter and calls for proposals for funding by FINEP with resources linked to the National Fund for Scientific and Technological Development (FNDCT) and approved in the period of 2000-2010.

The use of these records made it possible to access consolidated data of interaction projects from a single source of information, carried out throughout the national territory and covering different areas of research and, therefore, to overcome the difficulties of access to records of this type of interaction pointed out by Perkmann et al. (2013).

Another advantage of using contractual documents as a data source is that they evidence the record of the dynamics of the relationship established between the partners, but not from the expectation of collaboration between the university and the industry, as performed in some previous studies. The choice of this time frame is justified because, given the characteristics of the IU research studied, it would be difficult to access data from ongoing or recently completed projects for confidentiality reasons.

The information of the IU projects studied in Brazil was obtained through the Citizen Information Service, a prerogative of the LAI. The first set of requested data returned 4,399 projects for the period and, from these, 564 contemplated partnerships between universities and industries. Due to the absence or inconsistency of some information, some projects had to be excluded from the database, leaving 389 projects in the end.

Research secondary sources further comprised data obtained from the Lattes Platform and National Council for Scientific and Technological Development–CNPq's research group directory (concerning the project's coordinator, his or her ties with IES and the post-graduation programs to which he or she is linked), FINEP and Brazilian Science, Technology an Innovation Ministry-MCTI sites (complementation of project-related information), the Internal Revenue Service (data concerning firms), Coordination for the Improvement of Higher Education Personnel-CAPES Reports (score and time of existence of the coordinators' postgraduation programs) and the Spacenet patent database (patents of partner firms), as showed in table1.

Table 1 – Definition of the variables and data sources

Variables	**Measure**	**Data source**
Seniority of the coordinator	Number of years between the year of PhD completion and the year which IU start	Lattes Platform
Experience in projects of the coordinator	Number of research projects before IU	Lattes Platform
Research quality	Evaluation of the graduate program in the period of the IU start	CAPES reports
Research consolidation	Number of years between the year of the creation of graduate programs and the IU start	CAPES reports
Support of Technological Innovation Centers-NIT	Number of years between the year of the creation of university NIT and the IU start	Universities and TTO's websites
Guidance regarding IPR policy	Number of years between the year of the publication of institutional IPR policy at university and the beginning of the IU	Universities and TTO's websites
Firm size	Small (1); Medium (2); Large (3).	FINEP
Familiarity with the research process of the firm	Number of patent applications of firm before IU	Spacenet patente database
Research budget	Financial amount of the IU project (R$)	FINEP
Knowledge area	Knowledge area	FINEP
Team size	Number of the members in the project team	MCTI
Geographical proximity	Localization of university and firm (different regions=0; same regions=1; same state=2; same city=3	FINEP
Previous relationships	If the partners had previous interaction in other projects (*dummy*: 0/1)	Lattes Platform, FINEP and MCTI

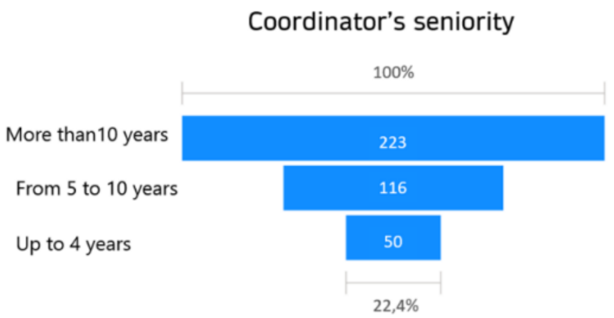
Source: Constructed by the authors

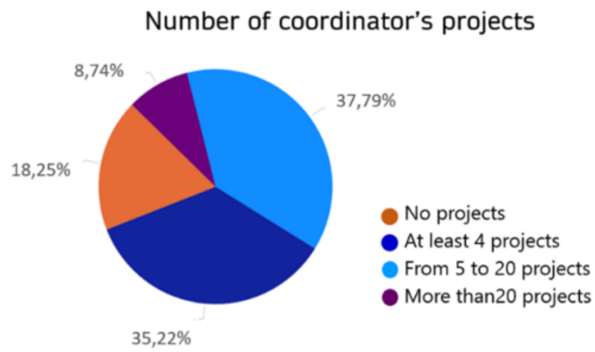
Finally, as to the approach to the problem, the research used the quantitative approach and the main techniques used for data analysis were summarization and clustering, which allowed us to better understand the main characteristics of the population studied.

Results and discussion

The FINEP-funded IU were mostly coordinated by experienced faculty members, both in terms of tenure and participation in projects, as can as presented in figure 1. These results are consistent with the study by Belkhodja and Landry et al. (2007), who, examining Canadian universities, concluded that years of post-doctoral research experience are significantly and positively related to involvement in collaborative activities.

Figure 1 – Experience of the FINEP-financed IU coordinator (2000-2010)

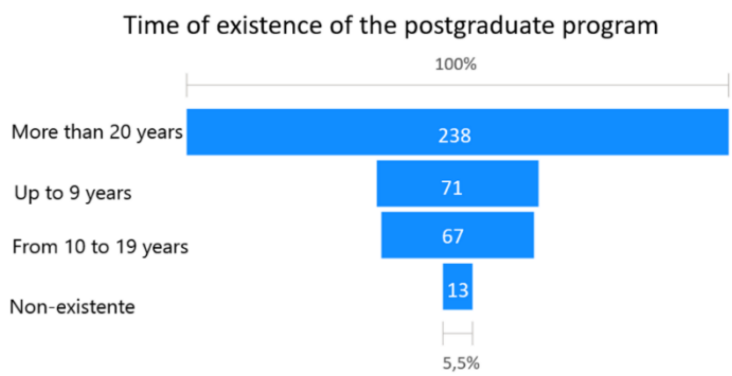


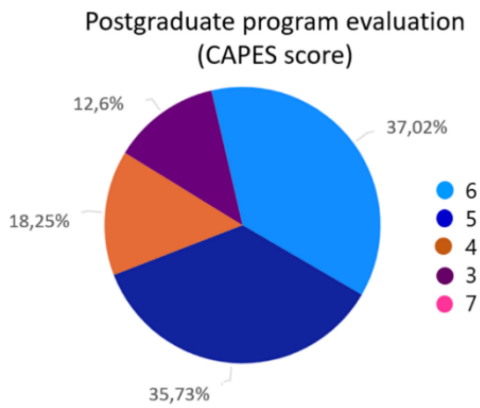


Source: Elaborated by the authors.

From the verification of the evaluation of CAPES reports in relation to graduate programs to which the coordinators of the interactions were linked in the initial period of the collaborative project, it was possible to realize that, for the most part, they were consolidated and well-regarded, as shown in figure 2. These programs usually have more qualified faculty, involved in research and with a high rate of publications. This shows that the quality of academic research developed at the university was a determining factor in the FINEP-funded IUs, as found in the studies of Bellucci and Pennacchio (2016), Bruneel et al. (2010) and Franco et al. (2014).

Figure 2 – Academic quality of the post-graduation courses of the IU coordinator funded by FINEP (2000-2010)





Source: Elaborated by the authors.

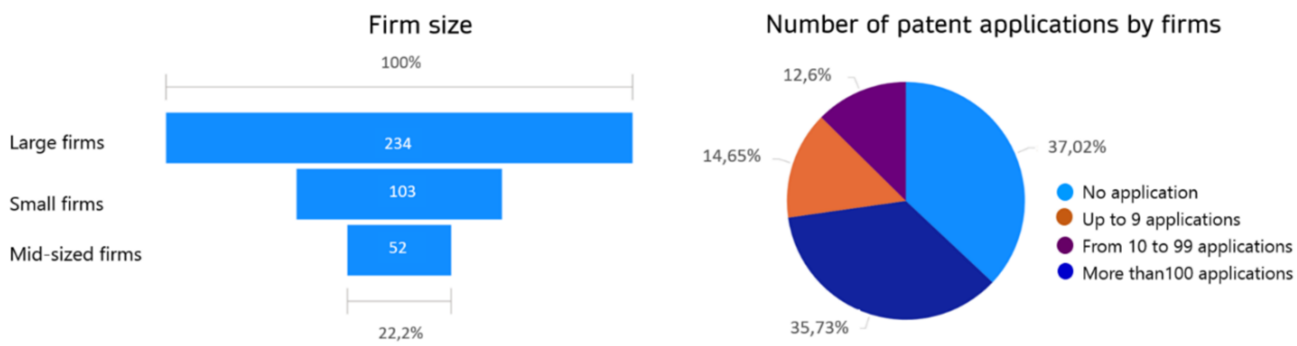
These results found in relation to the experience of the professor (project coordinator) and the quality of the research confirm the importance of reputation for the establishment of UIs, as pointed out by Bruneel et al. (2010). Additionally, they reinforce the assumptions that the acquired learning

(Bercovitz, Feldman, 2007; Closs et al., 2012) and previous positive experiences (Hemmert et al., 2014) tend to encourage new attempts at cooperation.

With regard to the geographical location of the Brazilian universities, it is observed that, most of them were located in the Southeast (48%) and South (33%) regions. These rates seem influenced by the determinant of research quality; after all, among the 63% of interactions that have as coordinators professors linked to graduate programs with grades between 5 and 7, 91% were from universities located in the aforementioned regions. And they also show that, as pointed out by Muscio and Pozzali (2013), the location of academic institutions in areas with little industrial activity reduces the opportunities for interaction and obtaining funding. In the context of the interactions studied, this scenario could be even more critical if there was no reserve of 30% of the resources of the edicts for the North, Northeast and Midwest regions.

With respect to the characteristics of the firm, the results found corroborate the propositions presented in previous works. From figure 3, it is possible to see that the collaborations studied were mostly carried out by large firms (Nelson & Winter, 1982), since they have more resources for investment in R&D (Belluci & Pennachio, 2016) and by the tendency to engage in formal institutional interactions (Bodas Freitas et al., 2013), such as those carried out with support from FINEP. In this sense, data on patent filing in the Spacenet database revealed that 62% of the firms participating in IU funded by FINEP already had this filing in the period prior to the beginning of the interaction. This association had already been found by Bercovitz and Feldman (2007). However, the fact that approximately ¼ of the interactions were carried out by firms that had no history of patent filing points to the importance of FINEP funding in including these firms in collaborative R&D&I activities.

Figure 3 – Characterization of firms participating in IU funded by FINEP (2000-2010)

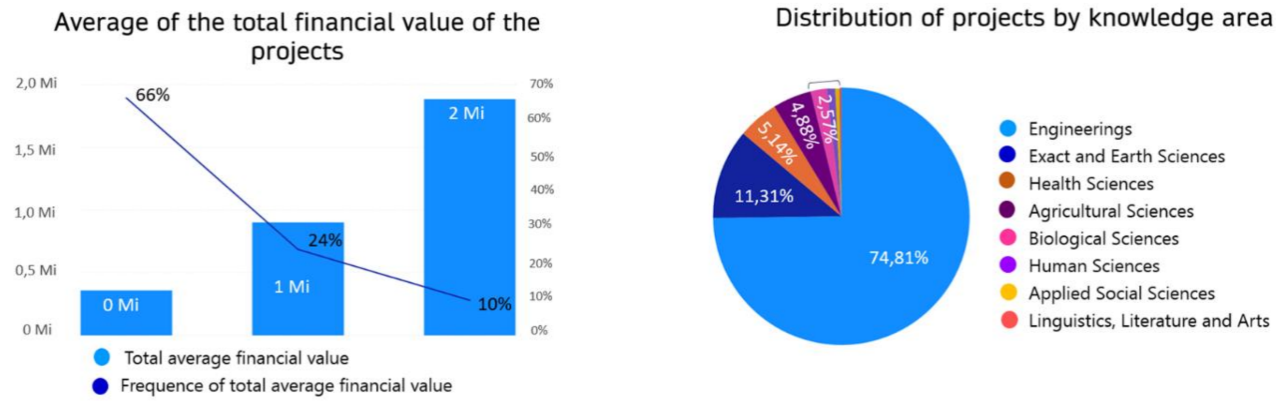


Source: Elaborated by the authors.

In regard to the financial amount of the projects, it was observed that the average value of the studied interactions was 0.65 million real, however a great variation of this amounts was verified, since it was possible to find projects with values between 0.30 million real and 4 million reais. From the clustering technique, it was verified that 66% of the projects had an average value of approximately 0.36 million real; 24% of 0.90 million real; and only 10% had an average value around 1.9 million real. Since the projects were evaluated by FINEP technicians for approval of the contribution in the calls for proposals and, due to the fact that 43% of these calls required financial counterpart of about 30% of the funding, the classification of the financial amount of the interactions, in a way, suggests the level of risk of the research and the interest of firms in its results. This assertion is based on the relationship, found by Rapini et al. (2014), between the pattern of the nature of funding and the objective of the interaction. It is also based on the assumption that financial availability allows firms to engage in more uncertain and long-term activities, as pointed out by Bruneel et al. (2016).

With respect to the area in which the research is conducted, the data revealed that 75% of the projects were concentrated in the major area of engineering, according to figure 4. These empirical results are consistent with studies that point out a higher propensity of occurrence of IU in applied and technology-based areas, mainly engineering (Belkhodja & Landry, 2007; Araújo et al., 2015). With the exception of the area of Agricultural Sciences, the results found are consistent with the areas that had the highest number of relationship records in the CNPq Directory of Research Groups, according to Rapini et al. (2016).

Figure 4 – Characterization of the object of IU contracts financed by FINEP (2000-2010)



Source: Elaborated by the authors.

About the physical proximity of the partners, the data revealed that in 32% of the interactions the partners were located in the same municipality; 33% in the same state; 14% in the same region; and 21% in different regions.

Although this table does not accurately provide a parameter on the proximity of the interactions, when compared to the geographical location of origin of the partner universities, it suggests that the quality of the research attracts distant business partners, as suggested by Muscio and Pozzali (2013) and Petruzzelli (2011). Of the 32% of interactions in which the partners were located in the same state, 79% are in the Southeast and South regions; and among the 21% in which they were located in different regions, 85% of the universities were in the Southeast and South regions, where there is a higher concentration of the most consolidated and highly-ranked graduate programs, as discussed at the beginning of this section.

Considering that geographical proximity enables more face-to-face interaction, the 32% of interactions where partners resided in the same municipality potentially had the chance to develop a closer relationship, with sharing of routines, alignment, and sharing of information (Bruneel et al., 2016). Such condition would also facilitate knowledge transmission (Hong & Su, 2013).

Regarding the previous relationship, it was possible to observe that in 70% of the projects the partners had already interacted previously. From the relational point of view, it can be considered that the fact of having a certain proximity with the partner reduces the possibility of conflicts, because the experiences developed previously can be accessed in this new interaction (Abramo & D'Angelo, 2021; Hemmert et al., 2014), which contributes to the management by the established routines and, consequently, the development of trust between partners (Bruneel et al., 2010).

Furthermore, the familiarity the partners themselves and between them and the research process can facilitate the management of the procedures related to IP aspects, which is especially relevant in the context of the studied projects. Due to the short time of regulation of the innovation law, we had a weak regulatory structure for aspects related to IP a technology transfer in that period.

Different from the international context, where TTO's have been pointed out as responsible for the growth of formal institutional interactions (Rossi, 2010) and determinants of academic spin-off and licensing of new technologies, in Brazil their low performance has been considered as one of the barriers to IU (Araújo et al., 2014; Delsidério & Zilber, 2016).

In 51% of the interactions, the teams had up to 11 members; 32% between 12 and 21; 12% between 22 and 33; and 4% with more than 35 members. From the relational point of view, having a reduced number of members facilitates the coordination of activities and reduces the possibility of conflicts, because the difficulty to conciliate incentives and expectations increases with team size (Dyer et al., 2007).

Conclusions

The research findings indicate that the characterization of the actors, the contractual object and the established relationship were aligned with the studies on the determinants of IU. The interactions in Brazil between 2000-2010 were mostly coordinated by experienced professors, linked to consolidated and well-regarded graduate programs. The participating firms were essentially large and familiar with the R,D&I process, judging by the number of patent deposits.

With respect to knowledge areas, the interactions in Brazil were concentrated in the fields of Engineering and Earth Sciences. These are pointed out in the literature as the most prone to the occurrence of IU due to their applicable nature, which induces the search for collaboration on both sides. Not coincidentally, these two areas have the largest number of research groups registered in CNPq's Directory of Research Groups.

The contribution values of the projects, in turn, were quite varied, possibly because the sample studied comes from different funding calls. Considering that the financial value can be associated with the level of radicality of the research, it is possible that there were interactions that differ in relation to the research objective, which may be of a more incremental or applied nature. This indicates that, even belonging to the same areas, there were interactions with different propensities to risk and possibly different types of results.

In most of the interactions, the partners were geographically close, that is, located in the same municipality. Considering that physical proximity enables the establishment of greater face-to-face contact, this is an indicator that these interactions had, in theory, greater possibilities of developing joint activities. As far as the spatial distribution of resources is concerned, as the partner universities are mostly located in the Southeast and South regions of Brazil, the interactions were also concentrated in these regions. This data reveals that if FINEP did not adopt the Brazilian policy of reserving 30% of the resources of the calls for proposals for interaction with institutions from the North, Northeast, and Midwest regions, the inequality could be even greater.

It was also found that 2/3 of the interactions in the period 2000-2010 were carried out by institutions that had already interacted previously. This suggests that the university and firm prefer safe and low cost collaboration, because repeated interaction reduces of costs related to the selection of the partner and the negotiation of the contractual terms, as well as the necessary adjustments to the execution of the project. In addition, the familiarity with the activities related to the project and the trust built among the partners contribute to the success of the collaboration.

Thus, this research fulfilled its purpose of qualifying the actors, the contract and the relationship between university and industry in Brazil. Having overcome the barriers of the cooperation process, the characteristics of these IU indicate some assertions that can help in the definition of conditions to be adopted so that the investment in these projects can have even more efficient results. This can help, therefore, in the strategic formulation of Brazilian policies to intensify the collaboration process. In addition, the research contributed to studies in the area with a differentiated perspective with regard to standardization and national coverage of information. These findings may highlight important determinants of IU in other countries with similar characteristics.

On the other hand, the use of this data source limited the scope of the analysis to a specific context in terms of financial assistance, submission to the assumptions and rules imposed by the funding notices. In this sense, it is important that these collaborations continue to be evaluated over time for a better understanding of their dynamics in the face of changes in the economic context, competition conditions and S,T&I policies, mainly because the changes in financial and institutional context to interaction university-industry can modify the research results. In recent years Brazil reduced public investments to IU and a growth of institutionalization of NITs and implementation of Innovation Policy by ICTs. While data from FORMICT (2019) indicate a growth of institutionalization of NITs and implementation of Innovation Policy by ICTs in recent years, economic studies present lower incentive of public investments to IU in Brazil.

Moreover, the fact that the study is based on consolidated data, despite being an advantage, limited the scope of the analysis to UI in the context of interactions funded by FINEP. In addition, the possibility of accessing the resource to execute the project may have influenced the formation of the partnership. In this way, future studies may expand the analysis for relationships that are not mediated by financing institutions.

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Barriers and enabling mechanisms for the achievement of results in R&D and technological innovation ventures in partnership between universities, scientific institutions and companies

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Abstract: This paper uses a case study to derive conclusions on barriers and enablingmechanisms for achieving practical results within research and development and technological innovation undertakings. The case consists of a series of projects developed within the R&D programme sponsored by the national agency for electric energy, in Brazil, which consolidateda methodology for training critical activities based on virtual reality technology, making use ofgamification techniques, and learning theories. The study was conducted in parallel with the development of the R&D project, gaining practical insights based on the difficulties and enabling mechanisms used within its management and thus contributing to the process of generating practical results. The purpose of the work is, therefore, to address what the literaturein general considers an existing gap in the policies to encourage scientific and technological development in Brazil: the lack of mechanisms that allow and assist the process of establishingnew technology businesses, especially those arising from scientific ventures, which, in principle, generate specialized knowledge and, therefore, an opportunity for a sustainedcompetitive differential.

Keywords: Innovation management, enabling mechanisms, R&D, University-industry relation.

Introduction

This work addresses issues that, in the context of the relationship between university and industry, significantly impact entrepreneurial results, focusing two aspects: 1) The concepts, methods and techniques used in the context of a partnership between university andindustry to maximize results, specifically addressing different types of barriers normally foundin such relationships; and 2) Issues related to the creation of new businesses based on academicactivities, which is a very complex task, particularly in Brazil. Specifically, aspects that characterize the difficulties encountered both by universities and by research institutions and companies were addressed.

The observations reported in this paper are based on the practical involvement in the development of the project, not only on interviews with the team. The leading researcher has coordinated both the project and the study reported here as a means to improve the extent of the results obtained and to make better use of the acquired intellectual capital aiming at the creation of a new technology business.

Theoretical background

The literature review allowed an analysis of the suitability of the methods used in conducting R&D projects. As far as internal difficulties in universities are concerned, the work of Muscio, Quaglione and Ramaciotti (2016) investigates the influence of the internal rules ofItalian universities and their institutional capacity to create ventures, considering the strategies and rules related to engagement activities and the impacts of funding on the academic results of faculty, reaching two important conclusions: a) monetary incentives provide significant benefits to spin-off venture creation activities; and b) very strict university rules regarding thecontracting of research and consulting activities negatively influence the ability to create spin-off ventures.

It is common sense that Brazilian universities suffer from strict rules that makeentrepreneurship activities difficult. The two issues addressed in the referenced work, namely,the role of monetary incentives and the rigidity of rules in the university organization, were analysed in the context of R&D projects carried out within the initiative described here.

Kaschuck and Klimova (2019), in their work on the commercialization of scientific results and the creation of academic spin-off ventures in Ukraine, substantiate, through a theoretical and conceptual approach, the need to develop organizational formats for small innovation ventures in the university environment. They also analyse prerequisites, factors andmechanisms for the creation and development of spin-off organizations. Finally, they present a set of measures developed to improve entrepreneurship activities in universities and stimulatethe processes of commercialization of scientific research results.

Son, Chung and Hwang (2019) conducted a survey in the context of public research organizations in South Korea, seeking to analyse whether technological entrepreneurship and its external relations always manage to promote technology transfer. The results showed that the degree of collaboration between public research organizations and industries has a negative effect on the creation of spin-off businesses, but positive effects on technology licensing agreements and licensing profitability. Entrepreneurship positively affects the technology licensing profitability of public research organizations and, simultaneously, has a negative effect on the relationship between spin-off business creation and industry collaboration with public research organizations. Therefore, directors of such organizations and policy makers, in the task of formulating strategies and policies for the commercialization of technology, must consider the different mechanisms and the opposing effects that some external relations exert on the results. The findings described in the paper were important in the elaboration of the strategy to define the most appropriate mechanism for exploiting the results obtained in the R&D initiative.

In another work in the context of research institutions in South Korea, Park and Cho (2019) analyse what factors contribute to the creation of spin-off businesses in government- funded research institutions. The empirical results showed that the creation of spin-offs is influenced by the degree of use of patents, the budget of the technology licensing office and the presence of an incubation centre. The authors draw special attention to the important role of the use of patents in the creation of spin-offs. The findings described above reaffirmed the use of the incubation centre based in the campus of the partner university in the venture.

The work of Li, Gagliardi and Miles (2019) defines R&D service companies as a particular type of technology-based and knowledge-intensive service companies. They have astrong and constant nature of innovation and have the special role of linking scientific researchto the market. The work makes an analysis, based on interviews with founders and executives(managers), of the innovation process of 32 of these companies in the United Kingdom. Resultssuggest that these companies are quite diversified about their primary innovation drivers, that is, if they are driven by market demands or technological opportunities, and by the results theyseek, that is, if their products are mainly customer services or a mix of services, products and intellectual property. As a result, four main guidelines were identified:

a) explorers of technology-based innovation;
b) explorers of science-focused innovation;
c) customer-driven innovation integrators; and
d) open innovation translators.

This variety of companies suggests the need for care in generalizing behaviour in termsof statistical clustering.

An important contribution for the work described here is that, given the variety of typesof innovation activities and their different characteristics and needs, care must be taken in the strategy, structuring, creation, and conduction of new businesses arising from R&D.

The work by O'Shea, Chugh and Allen (2008) proposes a conceptual framework, presenting a very important set of information related to spin-off activities in universities. Theyjustify their work because previous studies have suggested that innovations in universities stimulate economies by inducing product development, creating new industries, and contributing to the creation of jobs and wealth. This means that universities have been valued in terms of economic potential due to their scientific endeavours.

The conceptual framework developed by the authors suggests that six aspects influencethe rate of spin-off activity:

1. Characteristics of Individuals – Engagement in Entrepreneurship Activities: Spinoff-friendly behaviour reflects individual actions and is therefore highly dependent on the individual's personality, ability, career choice or willingness to engage successfully in entrepreneurship.
2. Organizational characteristics – the attributes of universities, such as human capital, commercial resources, and institutional activities: the greater the speed of innovation by technology transfer offices, the greater the propensity to generate return to the university through higher education rates of startups.
3. Institutional and cultural characteristics – the social context of universities, including barriers and impediments regarding spin-offs: the authors cite Djokovic and Souitaris (2008), who claim that the dynamic role of universities in terms of commercialization activities, combined with government institutional support mechanisms, has created fertile soil for the seeds of university spin-offs.
4. Characteristics of the external environment – external aspects such as regional infrastructure, which significantly impacts the spin-off activity: a region's knowledge infrastructure appears to be a key factor for spin-off activities. The authors also cite Goldfarb and Henrekson (2003), who suggest that national policies for attributing inventions to individuals can lead to an anti-entrepreneurship attitudeamong university leaders, since they do not gain anything from the entrepreneurialactivities of inventors. The authors also cite Sorenson and Stuart (2001), who claimthat the probability of a venture capital firm investing in a startup decreases with the geographic distance between the investing company's headquarters and the startup company.
5. The development and performance of spin-offs: the survival rate of university spin-off companies is extremely high. In addition, new technology companies are morelikely to survive if they exploit disruptive technologies and hold patents that are broad in scope.
6. The spillover effect of spin-offs in the regional economy: spin-off companies from universities constitute an important subset of startup companies because they are an economically powerful group of high technology companies.

More recently, Alexander et al. (2020) proposed a practical and strategic method to address key problems in knowledge transfer management by introducing what they call "meta-rules", following recommendations from Schultz and Hatch (2005), who identified which practical solutions are necessary in the construction and extension of theories. The proposed meta-rules seek to help solve common managerial problems found in knowledge transfer organizations (offices) when working in collaboration with the industry.

To this end, the authors make use of three different levels of organizational abstraction: a) corporate, b) departmental and c) focused on projects. The so-called meta-rules help in the interoperability between the three levels of abstraction and facilitate the strategic alignment of departmental and organizational goals, that is, they help to reduce the barriers that limit the transfer of knowledge.

Another concept that has proven to play an important role in the process of technological innovation, starting from scientific research up to the stage of a product placed in the market, is that of co-creation. Yakihara and Kato (2017) state that innovation encompasses three phases: a) idea creation; b) R&D; c) incubation. The authors report successin the task of structuring R&D units according to the following operational policies:

a) create innovation scenarios through co-creation and reflect them in R&Dactivities;
b) link R&D activities to new business incubation and acquire the necessarytechnology;
c) create a structure that allows the continuous development of R&D andtechnology and the training of human resources.

Roberts, Palmer and Hughes (2021) state that customer involvement in the innovation process implies significant changes in traditional innovation management and practice. The challenge, therefore, is no longer to produce the innovation itself, but also to innovate the innovation process and management methods to enable the practice of co-creation.

In Brazil, there is a very large gap between organizational levels, in particular, the onethat is seen as managerial and the one that can be designated as "project-oriented". This aspectseems to characterize the Brazilian context as a fertile field for the application of models like those found in this brief literary review.

Methodological Procedures

In view of the comparison of the state of the art of the literature with the strategies adopted in the development of R&D projects, the following questions were formulated:

a) What are the main factors that prevent or hinder the exploitation of intellectual capital produced in R&D projects? The analysis should also include subjective factors, such as the culture and attitude of Brazilian companies in terms of taking risks and planning for the long term.

b) In light of the policy and cultural aspects studied in the literature and the mapping of institutional organizational differences, what strategies and structural changes can be suggestedfor the institutions involved to achieve together the desired innovation result?

c) How barriers that hinder or prevent adequate interaction between academia and industry can be addressed, specifically at the project level, especially addressing aspects of cognitive differences, institutional differences, and social capital?

d) What is the role of the concept of co-creation in the context of the previous questionand how can it be explored? Can it be used to reduce the distance between academia and the company to allow science and technology-based enterprises to reach the final stages of the innovation chain?

Results

Question a) factors that prevent or hinder the exploitation of intellectual capital obtainedin R&D projects: This question was answered by considering the development of the whole initiative, since its conception, by comparing the foundations of the scientific literature and thetechniques, methods and mechanisms used during the development of the projects, in particular, confronting those that provided success in their objectives. and aspects related to resolved and unresolved difficulties.

The most strongly observed barriers are the cognitive differences between the participants of ventures in partnership between academia and business, which translate into distinct personal interests and a positioning of animosity between the participants of the partnerinstitutions, in which academics tend to value the scientific aspects and disregard technical andpractical knowledge and, similarly, company professionals tend to value their own knowledgeand belittle that related to academia, claiming that their activities are nothing more than ravingswithout practical benefits.

In terms of social capital, the history of partnerships between the institutions involved in the venture is a strong point. Organizational differences, in turn, can be addressed at the project level, in a "bottom-up" view.

Another common difficulty in projects like the ones dealt with here is the lack of empathy between the different teams, especially with regard to the ideation process and authorship of the results obtained. If one of the parties does not effectively participate in the ideas and, consequently, does not feel like co-author of the product, it will tend to be forgottenby the company and will no longer be explored and applied, implying the failure of the enterprise in terms of achieving its results.

Question b) strategies and structure changes to improve the desired results: From the experience gained throughout the development of the entire venture, it becomes evident that activities related to R&D, technological innovation and creation of spin-off businesses are diametrically opposed to the vast majority of other activities carried out in companies. This aspect is corroborated in the scientific literature, which states R&D differs from the vast majority of corporate activities, as it is not intended to generate immediate profit and generallybrings greater risk and uncertain return on investment. This shows that R&D activities requirea different structure in relation to that adopted by companies. This need implies a great challenge for companies, as they are reluctant to adopt differentiated structures according to the nature of the activities. The appropriate structure for activities of an innovation nature presupposes characteristics such that allow, for example, experimentation, the ability to interactfreely, greater freedom in terms of processes, the adoption of flexible control mechanisms, faulttolerance and, especially, the ability to deal with uncertainty. Thus, the establishment of an administrative unit that has the desired characteristics to perform R&D and technological innovation activities is essential, and it could be seen as the interface between the company's application areas and scientific partners.

Due to all the aspects presented, it is recommended that the administrative unit of the company dedicated to R&D, technological innovation and knowledge transfer be segregated from the traditional structure of the company. One way to do this is to create a subsidiary company, which can count on autonomy and a certain independence from the businessprocesses. This strategy was adopted, for example, by Xerox when it created its Palo Alto Research Center (PARC), five thousand kilometres away, precisely so as not to contaminate itwith the company's bureaucratic mentality and the day-to-day demands of its business.

Question c) factors that impede or hinder the interaction between academia and industryat the project level, especially aspects of cognitive differences, institutional differences, and social capital: The authors of the article on meta-rules (Alexander et al., 2020) report a real case of a project in partnership between academia and industry in which knowledge transfer took place mainly through emails, photographs, and reports. The participants' report at the endof the project demonstrated that the knowledge effectively shared was, in practice, exclusivelyexplicit. There was, therefore, no sharing of implicit and tacit knowledge. One of the mechanisms used throughout the development of the venture reported here, in turn, was the holding of workshops outside the business environment, which made it possible to transfer tacitand implicit knowledge, and not just explicit knowledge, commonly provided by traditional mechanisms. As reported in the discussion section, the adopted interaction mechanisms greatlyreduced cognitive differences and impacted institutional differences and social capital.

Question d) the concept of co-creation as a possible way to reduce the distance betweenacademia and the company: The concept of co-creation fully meets this challenge, providing solutions especially regarding the lack of empathy between the different teams and the feelingof authorship of the results obtained. The issue is, therefore, not only about cognitive differences, but also about social capital, since experiences have shown in practice that there are great difficulties with regard to the link between the institutions of the partnership, largelycaused by the discrepant perceptions between the objectives of each institution and its members. Therefore, it is essential to create an environment in which the importance of all the roles involved in the enterprise becomes clear, because they will make a significant contribution to the desired result.

To ensure that the creation of an environment conducive to innovation happens to a greater degree and in a greater number of ventures, the technology transfer office, here envisioned as a small independent subsidiary company, must play a role in guiding and encouraging practices that foster creativity and innovation. Many universities now haveinnovation agencies whose aim is to facilitate exchanges with the industrial sector and society in general. Research institutes, in turn, have administrative units in their structure that mediatebetween research work and its application. However, there is nothing analogous in companieswhose goal is to stand out and acquire a competitive edge through technological innovation.

Discussion

The scientific literature on knowledge transfer classifies the barriers to relationships between academia and the business world into three categories: cognitive differences, institutional differences, and social capital (Wit-de Vries et al., 2018). The experience reportedhere produced good results in terms of cognitive differences. At the research group and staff levels, there is a willingness to overcome cognitive differences and an awareness that differences in the type of competence bring benefits to the group. The challenges lie in issues related to institutional differences, due to marked discrepancies in the organizational structureof the partners, and to social capital, that is, aspects related to the link between institutions, due to the common perception that academia and industry have opposing interests. Institutional leaders do not seem to fully understand the nature of the benefits brought by such efforts. Thechallenge is to promote institutional awareness, resolve the difference in objectives, and then address communication and management methods.

The work described here allowed for a critical analysis of the whole initiative in termsof impacting factors, focusing on organizational, cognitive and mindset differences, and on challenges that have been successfully addressed.

The strategies adopted throughout the development of the projects to provide an atmosphere of creativity and innovation, with freedom for experimentation and ideation, and capable of maximizing results, are presented below.

Cognitive differences: One of the most important barriers in R&D ventures in partnership between universities and companies consists of the cognitive differences between project participants, given their different backgrounds, interests and attitudes. Despite their complexity, these differences can be addressed directly at the project level, without involving the institutional level (Wit-de Vries et al., 2018).

An important feature to note was that some of the team members were musicians and, as such, had a slightly more art-oriented attitude and, therefore, conducive to professional activities related to innovation and R&D. This stance facilitated the adoption of various interactional mechanisms within the monthly workshops, which involved all participants and sporadically invited people, including people in managerial positions in the institutions involved, and were carried out during the development of the projects. These interactional mechanisms satisfactorily addressed potential barriers arising from cognitive differences, and were based on intrinsic characteristics of the workshops, such as:

- They were conducive to the practice of co-creation (Pieters and Jansen, 2017), sincethe utility company's professionals were part of the project, who actively participated in the core activity, maintenance of live electrical networks.

- Provided bilateral levelling of knowledge. Both researchers and professionals of thecore activity acquired knowledge through interaction and presentations. As a result,all project participants participated in the co-creation process.
- They took place outside the company or the normal work environment, which guaranteed the exclusive attention of all participants.
- Systematic interaction: with time, it became normal for participants from one institution to interact with those from another.
- Warm-up sessions: the first part of each workshop was dedicated to free interaction, where participants exchanged ideas about possible solutions to specific problems. This mechanism was essential for the participants to feel part of the process and torealize that they could make important contributions. Informality also helped to overcome personal barriers of shyness.
- Several interaction mechanisms were used, including physical models, made with paper, wood, game elements and common objects.
- Call for contributions: all participants had the opportunity to present their ideas or topics relevant to the project.
- Monthly workshops took place even if there was no explicit need.
- Participants were generally aware of creative chaos.

The workshops also had the effect of making participants feel that the work structure was based on the antithesis of hierarchical organization, which made the environment more conducive to creativity and innovation.

This perception of freedom regarding the bureaucratic structure that deals with everyday life is corroborated by successful cases of research and innovation centres. One of the best examples is the research centres created in Silicon Valley. According to "TheInnovators", by Walter Isaacson, the research laboratories of important companies, such as Xerox and Bell Systems, were located far away from the headquarters in order for them "*not to be contaminated by the bureaucratic mindset of the corporation or the day-to-day demandsof its business*".

Co-creation: The monthly workshops held during the development of the projects wereessential to enable the practice of co-creation, which provides the involvement of end users inthe development process. The biggest challenge is to discover how this can be done satisfactorily, to the point that the interaction between professionals from different backgrounds, contexts and experiences can flow, produce ideas, and imagine alternative solutions.

The informal structure of the workshops was of great help in achieving success in theventures. The initial time dedicated to free interaction between people was essential, as well asthe constant stimulation, and even coercion, for presentations by all the professionals involved.

The result was highly satisfactory, as the main product of the projects came to be seen in the company as not only innovative, but with great value for the training process of critical activities. Some professionals reported that, at first, they did not believe that the R&D venturecould deliver the envisioned product and that they were convinced that it is possible to use cutting-edge technology and develop an innovative solution with great potential to generate benefits.

Social capital: Since the partnership between the institutions participating in theventure is long-standing, the conditions for achieving success are apparently propitious. However, when effectively carrying out a joint initiative, it becomes clear that this social capital has been losing strength over the years. The loss of these values may be a consequenceof the renewal of professional staff. The new staff members do not know the history of partnerships and tend to fail to value it. However, it is observed that the role of the top management of institutions is extremely important with regard to the preservation of values. Apparently, from a certain point on, management practices stopped privileging partnership andknowledge sharing. The paths began to diverge, culminating in the adoption of an isolationist stance. The problems caused by this range from operational aspects of project management tothose of a more subjective nature, such as attitude and behaviour.

Differences in attitude and mindset: In a context where the interaction between academia and business is historically lacking, institutional differences are the most prominent,followed by those related to attitude and mentality, as barriers become cultural. This type of difference becomes more pronounced as the hierarchical level increases.

In the context of regulated and compulsory incentive programs, the parties are obligedto interact. Despite the attractiveness of partnership activities, which contribute to the reputation of both sides, R&D ventures do not receive proper support, let alone attention. The positive side of this is that the undertakings are given great autonomy to establish their own working method, as long as the integration between all the participants is created and preservedthroughout the life of the project, and even beyond, as the innovation chain continues until thenew product developed is inserted in the market.

The most important requirements that must be addressed rigorously, with awareness and responsibility, by the team are:

- The company's requirements regarding the expected products; and
- The intrinsic requirements of the regulated incentive program.

On the other hand, the attractions found by the research team, especially in this case ofthe ANEEL R&D Programme, translate into the possibility of complementary remuneration, as observed in the work by Muscio, Quaglione and Ramaciotti (2016), mentioned before, whichstates that monetary incentives provide significant benefits to spin-off venture creation activities. Another attraction worth mentioning is the possibility of publications that report practical results, helping researchers to improve their reputation in terms of scientific production.

Differences in mindset can also be addressed by introducing team integration concepts,methods, and practices.

Experience shows that the most powerful impulse in an innovative project aiming to obtain a practical and ready-to-use product is the motivation of the project group, which must:

- Find their own way to produce the best possible results in terms of developmentand work structure;
- Bear in mind that they have the challenge of convincing the unbelieving mindsthat reside in the people who lead companies and institutions, even with regardto creative chaos, experimentation and unstructured working methods, which are essential for innovation.

An interesting aspect noticed during the development of the R&D venture was the favourable attitude of the researchers towards the result, that is, the opportunity to see their scientific work being transformed into a product that could be used to bring greater safety to professionals.

Conclusions

In relation to the country's innovation system, some deficiencies were identified, such as: a) Connections and articulations are still incipient; b) the corporate culture does not privilege sustainability; c) there is a lack of understanding, on the part of executives, about the nature of innovative activities; d) the academic system privileges publications and citations, but not innovations.

Incentive programmes are very important for the success of initiatives, as they providethe financial means to invest and the rigour to evaluate the results, which tends to ensure that projects strive to obtain the best results and the desired goals.

The organizational structure in companies is heavily based on hierarchy, which, in many ways, does not fit well in an environment focused on creativity and innovation. However, part of the organizational differences between institutions can be resolved at the project level,that is, in a bottom-up approach, as long as certain auxiliary mechanisms are applied, such as workshops held outside the company's headquarters, as well as leadership by capable professionals and researchers who are aware of the intrinsic difficulties in the interaction between such different contexts. The attitude of the top management of both academia and industry must be such that the group is granted full autonomy, enabling it to pursue its objectives. An additional role for senior management is to ensure that activities run smoothly.This can be achieved through periodic reports on the evolution of activities.

Regarding social capital, despite the historical collaboration that exists in this case study, experiences have shown that there is a great deal of opportunity for improvement. It is necessary that the partners make every effort to provide flexibility in the search not only for possible legal ways to implement the arrangement to commercially exploit the new product, but also for those that maximize the benefits for all actors. The reality in this context is that allinstances seek their own benefit as institutions. A new attitude is needed in this regard, otherwise innovation will be constantly relegated to a secondary position.

Cognitive differences can be resolved by creating a framework conducive to innovation, especially based on creative chaos and interaction. One of the essential ingredients for this is the freedom for the project's leaders, together with the entire team, to have full autonomy to define their way of working.

The main challenge of an R&D and innovation initiative, in relation to differences in mentality, is to balance the relationship between academic motivation and corporate responsibility.

There is also an evident lack of investment culture in the knowledge-based competitive differential. It can be seen from experience, but without a formal analysis, that companies in the electricity sector undertake R&D projects mainly because it is compulsory. It is noticeablethat the attitude of most companies is that it is better to invest the money destined for R&D toavoid possible fines than to obtain a possible competitive advantage or an innovative product.There is practically no willingness to create a “venture capital” portfolio. In fact, the R&D programme is still a kind of venture capital, but compulsory and subject to penalties if the venture is poorly managed.

The history of the link between the three institutions clearly shows that the most important thing in the construction of collaboration is the flexibility in the work structure, as well as the autonomy for researchers and professionals to create solutions. The role of top management is first to understand the attitude of entrepreneurs, and then to support research groups, providing what is needed and dealing with bureaucracy with agility.

Individual mindsets can change. The endeavour reported here shows this clearly. Fromthe moment that the practical results began to be evidenced, an interview was carried out with a professional from the company, directly involved with the subject, that is, training in the maintenance of energy transmission networks. In his account, he openly confessed that he wasagainst the project at first, but humbly changed his mind. He realized that the team was lookingto the future, exploring new technology for the application of an important activity in the company and that, once successful, the result would be valuable.

Having taken a long time to be developed, the project reported here opened a door for the participants, showing that research can be carried out and developed up to the moment when the benefits for society are consolidated.

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Transaction costs of university-industry interaction in Brazil: a study from collaborative projects financed by public funding

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Abstract: In this work we investigate to which extent behavioral assumptions and the dimensions of the Transaction Cost Theory (TCT) were present in the University and Industry (IU) in a sample of 28 contracts projects funded by Brazilian Funding Authority for Studies and Projects (FINEP) selected between the years of the 2000-2010. From qualitative analysis, we found that the conceptual dimensions and behavioral assumptions by the TCT are pertinent to the analysis of management collaboration. Furthermore, it was possible to identify that ex-ante transaction costs have been attenuated in the interactions studied due to the reputation of the partners and the recurrence of established interactions. On the other hand, the occurrence of the ex-post transaction costs were mainly associated with unpredictability related to environmental, technological and behavioral uncertainties, which impacted interactions, requiring the realignment of activities, and, therefore, renegotiation. Understanding how some characteristics of the IU may be related to the increase or mitigation of ex-ante and ex-post transaction costs can help define more efficient conditions for collaboration and subsidize public funding policies. Finally, this work is distinguished due to use an unexploited approach to understand IU and an unusual sample to empirical analysis.

Keywords: Contracts; Funding; Transaction Costs; University-Industry interaction; Brazil

Introduction

The university-industry (IU) collaboration has been stimulated by governments around the world. However, the distinct institutional nature of university and firms, associated to the complexity that involves the process of creation as well as knowledge transference, creates management challenges for the partnerships (Borges et. al., 2022; Kleiner-Schaefer & Schaefer, 2022). Although some attempts have been made with the objective of developing comprehensive theoretical frameworks to explain the conditions that allow such activities to take place in partnership between university-industry (Perkmann, et al., 2013), there is little focus on the economic incentives and management that support different forms of governance for these relationships.

For Doin and Fernandes (2016), the collaborative governance approach presents itself as an important complementary analysis lens to the Triple Helix, especially for the long-term interactions. It happens because, besides the research risks, this partnership can involve misalignment resulting from institutional, cultural and goal differences (Bruneel, D'este & Salter, 2010; Corsi, Feranita & Massis, 2021), which suggests that negotiating and drafting the contract and management of partnership are not trivial processes.

According to TCT, introduced by Coase (1937) and expanded by Williamson (1985), the costs associated with the negotiating, drafting, monitoring and enforcing a contract can be included in the transaction cost (TC). For Williamson (1985), these costs vary in function of the dimensions to which transaction are subordinated: asset specificity, uncertainty, and transaction frequency. Likewise, the transactions are affected by behavior aspects of agents: opportunism and bounded rationality. As a result, TC framework has been explored to investigate efficient governance structures.

Literature survey revealed that studies associating these themes have been more concentrated in interorganizational relationships. Corsi et al (2021), for example, investigated how government support can reduce TC at different stages of life cycle in the international SMEs R&D partnership. Andersen, Laedre & Aaarseth (2020) conclude that the quality of communication, project uncertainty, owner's organizational efficiency, change in orders, and trust were the greatest influence factors TC on project collaboration. By developing a theory to explain the dimensions of trust in interorganizational relationships, Connelly, Crook, Combs, Ketchen Jr & Aguinis (2018) address management of TC.

In the IU context, the transactional costs (being named by coordination, monitoring and agency costs) have been presented as barriers of interaction (Bercovitz & Tyler, 2014, Morandi, 2013; Bodas Freitas; Geuna & Rossi, 2013; Nsanzumuhire & Groot, 2020; Rybnicek & Königsgruber, 2018). In this way, some scholars have also explored the role of intermediaries or have suggested their importance in support of these collaborations (Borges et. al., 2022; Cirella & Murphy, 2022).

However, there seems to be a gap in the literature regarding identification of the increase or mitigation factors of TCT in IU. Even before that, how is it possible to analyze IU under the lens of TCT? In other words, which aspects of IU make it possible to analyze it by TCT? The purpose of this paper is to answer these questions: firstly, analyzing the relevance of the set of concepts related to of human and environment factors which are referred to in TCT are present in the IU interaction; secondly, testing the framework resulting from the analysis in a sample of 28 IU contracts supported by FINEP, approved in the period from 2000 to 2010.

This study makes a contribution to the research collaboration literature by extending the IU analysis under an unexplored approach. In addition, an empirical work can be considered innovator because it explores contract documents which make it possible to evidence dynamics of the IU relationship. Besides, the analysis of institutional partnerships of development projects from a single source of information, which covers the entire national territory and overcomes some barriers faced by studies about the IU, with regard to accessing data, pointed out by Perkmann et al. (2013).

The TCT approach contributes to the advancement of knowledge regarding the conditions that determine the increase and attenuation of its transaction costs and to what extent they influence its results. Thus, this research helps in the definition of contractual conditions that are more efficient, that can be used by development agencies, when they finance projects, and, even directly, by IU collaboration. In recent IU literature review, Nsanzumihire and Groot (2020) present that the number of studies from developed countries outweighs those from developing countries.

In addition to this introduction, this work has a section that addresses the behavioral assumptions and the dimensions of TCT and how it can happen in university-industry interaction. In section 3, the methodological procedures of the research are described. Subsequently, the results and discussion found are presented. Finally, section 5 brings together the conclusions.

Conceptual assumption of TCT in the context of IU

Considering collaborative research as an alternative transaction to the development of research carried out internally by the firm, IU incurs in ex-ante transaction costs. Such costs, described by Williamson (1985), involve collecting, gathering and processing information to select the appropriate partner, negotiating and elaborating the research contractual terms.

About these steps, Antonelli (2008) explains that any error in the identification of partners and/or implementation of an appropriate structure of incentives will have negative consequences for the results of the research and increase its costs. Kleiner-Schaefer and Schaefer (2022) pointed out the lack of information and difficulty in finding potential partners for IU as possible barriers and costs to the collaboration. These aspects can be solved when the potential partner is easily identified by its reputation, built from, for example, experience, quality of university research (Bellucci & Pennacchio, 2016; Cirella & Murphy, 2022) and the size and performance of the firm (Dyer, 1997).

Given the divergence of interests, culture and procedures (Bruneel et al., 2010), negotiating and drafting the contract are not trivial. In several studies on IU, contractual legal mechanisms and managerial issues appear as obstacles to partnership (Ankrah & Al-Tabbaa, 2015; Nsanzumihire & Groot, 2020; Rybnieck & Konigsgruber, 2019), activities that would potentially require the assistance of intermediaries (Borges et. al., 2022; Cirella & Murphy, 2022). This is particularly true for IPR exploration issues (Bruneel et al., 2010).

Transactions performed under conditions of uncertainty/complexity, according to Williamson (1975, 1985) are exposed to bounded rationality, because it becomes expensive - if not impossible - to process all the information or evaluate all alternatives for the most efficient decision making. Thus, it is possible to assume that the uncertainty inherent to R&D activities, reduces the scope for planning and specifying tasks in advance and amplifies the need for mutual adjustment mechanisms (Bozeman, 2012; Morandi, 2013; Rossi, 2010), causing losses not only at the ex-ante, but also extending throughout its entire process.

For Antonelli (2008) and Wang, Li &Lu (2021), the high levels of uncertainty that characterize research are related to the role played by creativity and chance, also by the difficulty of establishing the hierarchy and sequence of activities, as well as the resources needed to achieve their results. According to Morandi (2013), the interaction that is dedicated to the development of activities more distant from the application suffers greater exposure to technological and environmental uncertainty. This may imply a high cost of coordination and monitoring (Bodas Freitas et al, 2013).

The IU contractual incompleteness is aggravated because, besides seeking to specify in the present a certain future performance, these contracts condition such performance to the occurrence of events defined in advance in the future, such as the stages of research activities. In some cases, there are negotiation clauses for these possible results, such as Intellectual Property Rights (IPRs). Thus, numerous challenges need to be overcome from many transactions performed by partners (Bercovitz & Feldman, 2007).

According to Williamson (1985), the divergence of interests and asymmetry of information exposes the relationship to the possibility of opportunistic behavior by partners. This behavioral assumption was identified in Hong and Su (2013), associated with the uncertain nature of R&D activities, since it makes it difficult to specify what is or is not feasible, to evaluate the effort required to execute them, and also the divergence of interests, which does not favor self-enforcement. In other words, it is difficult to predict how partners will deal with unforeseen situations. They can show bounded rationality, make satisfactory decisions, or exploit the terms of the contract to the disadvantage of another part (Wang et al., 2021).

Dyer et al. (2007), in turn, suggested that the challenges associated with sharing and protecting knowledge increase the possibility of opportunism and its negotiation can generate conflicts, presented by Bstieler, Hemmert & Barczac (2015) and Bruneel et al. (2010), under the exposure of IPRs transaction barriers. Also recognized by Bercovitz and Feldman (2007), this situation can be aggravated by cultural distance between the partners, which can lead to difficulty of communication and relationship between them, hindering the sharing of information for problem solving (Andersen et al., 2020; Bruneel et al., 2010).

Additionally, Morandi (2013) explains that cultural and organizational differences increase the need for negotiation, mediation, and development of a common interpretation of the research objectives and their relation to gains for both parties. If these objectives are not well defined, they can cause a distorted view on the work of the other party, which enables frequent changes of direction in R&D activities or their termination before the completion of the project. This can be a great loss because the realization of these projects involves the commitment of many resources, including economic values that would be sacrificed, given the specialized use for which they were intended Wang et al. (2021).

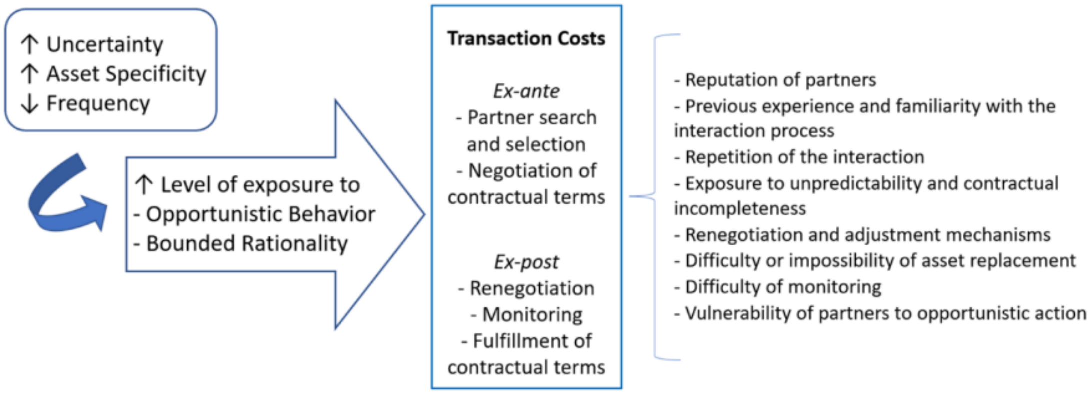
Thus, IU is a transaction characterized by asset specificity (Williamson, 1985), because it is impossible to assume that researchers have the same knowledge and experience for the execution of a certain activity, even if they work in the same area. Moreover, investments in human capital that are specific to the transaction evolve during its execution, and the specialized training and learning economy are not transferable to alternative transactions at low cost.

Different from the way other dimensions proposed by Williamson (1985) act on bounded rationality and opportunism, a higher frequency of transactions can minimize the vulnerability of the parties to these behavioral assumptions and, consequently, their exposure to transaction costs. Firstly, the knowledge gained in the previous experiences can help providing methods to operationalize the contract and make it possible to deal more quickly with unforeseen events. Secondly, the expectation that the partner will act according to its reputation can inspire cooperative attitude of the parties, decreasing safeguards (Wang, Li &Lu, 2021). That is to say these qualities signal ability and trustworthiness to potential partners (D'este et al., 2013; Hemmert, Bstieler & Okamuro, 2014).

In IU context, universities that have experience in projects and more consolidated and well-regarded programs gain recognition, reputation and legitimacy (Bruneel et al., 2010). Besides facilitating the searching and finding process of the potential partners, these qualities signal ability and promote trustworthiness among them (D'este, et al., 2013; Hemmert et al., 2014). Once the interaction grounded in trust through competence has been created (Connelly et al., 2018), partners have the opportunity to go through experiences that promote alignment of values and motives. In other words, the partners joint collaboration promotes face-to-face communication, allowing them to develop new operational routines to align their distinct ways of working (Bruneel et al., 2010). In this perspective, quality of academic research and some forms of proximity would have major impacts on collaboration (Cirella & Murphy, 2022).

Under these conditions, partners tend to make a greater effort to carry out the project activities (Hemmert et al., 2014; Santoro & Saparito, 2006), reducing the need for monitoring through the use of safeguards based on trust and self-enforcement (Dyer, 1997). Thus, the interactions with partners with whom one has already interacted previously reduces the need for complex contractual arrangements because the trust between the parties reduces the concerns about the potential exploitation of the partner's vulnerability. This condition, besides reducing the need for monitoring, also allows, in the presence of changes due to the occurrence of unpredictability, a reduction in the costs associated with renegotiation of commitments, change of roles and responsibilities, and penalties or even termination costs. These aspects reinforce the specificity of IU’s relations as a transaction subject to the conceptual dimensions and behavioral assumptions of TCT, as summarized in Figure 1.

Figure 1 - Conceptual dimensions and behavioral assumptions of TCT in the context of IU



Source: Constructed by the authors

Importantly, the framework presented finds similarity with the factors studied by Andersen et al. (2020), Corsi et al. (2021), Connely et al. (2018) and Wang et al. (2021) for analyzing CT in collaborative projects in the context of interorganizational relationships.

Methodological Procedures

The documentary research was developed from the contractual documents related to projects of scientific and technological development, carried out by Brazilian universities in cooperation with industries approved in the period from 2000 to 2010, selected by invitation letter and calls for proposals for funding by FINEP with resources linked to the National Fund for Scientific and Technological Development (FNDCT). Despite its limitations, the time frame is particularly appropriate and justified because, given the characteristics of the IU research studied, it would be difficult to access data from recently completed projects due to confidentiality reasons.

The use of this data source is a pertinent strategy for deepening IU because it overcomes some of the barriers of studying joint development projects. According to Perkmann et al. (2013), this type of relationship is empirically more difficult to detect because it is not documented by accessible records. For this study, it is important to distinguish between interactions that have a greater or lesser degree of social relationships, as proposed by Perkmann and Walsh (2007), since, in engagement-oriented interactions, relational aspects seem to be more important than those purely aimed at marketing. Even because coordination costs depend on the complexity and interdependence of activities.

The information on the studied IU projects was obtained through the Citizen Information Service, a prerogative of LAI (Law No. 12.527 of 2011). The first set of requested data returned 4,399 projects for the period and covered national territory. From these, 389 fulfilled the research objectives. Given the unfeasibility of analyzing this amount of documents of this quantity, FINEP was requested to access the contractual documents for on-site verification of a non-probabilistic sample of 33 projects.

The first projects analyses was carried out at FINEP and aimed at recognizing the documents contained in each IUE, the order and arrangement in which they were found, the identification of their contents and, finally, the indication of those which would be effectively consulted.

After the pre-analysis phase (Gil, 2006), samples that were more adherent to the objectives of the work were selected. This step revealed that the folders of each project were generally composed of ex-ante (proposal, evaluation form, agreement that regulated participants' rights and duties) and ex-post documents (correspondence on the release and reallocation of resources, documentation on technical and financial accountability, requests for term additions, intellectual property agreement, technical and financial reports), as presented in figure 2.

Figure 2 – Contractual documents and their contribution to the study

	Contractual documents	Focus of Analysis	Variables
Ex ante	- Submitted Project - Funder's opinion - Covenant	Institutional data of the partners	- Reputation (characterization of the partners).
		Mention of the previous relationship and/or whether the project is a continuation of previous research conducted between the partners.	- Frequency (repetition of the interaction and experience).
		Mention of the firm's participation in the project activities	- Frequency (familiarity).
	- IPR Agreement (circumstantially ex ante, circumstantially ex post, when assigned/delivered)	Requirements and determinations related to IPR; Date of signature.	- Exposure to unpredictability and contractual incompleteness
		Existence and extent of confidentiality clauses, ownership and exploitation of the IPR; Date of signature.	- Extension of the right to be negotiated (conflicts and future realignments).
Ex post	- Requests for rescheduling and deadline additions - FINEP's Opinions - Reports	Existence and frequency; Content covered and company participation (joint opinion, signature), realignment of activities.	- Exposure to unpredictabilities; - Renegotiation and adjustment mechanisms; - Difficulty or impossibility of asset replacement; - Difficulty of monitoring; - Vulnerability of partners to opportunistic actions; - Frequency (familiarity).
		Existence and frequency; Compliance with covenant requirements, interest and/or additional effort from partners to accomplish activities, rework.	
		Implementation issues. Description about difficulties faced in the project, relationship established between the partners; non-compliance of activities and others.	

Source: Constructed by the authors

A more careful and comparative analysis of the elements contained in the documents revealed the need to exclude 5 projects from the sample: 2 of them for having objectives that were very different from the others, and 3 for the absence of some information or part of the documents. Thus, 28 projects comprised the analysis of the contractual documents and the application of the clustering technique to the project value variable made it possible to see that the sample elements are distributed among the groups in almost the same proportion as the distribution of the total amount of 389 UI projects, as presented in table 1.

Table 1 – Characterization of sample of the study

	Groups	Total number of projects: Qty	Total number of projects: Value average (R$)	Sample: Qty	Sample: %
Sample distribution	1	351	505.306,36	24	7%
	2	32	1.755.970,33	3	9%
	3	6	3.013.634,12	1	16%
	Total	389	646.877,61	28	7%
Regions of Brazil (universities)	Southeast	185		17	9%
	South	127		3	2%
	Northeast	62		8	13%
	Midwest	13		0	0%
	North	2		0	0%
	Total	389		28	7%
Year of selection project	2002	55		5	9%
	2003	26		5	19%
	2004	125		4	3%
	2005	46		1	2%
	2006	106		12	11%
	2007	6		0	0%
	2008	11		0	0%
	2009	4		1	25%
	2010	10		0	0%
	Total	389		28	7%

Source: Constructed by the authors

Based in the structure presented in the figure 1, the exploration phase of content analysis was performed, which, according to Gil (2006) and Gomes (2012), includes clipping tasks, in which the choice of units was made from the highlights of excerpts, phrases, and fragments and their identification with the theme of interest. After this categorization, the most representative units were listed, interpretations and inferences were made about the evidence of the conceptual dimensions and behavioral assumptions of the TCT. From this information and considering the structure presented in the figure 2, it was possible identify the situations that favored the occurrence of renegotiation, monitoring problems, and difficulty of enforcement in project activities and under what circumstances these conditions were minimized.

Results and discussion

Two thirds of the projects analyzed had as coordinators professors linked to consolidated programs and renowned universities. In addition to the ability to perform the research by accumulated knowledge, these institutions have a reputation that facilitates the identification by the potential partner (Bodas Freitas et al., 2013), which contributes to a reduction in the time and costs expended for their research and selection and, therefore, of theex-ante transaction costs (Wang et al., 2021).

Another corroborating factor is the fact that the participating firms are mostly large, with outstanding performance in their segment. This both facilitates their identification by theuniversity and provides them with greater capacity to mobilize resources for accessing information, which contributes to a more effective measurement in decision making and raises the possibility of a more successful selection (Dyer, 1997). These aspects, according to Antonelli (2008), reduce the risk of unsuccessful partnerships and the occurrence of future costs. In addition, they contribute to a trust relationship based on competence (Connelly et al.,2018; Hemmert et al., 2014).

From this perspective, it was possible to verify that, in 24 projects, the partnership between the institutions had already occurred previously and, of these, 6 had the objective of continuing research. The option for maintaining established relationships tends to reduce the ex-ante transaction cost for the following reasons:

1. These interactions had the costs associated with the search and selection of the partner absorbed by the previous transaction (Williamson, 1985).

2. The previous experience helps the negotiation and drawing the contractual terms bythe acquired knowledge of the modus operandi, related to both the process and the partner (Bruneel et al., 2010; Cirella & Murphy, 2022).

3. This condition can also minimize ex-post costs, since the learning built in the previous interaction can facilitate the renegotiation and decrease the need for monitoring due the learning acquired about modus operandi and partner behavior (Wang et al., 2021), mainly if the partners have built a trust relationship based on integrity (Connely et al., 2018). Finally,partners' choice to maintain the relationship suggests that the previous partnership was successful in both partners evaluation.

The main document that regulates the interaction is the agreement signed between the funder, foundation, university and industry, since its clauses are subject to the regulations related to the granting of FNDCT resources by FINEP and there is little variation in the clauses from one agreement to the next. This indicates that the ex-ante costs related to the negotiation and decisions about the execution of the project occurred in a stage prior to the preparation of the contractual documents, which made it impossible to verify the pertinence of their application in these documents. On other side, the use of standard contract limits the scope of negotiation, uncertainty and information asymmetry in the early stages of theproject. Thus, this institutional mechanism can reduce the ex-ante TC (Corsi et al., 2021).

In the FINEP financing, the agreements foresee the elaboration of an IPRs term to regulate the secrecy, ownership, and division of possible results of the knowledge generated in the development of the project. Although it may help protect against opportunistic behavior regarding the appropriation of the results of the transaction, the mention of IPRs appears in only 2 proposals, out of the 28 projects analyzed. This reveals a tendency of the partners to postpone the negotiation of these terms because, possibly, they make the agreement process more difficult.

This proposition is reinforced by the fact that the non-delivery of the term at the beginning of the project's execution also occurred for those institutions that had the experience of complying with this clause in a previous project. What indicates that the lack ofknow-how for the elaboration of the term would not be the reason for the postponement ofthe assign. The fact that only one of the partner firms did not have a patent application also contributes to this assertion, suggesting that they had some familiarity with technological research and/or its transfer.

Thus, the postponement of delivery of the IPRs terms seems associated with the tendency of partners to avoid incurring in the possible conflicts involving the treatment and negotiation of this issue, identified by Bruneel et al. (2010) and Bstieter et al. (2014) as oneof the main barriers to the IU. In addition, the projects that made reference to IPRs were aimed at continuing the previous research conducted among the partners. In other words, greater knowledge about the possible developments of the research may have conferred more subsidies for the partners to define their division. Under these conditions, partners have more subsidies to establish an appropriate relationship between effort and incentive (Antonelli, 2008; Wang et al., 2021) and less risk of possible disagreements.

The costs related to contract renegotiation, which, according to Williamson (1985), constitute the ex-post costs, were also evidenced in the contracts analyzed from the uncertainty dimension and the behavioral assumption of bounded rationality, verified fromthe reallocations of resources, activities, goals and deadline additions requested to FINEP during the execution of the projects.

The unpredictability derived from the technological uncertainty (Morandi, 2013) was found, for example, in a project that, in its final technical report, presented a justification for not carrying out some activities because the research found a result different from thepredicted one. The occurrence of this type of unpredictability is associated with the very nature of R,D&I activities (Antonelli, 2008; Bozeman, 2012; Corsi et al., 2021), especially in the IU of joint research projects, which, according to Morandi (2013), is often characterized by more ambitious goals and, therefore, is more exposed to the influence of chance.

In a large number of requests for reassignments and term additions analyzed, we found also unpredictability caused by changes in the economic scenario, such as variation in exchange rate and equipment prices, related to environmental uncertainty (Morandi, 2013). These requests also impact the project since, for each adjustment, it is necessary an authorization by the firm, which implies sending the request with the firm's consent to FINEPfor evaluation. In some cases, the realignment of activities seems to have been easily resolvedby the trust and proximity between the partners or even by their experience (Bruneel et al., 2010; Cirella & Murphy, 2022; D'Este et al., 2013; Hemmert et al., 2014). In other cases, there was the presence of many documents and a long period to solve the same problem, revealing difficulties of adjustment between the partners.

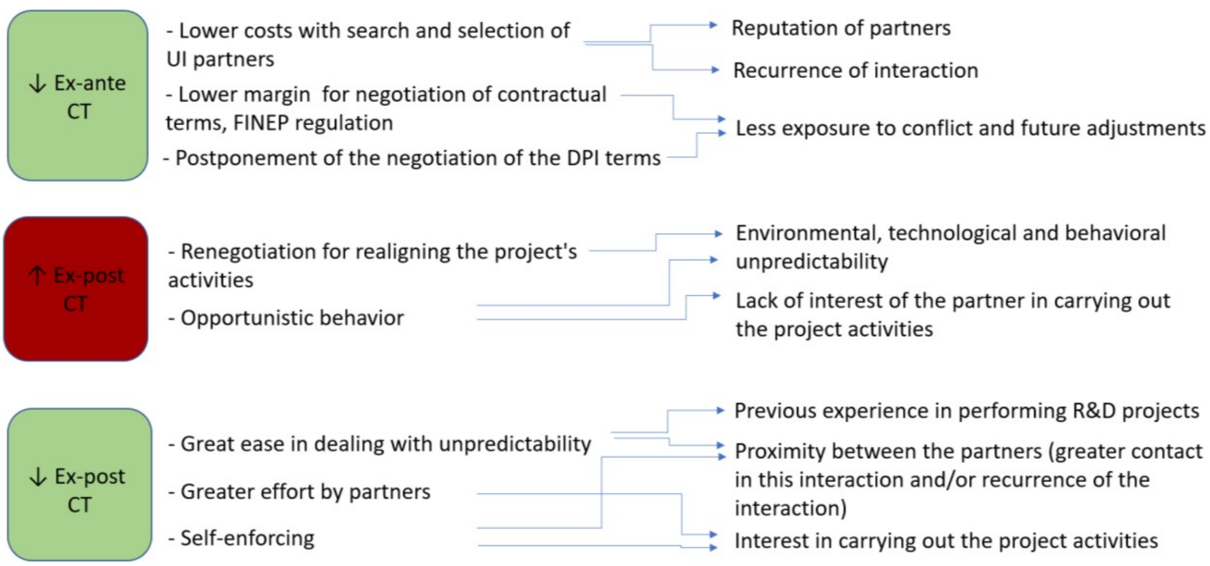
Delays in this type of project can be detrimental to its performance, especially when itforesees the use of scholarship holders to carry out the activities, since it is difficult to interrupt the scholarships during the period of suspension of project activities. Thus, when the research activities are regularized, the scholarship period will have already been used up, which implies the need to reschedule who will be responsible for performing the activities previously assigned to the scholarship holder. These aspects demonstrate that the collaboration established is subject to the asset specificity condition (Williamson, 1985; Wang et al., 2021), because the specific knowledge accumulated by the fellows that accompanied the project activities is lost in case of failure to renew the fellowships.

The need for consent of the firm in the correspondences, at first analysis, assumes a decrease in the possibility of occurrence of opportunistic behavior by the university since, being the project under its coordination, it could make decisions for its own benefit. However, based on the documents, it was possible to verify that this prerogative enables the occurrence of opportunistic behavior by the firm, which was also found by Hong and Su (2013). In a partial technical report, the coordinator registered that there was a delay in the research activities because the firm requested tests that were not foreseen in the schedule of activities as a condition for releasing resources of its financial counterpart and grant afavorable opinion in a partial report that would be delivered to FINEP.

On the other hand, it was possible to observe in other projects a greater effort of the partners to solve problems, such as the assumption by the firm of additional costs because of to changes in the price of equipment due to exchange rate changes, or even, the performance of research activities by the university in a period prior to the release of the financial contribution by the firm. These behaviors were associated with the level of interest in carrying out the research activities and building reputation with the partner. This is closely related to the common objectives and trust value elements pointed out as fundamental for collaborative practices by Andersen et al. (2020) and Cirella & Murphy (2022).

Besides benefiting the transaction by the additional effort to carry out its activities, these aspects provide a friendlier relationship by reducing the expectation of opportunism (Wang et al., 2021). When the partner perceives that the other party is not only fulfilling its commitments, but also putting more effort into the transaction willingly (Connelly et al., 2018; Santoro & Saparito, 2006), it encourages transparency, which enables the development of reliable commitment between the parties. This context mitigates monitoring costs due to self-enforcing (Dyer, 1997) and the security of greater predictability of the other party's behavior (Hemmert et al., 2014) acquired from the exchanges experienced by the partners. In this way, figure 3 shows how the TCT is present in the IU and also how some of their characteristics can be related with the increase or decrease of transaction costs ex-ante and ex-post.

Figure 3- Transaction Costs in UI projects funded by FINEP 2000-2010



Source: Constructed by the authors

Conclusions

From the content analysis of the IU contracts, it was found occurrence of transaction costs influenced by conceptual dimensions and behavioral assumptions. Thus, the TCT proved to be applicable to the analysis of these interactions according to the factors presented in the proposed framework. Based on the empirical study, it was possible to verify that the ex-ante costs have been attenuated in the interactions studied due to the reputation of the partners, standardized clauses established by FINEP and the recurrence of established interactions, and they were possibly increased by the negotiation of terms on IPR.

With regard to the ex-post transaction cost, its occurrence was mainly associated with unpredictability related to environmental, technological and behavioral uncertainties, which impacted interactions, requiring the realignment of activities, and negotiation. From this perspective, the actors' experience (previous relationship), greater physical contact established (firm participation in project activities) and linkage between partners (higher levelof interaction developed) acted as mitigating factors. In the absence (or presence in low intensity) of these factors, there was a higher frequency of occurrence of problems in the execution of the contract and the need to undertake more time and dedication for the realignment and execution of activities, especially in projects with a higher level of monitoring by the FINEP.

This study can be considered innovator by theorical approach and data source used. Besides contributing to studies on managerial aspects of IU and to cover this gap by the literature from developing countries context, this work is carried out in an unexplored approach. Moreover, we used consolidated data from institutional partnerships covering the national territory, which makes it possible to evidence dynamics of the IU relationship. In a more practical way, our findings can help define contractual conditions that are more efficient, that can be used by development agencies when they finance projects, or even directly by industries and universities that are collaborating with each other. In the first case, this is especially important because it can be a guide to a subsidized public policy.

The fact that the study is based on consolidated data, despite being an advantage, limited the scope of the analysis of the proposition to use the TCT to the IU not only in the context of interactions financed by FINEP, but, above all, in situations evidenced from the data available in the contractual documents analyzed. In addition, many terms may have beeninfluenced by the conditions of the public notice, leaving little room for effective negotiation between the partners.

In this sense, further studies should be carried out to deepen the understanding of how the TCT approach expands the scope of exploration of the managerial aspects of IU. Especially, studies on contractual relationships that are not mediated by funding institutions and that explore different characteristics for the interactions established between partners and asset specificity levels.

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SECTORAL INNOVATION III

May 3rd: 10h30 am – 12h30 pm

Chair

Fábio Gama (Halmstad University, Sweden and University of the State of Santa Catarina, Brazil)

Papers

Lost in Red Tape: Conforming Medical Device Developments into Adaptive Regulations
Fábio Gama, Stefano Magistretti

Learning and innovation in brazilian water and sanitation company: The case of SANEPAR
Cristina Ferigotti, Gustavo Rafael Possetti, Christian Luiz da Silva

The role of technological readiness (TRL) and commercial readiness (CRL) methodologies for innovation management: a case study of an Oil & Gas R&D center in Brazil
Oscar Chamberlain, Flavia Alves, Fabio Oroski

Structural Ambidexterity and Coopetition Capability for Industry Incubation： Mission-led Grand Challenges in Japan's Hydrogen Station Industry
Tomonari Komiyama

Sustainable fuel distribution: A strategic foresight analysis for corporate R&D planning in the brazilian natural gas sector
Kamila de Sá Oliveira, Leonardo Vieira Teixeira, Victoria Emilia Neves Santos

Lost in red tape: Conforming medical device developments into adaptive regulations

Abstract ID#161

Fábio Gama (Halmstad University, University of the State of Santa Catarina); Stefano Magistretti (Polytechnic University of Milan)

Purpose

Innovations that employ novel technologies can be problematic, particularly when sources of uncertainty can lead to severe financial, social, and reputational losses. Nowhere is this more evident than innovations across Medical Device (MD) developments. In healthcare, described by stricter safety requirements, adapting the MD process to ongoing regulatory principles intended to balance benefits and risks is often elusive. The stricter standards generate excessive uncertainties that often lead to delays or inactions, typically called "red tape" circumstances. Healthcare firms frequently use traditional MD processes to create or advance emerging technologies. However, this process is often reactive, seeing the uncertainty stemming (e.g., data privacy) from the regulatory environment as a static information source. Leading governmental agencies such as US Food and Drug Administration understood the challenge. They started to test pre-certification programs to streamline software medical device accreditations, including continuous certification of the firm's processes. Yet the influence of pre-certification programs on MD processes is unclear, creating a murky landscape to innovate. Understanding the influence of the regulatory environment on the MD process is crucial, creating a dilemma as to how a firm with a traditional process can successfully adapt its developments in an adaptive regulations environment.

We investigate a single case study comprising four medical devices technology developments implemented in products and services. This study explores how a healthcare firm change its medical device development process to adaptive regulations?

Literature Review

We base our work on three pieces of literature. First, the literature on Technology Development (Cooper, 2006) depicts what characterizes such process and their requisites necessary to manage the development of MDs (Soenksen & Yazdi, 2017). The literature on organizational changes contributes with insights into which phases and activities to expect in innovation (Armenakis & Bedeian, 1999). The regulatory perspective complements the organizational change literature (Roca et al., 2017) regarding elements to be considered and the influence of new standards on the MD process.

Methodological Procedures

Since our goal is to understand the adaptations of the MD processes to accommodate the demands originated by the regulatory environment, we looked at a Swedish global healthcare company, where the phenomenon is salient. In doing so, we relied on the Eisenhardt´s method to collect the best data possible to inform a complex phenomenon as MD processes adaptation in the case of adaptative regulations (Eisenhardt, 2021).

Our case company employs over 46.000 people worldwide and is a global player in healthcare innovations. The company has successfully integrated emerging technologies (e.g., ultrasound sensors) into its products and services worldwide. See illustrative cases in Table 1.All cases were challenging, given the need to constantly monitor regulatory aspects related to patients' privacy and consent, awareness of algorithm bias, and cybersecurity breaches.

Table 1 – Illustrative examples of the use of emerging technologies

Illustrative case	Case description	Technology Readiness Level
Case 1: Geriatric diapers with wearable ultrasound technologies	A reusable digital sensor that notifies when an incontinence product needs to be changed	Actual system proven functional
Case 2: Digital wounds assessment and product recommendation	The solution records through pictures wound characteristics and suggestions of preferred products	Actual system proven functional
Case 3: Real-time professional cleaning	Cleaning staff have access to real-time data about cleaning needs	Actual system proven functional
Case 4: Virtual reality training	Virtual reality training solutions to educate healthcare professionals	Functionality is being optimized

This firm has been selected based on three attributes. First, the firm has invested significantly in integrating novel technologies into its solutions. Second, we secured interest and commitment, giving us access to appropriate respondents. So far, we have observed three exploratory workshops. We conducted 15 exploratory and plan about five in-depth interviews with developers of the technology and healthcare counterparts at healthcare firms that invest heavily in integrating emerging technologies into their solutions.

Findings

We draw on the change management theory (Armenakis and Bedeian, 1999), formalized in the context of emergent technologies as consisting of three generic phases unfreezing, moving, and institutionalizing in reporting our findings.

Table 2 – The adaptations on the TD process to adaptive regulations

	Project Scoping	Technical Assessment	Detailed Investigation
Unfreezing	- Revisit the search frame - Engage regulatory experts from medical technology institutes prior scoping	- Collaborate with start-ups for lab and technical feasibility that enable a new touch with the market	- Identify frequency/demands for different markets
Moving	- Periodically visit safety standards and compliances locally and globally - Reflect on the use of the new technology will require change or reinterpretation of regulatory framework	- Empower R&D members to establish a connection with regulators - Start preliminary tests on sandbox environments	- Reflecting on reasonable assurance of product safety and effectiveness
Institutionalizing	- Formalize scoping activities with regulatory KPIs	- Employees rotating roles - Agreement with research institutes for certification	- Deploy feasibility plan in line with latest regulatory guideline

Notes: Adaptation phases by Armenakis & Bedeian, 1999.

Research implications

Our study offer three contributions. First, we contribute to the innovation literature by proposing a flexible MD process in which safety standards are continuously revised, and development stages are regulated differently. For example, when the legal and regulatory aspects of the emerging technologies are unpredictable, unknown firms are encouraged to de-risk the early-stage potential problem in adopting the emerging technology. Second, we contribute to the literature on Technology

Development by showing how introducing digital technologies innovation requires a significant change in the culture and mindset of the organization. In the healthcare industry, where rules and procedures are hindering risky and uncertain investment, nurturing the culture of people towards risk-taking and learning from failure is a crucial dimension for digital transformation. Third, we propose a combined process that leverages traditional MD phases. The change management theory suggests a way to enact a digital transformation in a hyper-regulated environment.

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Learning and innovation in brazilian water and sanitation company: The case of SANEPAR
Abstract ID#260

Cristina Ferigotti (FESPPR, BR), Gustavo Rafael Possetti (SANEPAR, BR), Christian Luiz da Silva (UTFPR, BR)

Innovation in emerging economies has put bioenergy in the spotlight. The growing concern with environmental issues is associated with the knowledge base, technological capabilities and learning of industrial and services sectors. This can redefine local and imported knowledge, shared trough multiples form of collaboration, included strategies of public and private actors. Concomitantly, many investments have been made to implement and strengthen technological infrastructures, such as the promotion of international cooperation, which provide for the absorption of knowledge in emerging economies

Currently the technology trends for energy production reflect modularity, decentralization, and small scale for heat and electricity production, and often involve grid development and local use, which are an important part of the business opportunities. In this sense the biogas production from domestic sewage treatment and its energy recovery is a trend to promote the social-green innovation (Lopes et. al., 2020). In the following, this context distinguishes two research questions: i) How does the learning process affect the generation of technological capabilities in Sanepar, a Brazilian water and sanitation company? ii) How have these technological capabilities impact sustainable technological innovation? To better understanding, how learning implied in the technological capabilities and sustainable innovation, this study focuses on biogas domestic sewage treatment in Paraná State, Brazil.

Technological learning processes to accumulate capabilities for production to innovative activities involve deliberate efforts construct through internal e external learning mechanisms (Figueiredo et. al, 2021). In another perspective the Absorptive Capacity (AC) originally elaborated by Cohen and Levinthal (1990) acknowledge the interaction between external and internal learning, by emphasizing the relationship between firm-internal investments in research and development (R&D), and the ability to effectively utilize external sources of learning. Thus, the AC is divided into both potential and realized absorptive capacity, in differently dimensions: acquisition, assimilation, transformation, and exploitation of knowledge (Zahra & George, 2002). But, as argue by Figueiredo (2021), the literature has been calling for an empirical exploration of AC in non-intensive R&D contexts through metrics that capture the learning processes in an appropriate context, namely in emerging economies.

This study adopts a broad understanding of the concept of technological capabilities and learning processes follows Figueiredo et al., (2012) and Zahra and George (2002), innovation capabilities can be explained by knowledge base and absorptive capacity, i. e. ability to identify, acquire, assimilate, transform an exploit knowledge. Despite extensive literature on firm-level learning in emerging economies addressing the role off different factors and actors in internal and external knowledge transfer and innovation as the outcome of knowledge management (Zhao et al. 2021), there is limited knowledge on how different learning mechanisms can deepen the technological capacity of renewable energy firms, specifically biogas sector. The focus is on prominent but relatively little explored in studies (Hansen & Lema, 2019). To address this knowledge, this paper was oriented to understand the phenomenon builds on tradition qualitative case studies (Dantas & Bell, 2011; Mills et al., 2010). The definition of the research sample was by convenience whose strategy involves significant cases from a political point of view and considerable attention (Patton, 2003). The data collection procedures included exploratory research carried out with the organization's key manager with semi-structured interviews. Also, the study uses data survey techniques in documentary and bibliographic research, through secondary sources, such as laws, decrees, projects, programs and institutional sites. The notes raised in interviews and research data resulted in reports for further analysis according to Bardin (2011).

The empirical material collected allowed to observe key aspects of the learning trajectory and innovation capacity, such as the enabling environment for co-development of innovative products, processes, and services, cooperation agreements with renowned national and international organizations, specialized engineering teams engaged relationships with foreign technology suppliers. As a result, this study argues about the solutions of innovation and sustainability as a knowledge base problem, for the development of technological capacity. The biogas and its industrial structure are still in formation in Brazilian environmental sanitation sector and is considered promising as an alternative for reducing greenhouse gas emissions and promoting the renewable energy sector. The study has provided understanding on how internal and external sources of knowledge are used for the development of innovation capability, shedding light on particular insights on how to develop innovation activities. The paper also has some limitations, the focus on biogas, their idiosyncratic characteristic it is less suited to compare with other industries. Further research could therefore identify similarities between another renewable energies.

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The role of technological readiness (TRL) and commercial readiness (CRL) methodologies in innovation management: a case study of an oil&gas R&D center in Brazil

Abstract ID#327 | Full paper ID#395

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Abstract: This article discusses the application of Technology Readiness Level (TRL) and Commercial Readiness Level (CRL) methodologies in an Oil and Gas R&D Center in Brazil. The compulsory R&D spending by energy companies is an important policy for development in Brazil, but the funding has not always resulted in commercial innovation. To address this problem, the R&D Center implemented management tools that evaluate both TRL and CRL levels. The case study was conducted through a literature review and semi-structured interviews with researchers and managers in the field. The results of the study were organized into categories such as stakeholders, project appraisal methodologies, project typologies, learning processes, and cultural issues. The study found that the CRL methodology complements the TRL and contributes to the innovation process by identifying customer needs, communicating with stakeholders, and providing a clearer vision of future implementation. However, some challenges were identified, including the risk of excessive management and monitoring, difficulties in fitting all project types into the maturity scale, a strong focus on economic and financial performance, and restrictions in applying the methodology to emerging technologies. To overcome these challenges, the study recommends considering broader strategic challenges, defining development pathways, assessing different project typologies comprehensively, introducing environmental and social drivers for assessment, and establishing a different scale for emerging technologies. Overall, this case study demonstrates the importance of using both TRL and CRL methodologies in R&D centers to increase the chances of successful commercialization and bring innovative solutions to the market.

Keywords: R&D and New Product Development, Project Management, Technology Readiness Level (TRL), Commercial Readiness Level (CRL), Innovation Management

Introduction

To meet mandatory R&D spending (ANP, Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, nd) the investment of Oil & Gas companies in R&D projects in Brazil was in the order of 1.5 billion US dollars in the period 2018-2021, being one of the four sectors where local companies more invest in R&D (Grassano, N., Hernandez , H., Fako, P., Nindl, E., Georgakaki, A., Ince, E., Napolitano, L., Rentocchini, F. and Tübke, A., 2022). However, between scientific knowledge and the commercial implementation of an idea, there is a long journey, which demands entrepreneurship, innovation management, as well as human and financial resources. For this reason, public funding for R&D activities have not necessarily been translated into commercial innovation (Zuniga et al., 2016). R&D projects must overcome the "death valley" (Markham; Ward; Aiman-Smith, & Angus, 2010) to reach technological and commercial maturity that translates into industrial deployment or commercial application.

To mitigate this problem, different management tools have been applied, such as technology readiness level (TRL) and commercial readiness level (CRL), which assess technological and commercial readiness levels. Most of the technological risks are addressed in the TRL, but there are many commercial uncertainties and related risks in the demonstration and deployment phases (ARENA, 2014). Paun (2012) mentions that Technology Push and Market Pull approaches are not independent and the successful exploration and implementation of an idea takes place through a hybrid approach. Vik, Melas, Stræte, and Søraa (2021) consider that technology development and implementation should involve understanding the product potential, market access and financial capital, manufacturing possibilities, and benefits. They judge that even if projects have a high level of technology and market readiness, it does not mean that the new technology is ready and will be adopted and applied by customers. Joyce & Paquin (2016) proposed the triple-layer Business Model Canvas to consider the evaluation of environmental and social aspects complementing the economic assessment. The literature does not mention the creation of the CRL scale, but there is a reference to its application by ARPA-E (2014). The CRL methodology encompasses several aspects proposed to improve the TRL by Paun (2012) and Vik et al (2021).

Reviewing the literature and through semi-structured interviews with researchers and managers of an R&D Center of an Oil and Gas company, we analyzed the application of these methodologies by observing the benefits, challenges, and barriers; looked for insights to improve the efficiency of the innovation management process. Our purpose is to contribute to answering some questions such as: What does it take to drive an invention until it reaches its commercial implementation? What are the contributions of applying TRL and CRL conjointly for developing and implementing a new technology, considering the case studied?

To answer these questions, we grouped the contributions obtained from the interviews and bibliographic references into different themes: stakeholders, project valuation methodologies, project typologies, learning process, and cultural issues. The application of the CRL methodology contributes to the clear identification of customer needs, communication among stakeholders, a clearer vision of the implementation of future projects or technologies and complementing the TRL methodology in its weakness by considering the market and customer objectives.

Literature Review

TRL (Technology Readiness Level)

In 1970, NASA introduced the TRL Technology Readiness Level (Mankins, 2009). The definition of maturity levels was complemented with two more scales in 1995 (Mankins, 2009) and subsequently adopted by the U.S. GAO (United States Government Accountability Office) and the US Department of Defense (DoD), and the Department of Energy (DoE). The TRL levels are a globally accepted benchmarking tool to track the evolution and support the development of a specific technology from the early stages of the development chain, such as blue-sky research (TRL1) to the demonstration phase in a real-world environment (TRL9). Since its origin, the TRL has been applied to facilitate communication of the organizational and financial visions between technology development agents, companies and entrepreneurs, and development and financing agencies (Héder, 2017). The European Union has adapted and applied the TRL scale to its public innovation policy within the Framework Program Horizon 2020 (Cloudwatchhub, 2017). ARENA applies TRL in the Emerging Renewable Energy Program to help applicants identify the development stage of their innovations in the early stages of technology (ARENA, 2014).

The application of the technology readiness assessment methodology (TRA – Technology Readiness Assessment) together with the TRL offers clear benefits: assessment of the evolution of the development of a technology for decision making; comparison of technological routes; better communication within the organization; estimation of time-to-market; identification of potential partners and suppliers; support for technology acquisition processes; support for decision-making on internal or external development and risk reduction in development (Leite et al, 2015), (Lavoie & Daim, 2017). Table I describes the level of development and definition of the TRL levels organized in three phases and summarizes all nine TRL levels.

Although the TRL methodology is widely applied, it has limitations. Table II summarizes the survey of the limitations observed in the application of the TRL scales. To overcome these constraints, Hicks et al (2009) suggested a more comprehensive framework that takes into account the technology-product life cycle. Jimenez & Mavris (2014) proposed a TRL approach that integrates all technology components, their interfaces, and interactions with all system elements. Peters (2015) explored the concept of manufacturing maturity to circumvent the TRL focus on technologies rather than the product. Olechowski et al (2015) suggest improving the application of TRL by using a waterfall model, as a Stage-Gate approach. But all these approaches do not take into account customer positioning and market readiness.

Table I. Technology Readiness Levels

TRL 1	TRL 2-4	TRL 5-6	TRL 7	TRL 8	TRL 9

	Phase I	Phase II	Phase III
Phase	Knowledge	Test and Prototype	Proven Technology
Scale	Lab	Pilot (TRL 5) Demonstration (TRL 6) Semi-commercial (TRL 7)	Commercial
Environment	Lab	Simulation (TRL 5) Real (TRL 6-7)	Operational

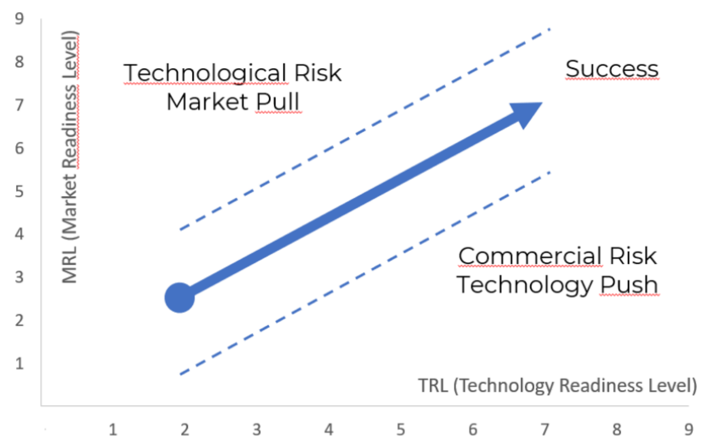
Table II. TRL limitations summary

Limitations	References
TRL focuses on technology leaving aside the vision of commercial deployment or market attraction.	Hjorth & Brem (2006) ARENA, (2014), Hasenauer; Gschöpf, & Weber, (2016)
Difficulties in addressing either a new technology or an incremental improvement of existing technology.	Hicks et al. (2009) Peters (2015)
The scope of the TRL assessment can be narrow, and the list of questions checklist is quite complex. The scale focused on a specific field.	EARTO (2014) Olechowski et al (2015) Buchner et al (2019) Leite et al (2015)
Technology development time does not match product timing. Lack of life cycle analysis	Hicks et al. (2009) Peters (2015) Earto (2014)
Lack of differentiation between technology and products. Evaluation of systems with multiple technologies involved.	Hicks et al. (2009) Jimenez & Mavris (2014) Olechowski et al (2015) EARTO (2014)

MRL (Market Readiness Level) and CRL (Commercial Readiness Level)

Paun (2012) mentions that the Technology Push and Market Pull approaches do not exist independently and that the successful exploration and implementation of an idea takes place through a hybrid approach. Although technology maturity levels are generally defined linearly in time, market maturity may not evolve in the same way (Petit, 2011; Hjorth et al, 2016). Hasenauer et al. (2016) studied startups cases in which they found that the integration of technology and market analysis leads to successful implementation outcomes. They analyze the market through the MRL (Marketing Readiness Level) with four maturity components: supply, demand, customer, and product. Figure 1 shows the relationship between market and technological maturity. Technological risk corresponds to a low TRL and high MRL; customers want a solution, or there are latent market opportunities, but the technology is not commercially available. Market risk exists when the technology is available (high TRL), but no customers are willing to apply the solution, or a new market is created (low MRL). Success is achieved when the technology development evolves to meet the demand or market window at the right time. (Hasenauer et al., 2016, Paun 2012).

Figure 1. MRL vs. TRL (Hasenauer et al., 2015, Paun 2011)



Petit (2011) argues that assessing product maturity requires a thorough understanding of the market. They consider that just as technology developers and licensors take technological risk into account, market risk must also be validated. For Vik et al (2021) MRL is a recent concept and the definitions and operationalization of maturity for the market are, therefore, less accepted and consolidated than the TRL. Vik et al. (2021) consider the development, adaptation, and implementation of a technology as a process with non-linear and uneven characteristics and, it is necessary to understand the potential of the product, its access to the market and financial capital, manufacturing possibilities, and profits. They consider that even if the technologies have a high TRL and MRL, it does not mean that the new technology is ready and will be accepted and applied by customers.

Vik et al. (2021) go beyond the integrated analysis of Market Pull and Technology Push analysis to propose a balanced maturity scale that considers five dimensions: TRL - technology maturity level, MRL - market availability level, RRL - regulatory maturity level, ARL - acceptance level and ORL - organizational maturity level. This approach increases the complexity of the methodology with five scales. Thus, the methodologies proposed by Paun (2012), Hasenauer et al. (2016) and Vik et al (2021) could be considered for a broader concept such as CRL Commercial Readiness Level.

The literature does not present references to the creation of the CRL methodology, but only about its application by DARPA (2020), ARPA-E (2014), and its partners and by the PETROBRAS

R&D Center (PETROBRAS, 2021). This methodology introduces concepts that overcome the limitations of the TRL, as noted in the previous section. The CRL combines the market, the customer, partners, suppliers, intellectual property, regulatory issues, and technology valuation considering costs and value generation (DARPA 2020, PETROBRAS 2021).

The CRL methodology was introduced at the R&D Center in 2019 with a checklist for each maturity level as detailed in Figure 2. Each level has specific deliveries, for example, at level CRL-1, Base Hypothesis, the problem, or opportunity is defined, with its assumptions, benefits, and opportunities. At this level, the knowledge of the proposal's applications, its use, and market constraints are incipient, or not yet known (DARPA, 2020).

Table III summarizes the evolution of the levels considering aspects such as potential customers, critical activities and resources, suppliers, partners, and the construction and execution of the implementation plan (PETROBRAS, 2021).

Figure 2. Description of Commercial Readiness Level

(Ref: https://sigitec.petrobras.com.br/SIGITEC/manuais/manual-competitividade.pdf)

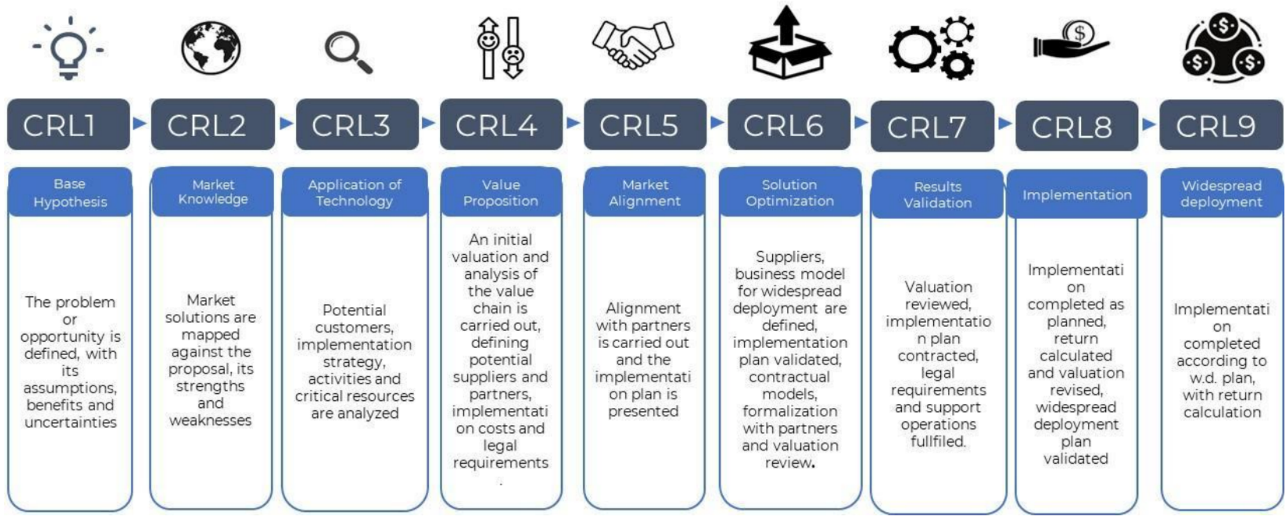


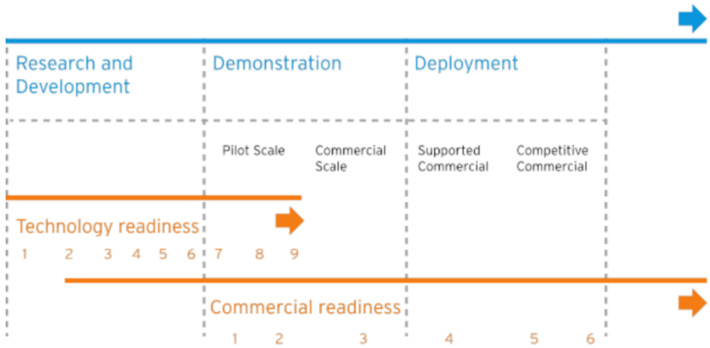
Table III. Commercial Readiness Level

	CRL 1 / CRL 2-4	CRL 5-6 / CRL 7	CRL 8 / CRL 9
	Phase I	Phase II	Phase III
Phase	Theoretical Feasibility	Commercial Feasibility	Deployment
Customers and Partners Plan	Value Proposition	Implementation Plan Defined	Widespread Plan completed
Valuation	Base Model	TEFS Cash flow study	Profit Verification

CRI (Commercial Readiness Index)

The Australian Renewable Energy Agency (ARENA, 2014) developed the CRI (Commercial Readiness Index) to assess the level of commercial maturity of renewable energy technologies. De Jager (2017) noted that the CRI could be used to influence policymakers by breaking down some barriers in the commercialization of renewable energy technologies. He further states that the CRI goes beyond the proof of function measured by TRLs toward an assessment of commercial maturity. Figure 3 shows the position of the TRL maturity level and the CRI in the technology development stages. The CRI responds to some of the constraints of CRL when the market or customer are not clearly defined, and legislation needs to be established.

Figure 3. TRL and CRI mapped on the Technology Development Chain, (ARENA, 2014)



BMC (Business Model Canvas) and TLBMC (Triple Layer BMC)

The business model proposed by Osterwalder and Pigneur (2010) provided an economic analysis based on nine interconnected components: value purpose, customer segment, customer relationship, channels, partnerships, key activities, critical resources, costs, and benefits. Joyce and Paquin (2016) developed a methodological approach called Triple Layered Business Model Canvas (TLBMC) to address the elements of a business model based on the three pillars of sustainability (economic, environmental, and social). This tool enables effective decision-making that includes all aspects of sustainable development, generating value and benefits for society and the environment. The BMC is an effective tool to complete the CRL levels information.

Methodological Procedures

This article was the result of bibliographical research and exploratory qualitative research, which used the single case study method with key actors of an Oil & Gas R&D Center of an important company in its sector in Brazil. This R&D organization focuses the efforts of its project portfolio to meet the demands and business strategic drivers of the internal customer.

Data were collected through semi-structured interviews with researchers responsible for the R&D projects and technology managers in three levels of the organization structure. We interviewed 37 participants in the period from September/2021 to February/2022. Interviews lasted between 60 and 120 minutes on average and were carried out face-to-face via online platforms.

The interviews were oriented through the following questions:

a) TRL/CRL Maturity Levels: What is the relevance of the TRL/CRL maturity levels in the innovation process? Does the level of TRL/CRL maturity influence the definition of internal or external resources?

b) Application of TRL/CRL: When do you use this scale? (e.g., opening, monitoring, closing, interaction with customers, suppliers, and partners) What is the main application of TRL/CRL (e.g., communication, decision-making, identification of critical points)? What is the importance of TRL/CRL in the customer relationship? Is the TRL/CRL checklist adequate?
c) Project Management: How many projects are you responsible for? Is the risk estimate for the project adequate? Which project management processes (e.g., Canvas, Stage-Gate, Lean Methods) are applied in addition to TRL and CRL?
d) Other Issues: What aspects of innovation management and TRL/CRL maturity levels should be strengthened or eliminated?

All interviews were recorded and transcribed, resulting in a corpus of 265,000 words. This corpus was subsequently analyzed using categorical analysis, which involves breaking down the text into codes and grouping them into categories, according to Bardin (2016). Coding involves selecting and combining portions of text to represent and describe its content (Bardin, 2016). In this research, topics such as record and context units were applied to study respondents' opinions and perceptions regarding the impact and benefits of the TRL and CRL methodology in the innovation management process. Categorization involves classifying coded data elements into categories and subcategories based on similarities and relevance, with the aim of regrouping them later according to defined criteria (Bardin, 2016). Thus, the inductive method was applied to identify sub-categories and categories from the corpus material and codes

The ATLAS.ti software was applied to perform the analyses.

Results and Discussion

The objective of this research is to evaluate how the R&D Center applied the TRL and CRL methodologies to drive an invention up to its commercial implementation, and thus accelerate its innovation process, assess the interviewees' input and finally, provide recommendations.

Based on the content analysis procedures described in the previous section, we organized the interviewees' perceptions of the TRL and CRL methodologies. Several cycles of codes identification and grouping into sub-categories and categories were carried out and the relevance and frequency of codes were evaluated. Table IV presents the consolidation of the categories and sub-categories.

Table IV. Categories and sub-categories obtained from stakeholders' interview

Category (% category comments/total comments)	Sub-category
Stakeholders (35 %)	Customer communication
	Handover responsibilities
	Roles in the project management
Project Follow up (35 %)	Excess of projects in the portfolio
	Follow up approach
	Simplification
Projects Typology (18 %)	Methodology Suitability
	Emergent technology projects
	Knowledge creation projects
Valuation and other methods (11 %)	Project valuation
	Agile methods, Business Model Canvas, and Stage-Gate
	Risk valuation

Stakeholders

The stakeholder category groups' comments were made by 37% of Level-1 managers, 28% of Level-2 managers, and 34% of Project Coordinators regarding the general opinions of their specific group. Table V shows the interviewees' perceptions for this category.

Respondents defined communication with the customer as one of the benefits brought by the introduction of the CRL. Lavoie & Daim (2017) and Leite et al (2015) mentioned the better communication with the organization as a contribution of TRL, however, Hjorth & Brem (2006) and Hasenauer; Gschöpf, & Weber, (2016) registered the lack of the vision as for commercial deployment or market attraction in the TRL approach. The combination of TRL and CRL consider customer identification and profile, requirements mentioned by the interviewees to increase the probability of project success.

The sub-category of handover responsibilities raises questions about the roles of R&D representatives and internal customers in the different phases of technology development and implementation. The innovation cycle will hardly be completed without customer project buy-in and conditions for commercial exploration. Hasenauer et al. (2016) and Paun (2012) mentioned that technology development has to match the demand or market window at the right time to complete the technology implementation.

Although the TRL and CRL do not mention requirements for the roles in project management, this is a critical point raised by the interviewees that may hinder project evolution. R&D team roles require not just specialist members but also a contribution for the project management role.

Table V. Stakeholder Category

Sub-categories	Interviewees' perceptions
Customer communication	The CRL methodology contributes to improving the communication of value creation to customers, helping to prioritize the portfolio, increasing the probability of project success, and finally engaging and motivating them.
	Communication and interaction must be customized according to the customer profile, more strategic or detail-oriented, more innovative, or operational driven.
	Identifying the customer and defining the implementation of the above steps are key drivers of the methodology.
Handover responsibilities	TRL responsibilities are more related to the R&D team, while the CRL is linked to the internal customer role.
	Integrating the R&D center and client system management methodologies helps to promote the acceleration of deliveries.
Roles in the project management	Some managers described that different technological development and innovation management profiles are necessary.
	Other interviewees consider that an entrepreneurial profile is not required to navigate CRL and TRL methodologies, this would be more related to project management.
	Some researchers and project coordinators reported having too many tasks beyond the technical ones, so they expect some support for deployment and commercialization.

Project Follow-up

The project follow-up category aggregates the comments made by 35% of Level-1 Managers, 40% of Level-2 managers, and 34% of Project Coordinators regarding the general opinions of their specific group. Table VI presents the interviewees' perceptions for this category.

The size of the project portfolio is not related to the TRL and CRL but as mentioned by the interviewees it is a relevant aspect for the success of TRL and CRL implementation and it is closely related to culture and organizational structures. They mentioned that an excess of projects in the portfolio results in increased technical and administrative management. Nyandongo (2021) when studying the movement from traditional to agile project management considered similar aspects: company structure, organization culture, executive directives, project size and complexity, and project deadline or timeframe. In our case, the review of the topics, project size and complexity, will contribute to the simplification of the methodology. The definition of an optimized portfolio project size is required to obtain a balanced TRL and CRL monitoring, fulfilling all the steps for a successful commercial implementation.

Projects Typology

The Project Typology category aggregates comments that were made by 18% of Level-1 Managers, 19% of Level-2 Managers, and 18% of Project Coordinators in relation to their specific group overall opinions. Table VII presents the interviewees' perceptions for this category.

Respondents mentioned that out of the five project typologies applied in the R&D Center, CRL is appropriate for three (product, process, and software development projects) but not for the other two such as emergent technology development or knowledge creation project.

ARENA (2014) commented on the lack of an accepted process to benchmark the commercial readiness of renewable energy technology, an example of emergent technologies in the energy field, through the stages of a typical investment due diligence process following successful initial demonstration. ARENA (2014) has developed the Commercial Readiness Index (CRI), described in the literature review C, as a tool to overcome these difficulties.

Knowledge creation projects are necessary to answer specific internal customer questions or build bases for future development projects, but the CRL is not suitable for this typology as mentioned by interviewees.

Figure 4 illustrates the breakdown of project typology and its different approaches. Projects with product, process, and software typology can advance through the levels of CRL followed by the traditional business model canvas. Projects with a typology defined as knowledge creation that do not fit into the CRL levels can be managed by the desired information and the client's expectations regarding the information deliver timeline.

Figure 4. CRL and CRI application depending on projects typology

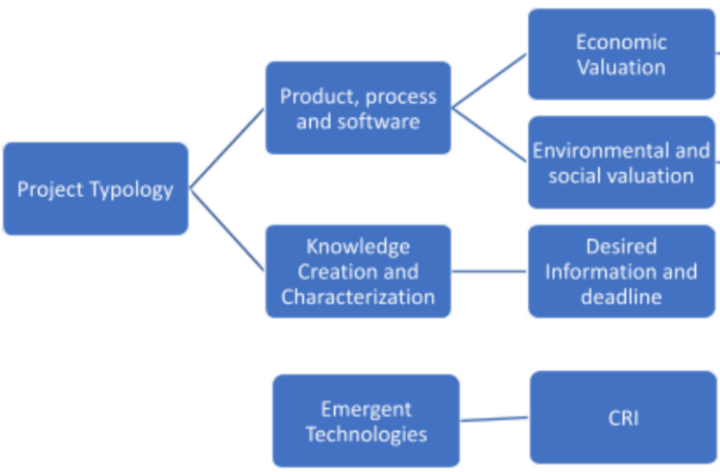


Table VI. Project Follow-up Category

Sub-categories	Interviewees' perceptions
Excess of projects in the portfolio	There is a high number of projects in the portfolio and their optimization can contribute to focus portfolios and lean management; projects should be organized considering the organization's challenges and a multi-year planning timeframe.
	A high number of projects may be associated with the culture of the R&D Center, due to reported aspects such as: - Researchers' perception that being a project coordinator has more opportunities for recognition. - The methodology implementation strategy requires a specific definition for each implementation location, specific scope, and valuation, which contributed to the dispersion of projects with similar characteristics. - Researchers with high specialization in specific themes may influence the orientation of the portfolio towards segmented and dispersed studies, with small teams.
	Adaptation of the research team profile, with a balanced combination of technical and managerial competencies and behavioral profiles, could contribute to greater flexibility and integration for more focused technological challenges.
Follow-up approach	Project monitoring depends on the approach and role of managers at their various levels and the indicators system. The role of the manager is to promote connections with the business area and to adapt the governance models to specific needs.
	Monitoring of the project portfolio is carried out at various management levels. Project coordinators reported that the number of management interfaces in the organization, from 3 to 4 levels, reduces the visibility of the project manager and the researchers. They expect a closer relationship with all levels of management, establishing a good understanding and support for the research process.
	The numerous indicators result in a high number of follow-up meetings. The indicators system requires simplification and improved communication for the different levels of stakeholders.
	The gate from levels CRL 4 to 5 was mentioned as a positive change in terms of reflection, learning, and contributions to implementation.
Simplification	The methodology checklist, rules, and templates should not change frequently. Continually changing in methodology undermines the learning process and cultural change.
	The process is considered time-consuming because of information gathering and consolidation. A balanced bureaucracy that considers more time for RD&I is expected.

Table VII. Projects Typology

Sub-categories	Interviewees' perceptions
Methodology Suitability	The CRL methodology is considered appropriate for product, process, and software development, but even in these cases, it requires a proper definition and interpretation.
	The CRL methodology is difficult to apply for projects such as knowledge creation and characterization, although the methodology is flexible, it is not enough for all types of research.
Emergent technologies projects	CRL is not suitable for emerging technologies; these must be managed differently than current business technologies, with known development paths and customers. Emerging technologies often require value chain development, and, in some situations, there are no customers and required legislation does not exist.
	The goal of the emerging technology project is to foster innovative ideas. In these projects, a proof of concept would be verified with few resources and could go through an advanced TRL level as long as regulatory, or market conditions are not defined.
	Although emergent technologies are considered necessary, there are criticisms regarding their existence in the portfolio. Some managers stated that this type of project was removed from the portfolio to increase the attractiveness of the economic valuation.
Projetos de geração de conhecimento	Projects with the Knowledge Creation and Characterizations (KC&C) typology showed difficulties in applying the CRL. Information from these project typologies may contribute to decision-making or strategic decisions of the company but does not represent a product or process.
	This project type should not be within the CRL. However, another approach is needed to help the visibility of researchers, as one of the positive aspects of CRL.

Valuation and other methods

The category of project Valuation and other methods aggregates comments that were made by 10% of Level-1 Managers, 13% of Level-2 Managers, and 13% of Project Coordinators in relation to their specific group overall opinions. Table VIII presents the interviewees' perceptions for this category.

Valuation is the basis of BMC; however, interviewees point out that this cannot be just economic and needs to consider other externalities such as process safety and environmental and social aspects. Joyce and Paquin (2016) proposed a Triple Layer BMC approach to define the evolution of CRL levels, evaluating the benefits and impacts of the environmental life cycle and social aspects, and avoiding the restrictions required by financial valuation. This approach responds to one of the critical points of CRL mentioned during the interviews.

Successful implementation of the methodology will depend on training, management support and experience sharing. CRL and TRL methodologies are part of the management process involving other key issues such as team building, management approaches and environmental organization.

Table VIII. Valuation and other methods

Sub-categories	Interviewees' perceptions
Project Valuation	The valuation process is a task present at all levels of the CRL methodology, focused on economic and financial profitability.
	Valuation is a challenging process that depends on assumptions, therefore, influenced by the level of maturity and the risk estimation itself. Valuation demands constant review as CRL levels evolve.
	When valuation involves the internal customer and other areas outside the R&D Center, acceleration in the development of the process is observed.
	Valuation cannot be just economic and needs to consider other externalities such as process safety and environmental and social aspects. Although the focus of the CRL methodology is based on economic dimension, it is necessary to include other aspects with social and environmental drivers.
Risk valuation	Risk analysis is a complementary tool in the application of the CRL methodology and project valuation as well as a fundamental decision-making tool for project portfolio managers.
Business Model Canvas, Agile methods, and Stage-Gate	The business model canvas (BMC) is one of CRL's requirements. Managers mentioned that the BMC helps to understand the project from a broad perspective, while project coordinators reported that in some cases as knowledge creation projects, it was not possible to build the BMC.
	Respondents recognize that agile methods contribute as inducers to CRL acceleration, however, it should be applied for specific cases with multidisciplinary teams and the required priority.
	For long-term deliveries, where experimentation time is long and budget resources are high, the recommended methodology mentioned was still Stage-Gate.

Conclusions

From the perception of the interviewees, it appears that the CRL methodology contributes to the innovation process with the clear identification of customer needs, communication with stakeholders, and a clearer vision of a future implementation. Some drawbacks of the methodology are related to excessive management monitoring and bureaucracy. Focusing projects on strategic challenges and well-defined deliverables can optimize the projects portfolio, reducing administrative routines and increasing the collaborative R&D team effort. The definition of development paths considering different project typologies will allow a more comprehensive assessment and project valuation. The CRL methodology should include sustainability drivers for valuation, expanding from just the economic point of view, as proposed by Joyce & Paquin (2016). Projects with emerging technologies do not fit into the CRL methodology and need a different approach such as CRI (Commercial Readiness Index) (ARENA, 2014), which defines a TRL evolution before commercial conditions can be defined. Finally, we observed the demand for separate roles in project management encompassing the technical leader and the project manager (PMO).

Implications

Based on this single industry case, this document provides researchers and managers with insights into best practices and suggestions for the improvement of process innovation management. It also contributes to the better application and combination of TRL and CRL in the management process helping the organization to achieve its objectives and enhance the commercial implementation of the developed technologies. The results provide lessons that may be extrapolated to the sector.

Further Research

The case study was focused on an R&D center that interacts with an internal customer and part of the perceptions observed can be related to its organizational culture. CRL is based on valuation but for this case no quantitative analysis of the benefits or impacts of the methodology was performed. Future research should expand to other organizations and different levels from startups to conglomerates. A quantitative evaluation of benefits or impacts to the innovation process would be required to complement the observed stakeholder's perception. Finally, the team readiness is one additional aspect to be considered in the research and may be a key factor.

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Structural ambidexterity and coopetition capability for industry incubation: Mission-led grand challenges in Japan's hydrogen station industry

Abstract ID#147

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Purpose

Firms face ambidexterity issues of paradoxical tensions between exploitation business for profit maximization and exploration business for innovation as they pursue future growth. Prior studies have been conducted at the firm level to investigate the organizational design to manage structural ambidexterity (e.g., Raisch et al., 2008). However, there is a lack of conceptual understanding of how the government and the private sector can work together to design a business organization for structural ambidexterity at the industry level in a grand challenge such as climate change, which is difficult to resolve by a single firm. Therefore, to respond "Why and how is structural ambidexterity at the industry level formed for industry incubation in the grand challenge businesses?", I use an in-depth case study approach to focus on examining the Japanese hydrogen station industry. In Japan, fossil fuel-based firms have been forming a new industry by embarking on the hydrogen station business to supply hydrogen fuels for fuel cell vehicles (FCVs), which emit no carbon dioxide. However, due to the limited number of FCVs on the road and the much higher cost of hydrogen production than that of gasoline, the hydrogen station business unit of each firm faced financial difficulties with increasing deficits. Stakeholders from both the government, which wants the fossil fuel industry to take stronger action against climate change, and the automobile industry, which wantsto sell FCVs nationwide, have demanded that each firm expand its loss-making hydrogen station business, placing the hydrogen business unit in a paradoxical position. To overcome this paradoxical predicament, 11 firms from related industries and the government established a collective enterprise that separated the hydrogen station business from each of the fossil fuelbased firms. In this paper, this phenomenon is the subject of a case study of structural ambidexterity at the industry level.

Literature review

Prior research has shown that four necessary conditions for structural ambidexterity at the firm level. First, there should be a structural separation of exploration and exploitation within the firm so that exploration can ensure autonomy and avoid potentially harmful spillovers from exploitation (e.g., O'Reilly et al., 2016). Second, front-line managers and employees in each separated business unit should specialize in either exploration or exploitation (e.g., Gupta et al., 2006). Third, the separated units should be strategically integrated so that they can complement each other's internal resources under a common vision (e.g., O'Reilly et al., 2016). Fourth, corporate leaders are responsible for strategically linking exploration and exploitation under a common vision (e.g., Ossenbrink et al., 2019). However, in grand challenge businesses, even when these four conditions would be met, it would be 2 difficult for a single firm with limited internal resources to manage the paradoxical tension between exploration and exploitation. Research on the transitional process from structural ambidexterity at the firm level to structural ambidexterity at the industry level with collective action principles (e.g., Ostrom, 1990) is still underdeveloped.

Methodological procedures

This study utilizes an in-depth study approach to analyze data from documents, archives, observations, and interviews, which are sources of information about the hydrogen station industry and the fossil fuel industry in Japan, in order to analyze the factors and processes that lead to the establishment of a structural ambidexterity at the industry level.

Findings

Through this study, I found that, in addition to the four basic conditions identified in prior studies, the establishment of the industry-level collective enterprise in the grand challenge businesses requires two new factors: a mission-led government initiative for industry incubation and the coopetition capability of firms at the industry level. First, the government's initiatives became the driving force to set shared visions, goals, and commitments between the government and the industry for the industry incubation that would help solve the climate change problem. The initiatives are discussed as a means of countering uncertainty in the hydrogen fuel market and facilitating collective action at the industry level by diverse participants. Second, it is argued that in order to make a long-term commitment to collective action at the industry level, participating firms needed the coopetition capability to manage the paradoxical tension between inter-firm competition for cost-reducing technologies and interfirm cooperation to accelerate hydrogen demand generation, while maintaining paradoxical tensions between exploitation and exploration at the firm level. Under the two additional conditions described above, each firm had to make an economically rational decision about making simultaneous long-term collective commitments to the hydrogen station business that was predicted to accumulate losses. The process by which the participating firms made economically rational decisions to move from structural ambidexterity at the firm level to structural ambidexterity at the industry level with collective action is explained by introducing a model of structural ambidexterity at the industry level.

Implications

This study suggests a theoretical contribution to the ambidexterity and innovation literature by introducing a model of structural ambidexterity at the industry level that collectively evolves from the structural ambidexterity at the firm level to understand the phenomenon for industry incubation in the grand challenge businesses. This study limits to this single case study for structural ambidexterity at industry level due to the restrictions of antitrust law for the establishment of a collective enterprise at industrial markets. Therefore, there is still much future possibilities for research regarding the transferability of the introduced model of structural ambidexterity at the industry level to other industries.

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Sustainable fuel distribution: a strategic foresight analysis for corporate R&D planning in the Brazilian natural gas sector

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Abstract: Achieving carbon-neutral and sustainable energy systems is a fundamental challenge for global society and gas distribution sectors are central to this transition by supplying lower carbon fuels such as natural gas, biomethane and, potentially, hydrogen. However, currently the sector still deals with a fossil fuel, so identifying alternatives for its decarbonization is paramount to guarantee compliance with climate goals. This paper encompasses the main results of a roadmap developed by SENAI CETIQT in partnership with Comgás - São Paulo natural gas distribution company - to indicate the challenges and actions necessary to decarbonize the sector. The roadmap construction involved a literature review, expert interviews, punctuations, and workshops. The main challenges identified are the deployment of low-carbon gaseous fuels such as biomethane and hydrogen, carbon markets, carbon capture, utilization and storage (CCUS), and cogeneration strategies. Many actions are already underway to tackle these challenges at the corporate, regulatory, and research levels. Yet, cooperation among stakeholders in Brazil will be key to guarantee successful advancements. With this unprecedented roadmap, Comgás will be able to be a protagonist in Brazil in decarbonizing the sector and, hopefully, aid other distributors with their own strategies.
Keywords: sustainability, climate transition, decarbonization, natural gas distribution, roadmap

Introduction

Natural gas (NG) has been recognized as a bridge for sustainable energy systems in Brazil and abroad due to lower levels of emissions per unit of energy than coal and oil (Gillessen et al., 2019). Additionally, NG can display synergies with renewable energies by providing uninterrupted energy even during peak hours with more flexible on-off cycles and is versatile to be used by both industrial and household consumers (Baron, 2013; Gürsan & de Gooyert, 2021). However, there are also concerns regarding the delay of a sustainable transition due to lock-in effects caused by continued investments in fossil fuels, i.e., the maintenance of path dependencies associated with the fossil economy (Baron, 2013; Unruh, 2000).

As highlighted by the 2019 International Energy Agency (IEA) report "The Role of Gas in Today's Energy Transitions", switching to NG has helped limit the rise of global emissions since 2010, along with the increase in renewable and nuclear energy, and energy efficiency measures. The report finds that NG can also contribute to important additional emissions reductions and air quality improvements, especially in emerging economies. On the other hand, the sector still needs to minimize emissions, particularly methane, and heavily explore biomethane and low-emissions hydrogen (IEA, 2019a). These insights highlight both the importance of NG to the energy transition and its challenges.

Comgás is Brazil's largest NG distributor in volume, with over 21,000 km of installed gas network and 2.2 million customers in the residential, commercial, industrial, automotive, and other segments (Compass, 2023). The company is highly committed to becoming carbon neutral and has been heavily investing in this direction. Comgás has the goal to become net zero in Scope 1 and 2 for greenhouse gas (GHG) emissions by 2025 (Compass, 2021; Filippe, 2022).

However, the transition toward sustainability is a major societal challenge that goes beyond the actions of a single stakeholder. Transitions are complex, far-reaching technological, economic, social, and ecological changes. This implies that planning and coordinating transitions are very difficult tasks (Köhler et al., 2019), with the decarbonization strategy of company requiring a multifaceted view encompassing social, technological, market, and regulatory aspects.

In this sense, roadmaps are powerful tools for guiding the energy transition, being extensively used by policymakers. They display the main stakeholders involved in a specific theme together with the current status of a technology, perspectives for future developments, and main needs and priorities (Gatto, 2022; McDowall, 2012).

This study presents the main results of a project that aims to support Comgás in the evaluation of such aspects, through the construction of a roadmap of challenges and actions required to achieve net-zero. The roadmap covers current and future trends, highlighting actions to be carried out by the company up to 2050, supporting Comgás to establish its long-term RD&I portfolio, and market and regulatory actions which the company will need to be engaged with. The methodology and results presented herein can serve as reference for policymakers and other companies in the energy sector to define their own strategies.

Following this introduction, the next section brings the theoretical background, briefly reviewing sociotechnical transitions for decarbonization. Next, we discuss the methodological approach deployed in the roadmap construction, which is followed by the results. Then, we present an in-depth discussion on main findings and conclude by indicating the key take-aways of the roadmap, as well as how its results could be internalized by Comgás.

Theoretical Background

The reduction of GHG emissions is of paramount importance for global sustainability and will require low-carbon transitions in sectors such as electricity, transport, heat, industrial, forestry, and agricultural systems. These transitions encompass changing the well-established and interdependent set of technologies, infrastructures, organizations, markets, regulations, and user practices that form our fossil-based economy (Geels et al., 2017).

The current energy systems are largely structured around fossil resources, such as petroleum, natural gas, and coal. These energy sources dominate the global energy matrix (Enerdata, 2023). The fossil-based energy systems form a socio-technical regime of interrelated relationships, constructs, and norms. These factors guarantee coherence and the proper function of the systems, leading to hard-to-change structures and technological lock-ins (Geels & Schot, 2007; Unruh, 2000).

Decarbonization became a topic of utmost importance, especially after the 1990s. The United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, in 1992, was a milestone of this process, in which the participant countries agreed on reducing greenhouse gases emissions in order to retard global warming (CGEE, 2010). The global movement towards sustainability can be regarded as a landscape pressure, i.e., major trends that impact established regimes and can be the triggers for the emergence of disruptive technologies arising from technological niches. However, regime changes are processes that may span decades (Geels et al., 2016). More recently, the war between Ukraine and Russia has been propelling a shift in Europe from the Russian natural gas supply to other sources of clean energy (IEA, 2022). Following these trends technologies, regulations, policies, and markets are evolving to implement low-carbon energy alternatives.

Methodological Procedures

The complexity of contemporary global issues and the interconnection necessary to solve them compel the use of methods as rigorous and participatory as possible. Hence, strategic foresight methods emerge to help direct corporate and policy efforts (Godet et al., 2009). Analyses of emerging technologies and their implications are vital for today's economies. In this context, setting priorities for R&D efforts is an example of a decision that needs to be well-informed and aligned with organizational aspirations, so that strategic foresight become a key tool for identifying future possibilities and determining the best course of action (Woensel, 2021).

Foresight methods can be characterized on two basic attributes: nature and capabilities. Regarding their nature, foresight methods can be qualitative, quantitative or semi-quantitative. Qualitative tools rely mostly on subjective interpretations, including SWOT analysis, questionnaires/surveys, futures workshops, among others. Quantitative tools, in turn, generally measure numerical variables and apply statistical analyses. Some methods in this category are bibliometrics, modelling/simulation, and trend extrapolation/megatrends. Finally, semi-quantitative methods apply mathematical principles to quantify subjectivity, rational judgements, and viewpoints of experts and commentators. These include multi-criteria analyses, (technology) roadmapping, Delphi method, among others.

On the other hand, the capability dimension of foresight methods refers to their ability to gather or process information based on evidence, expertise, interaction, or creativity. Evidence refers to the support of reliable documentation, statistics, and other forms of analysis to help explain/forecast a specific phenomenon. Expertise, in turn, refers to skills and knowledge of individuals, providing advice and recommendations. Foresight studies can be conducted through interactions, recognizing that expertise often gains a lot when challenged to articulate with another knowledge sources. Finally, creativity relies on inventiveness and ingenuity to provide imaginative thinking (Popper, 2008).

Given the need of Comgás to have trustworthy, company-oriented, and relatively quick responses to which decarbonization trends will be more impactful for the sector in the following decades, a combination of qualitative and semi-qualitative methods have been employed in the project. They encompass mostly evidence, expertise, and interaction dimensions.

At first, a literature overview has been carried out on technologies, market, and policy trends to decarbonize natural gas utilities. The overview also comprised a benchmark of natural gas companies' strategies toward decarbonization in Brazil and abroad. Benchmarking is an approach based on surveying and emulating best practices of a firm's competitors or those companies renowned as industry leaders. Although based on existing references, such practice can fuel innovative work (Camp, 1992). Also, regular meetings have been conducted throughout the project with Comgás' teams of sustainability and new business to discuss findings, leverage new insights and validate next steps.

In the sequence, a questionnaire has been developed to guide semi-structured interviews with seven experts, which have been selected based on their experience and knowledge, and comprised individuals from oil & gas companies, hydrogen technology developer, equipment supplier, international chamber of commerce and industry, sectoral associations, and carbon market consultancy. The questionnaire has been structured from a pre-defined matrix correlating three dimensions (Technology, Market, and Regulation) and four sectoral scopes (Fuels, Supply and Infrastructure, Uses and Applications, and Business Models). The identified trends were then ranked according to the Analytic Hierarchy Process (AHP) methodology (Vaidya & Kumar, 2006) and guidelines proposed by Henriksen and Traynor (1999). A public workshop has then been held with other academic, corporate, governmental, and other stakeholders to validate the findings and gather additional insights.

From these results, a roadmap was designed by SENAI, indicating the key challenges for the decarbonization of the sector, associated bottlenecks, and propositions of short- and mid-term actions to address these bottlenecks. The roadmap has been organized into current (2022-2023), near-term (2024-2030), medium-term (2031-2040), and long-term (2041-2050) views. Then, it was further refined based on additional interviews with four experts from an oil & gas company, a carbon market specialist, an energy planning academic researcher, and an specialist in environmental regulation.

Finally, a closing workshop was conducted with Comgás and other gas utility companies for the roadmap validation. The consolidated roadmap included a shortlist of project recommendations for these firms so that they may be able to reach the net-zero goal by 2050. Yet, it is worth noting that further rounds of discussion of this shortlist shall be conducted in the next months by Comgás.

Results

Overview of the Natural Gas Distribution Sector in Brazil

In Brazil, natural gas is used mainly for the energy and industrial sectors, though there is also demand for transportation, commercial, and residential consumers. Projections show an increasing demand for natural gas in the next decades, especially to guarantee flexibility to the national energy system in the context of expansion of intermittent renewable energy sources (wind and solar) in the national grid (GIZ, 2020; EPE 2021). Such perspective has implications on existing infrastructure and regulation.

Regarding NG transportation, the construction, expansion and operation of oil pipelines must be authorized in advance by the Oil and Gas Regulatory Agency's (Agência Nacional de Petróleo, Gás Natural e Biocombustíveis – ANP). It can only be performed by companies or consortia organized under Brazilian laws, with their headquarters and administration in the country, under the authorization regime. Gas transportation companies are not allowed to trade or market gas, except for their own consumption (Pires & Mello, 2022).

Unlikely gas transportation services, which are regulated at the federal level, the piped gas distribution is under the authority and jurisdiction of each state of the Brazilian Federation. The performance of piped gas distribution is granted under concession contracts, resulting from a public bid, to be signed between the local distribution company (LDC) and the relevant state. Each state has its own rules for the construction and operation of a gas distribution network within its territory. Furthermore, the construction and operation of gas distribution pipelines also require specific authorization from the relevant environmental agency (Pires & Mello, 2022). Comgás is one of the three LDCs in the State of São Paulo, regulated by Agência Reguladora de Serviços Públicos do Estado de São Paulo – ARSESP.

Emissions' scope 1, 2, and 3

Scope 1, 2 and 3 is a way of categorizing GHG emissions of a company's own operations, and corresponding value chain. The term appeared in the first edition of the Greenhouse Gas Protocol Corporate Accounting and Reporting Standard, published in 2001 (Deloitte, [s.d.]; The Greenhouse Gas Protocol, 2004).

When accounting and reporting GHG emissions, a company must first set its organizational boundaries to consistently apply the calculation tool, and thereof, accurately estimate its emissions. The three "scopes" (scope 1, scope 2, and scope 3) are defined for GHG accounting and reporting purposes, and help delineate direct and indirect sources of emission, while improving transparency, and better informing climate policies and business goals (The Greenhouse Gas Protocol, 2004).

Scope 1 corresponds to direct GHG emissions, i.e., from sources that are owned or controlled by the company. It encompasses for instance emissions from combustion in owned or controlled boilers, furnaces, and vehicles; and emissions from chemical production in owned or controlled process equipment (The Greenhouse Gas Protocol, 2004).

Scope 2, in turn, accounts for GHG emissions from the generation of purchased electricity consumed by the company. These emissions physically occur at the facility where electricity is generated but are accounted by the demanding organization (The Greenhouse Gas Protocol, 2004).

Finally, scope 3 is an overall optional – but increasingly required – reporting category that allows for the treatment of indirect emissions (other than electricity's), i.e., which are consequence of the company's activities but are generated from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services (The Greenhouse Gas Protocol, 2004). This category is tricky, because it includes all the emissions associated but not stemmed from the company itself. In the case of Comgás, scope 3 account for 99.9% of total emissions. For this reason, this project focused primarily on addressing this category.

Literature Overview: Identifying Main Trends

Many recent references were consulted at this project stage, e.g.: Entsog, 2019; Colvin, 2022; Fanailoo & Brown, 2022; McKinsey, 2022; Rosa & Almeida, 2022; Thomson et al., 2023. Overall, it is a consensus that NG is an important path for the transition to a decarbonized energy sector. Yet, utility companies need to increase the participation of low-carbon methane in their supplies, which largely means increasing the use of biomethane. Biomethane offers a drop-in solution if biogas upgrading technologies are available. It can be sourced from residues and waste streams (Prussi et al., 2019).

Another relevant trend is the advent of hydrogen as a clean energy carrier. In the past few years, it has received unprecedented political and business attention, with policies and projects worldwide rapidly expanding. A 2019 IEA report (2019b) indicates that the time to scale-up technologies and reduce costs to consolidate low-carbon hydrogen is now. In this sense, gas utility companies can play a decisive role by blending hydrogen in existing (bio)methane pipelines and using their gas transportation capabilities to build dedicated hydrogen distribution systems or repurpose old pipelines (DiChristopher, 2023).

CCUS has also been associated with initiatives towards carbon offsetting and has been the subject of renewed interest. The pipeline of new CCUS projects has been growing, spurred by strengthened national climate targets, policy incentives, and decreasing costs. Additionally, new business models are emerging to improve the feasibility of CCUS, since technologies associated with CO2 use and carbon removal are advancing (IEA, 2020b). In addition to CCUS, carbon offsetting can be carried out through regulated and voluntary carbon markets. Despite international movements to structure these markets, they are still in their infancy in Brazil, due to regulation frameworks yet to be developed.

Finally, cogeneration of heat/power has been pointed as an alternative to decarbonization, whether using (bio)methane or hydrogen. Brazil holds great potential for cogeneration, considering also biomasses as feedstocks (BNamericas, 2023). The electrification trend is a factor spurring the increase in cogeneration. It is sustained on, for instance, the growth of the light electric vehicle market, and the retrofit of industrial equipment and processes (Pereirinha et al., 2018; Un-Noor et al., 2022).

Benchmark of Natural Gas Distributors

The NG distributors analyzed include Companhia de Gás do Ceará (Cegás, Brazil), GasBrasiliano (Brazil), Southern California Gas Company (SoCalGas, USA), Enbridge Gas (Canada), among others. The benchmarking shows that several companies already have inventories of their emissions and have conducted roadmaps or scenario analyses to prioritize decarbonization strategies.

SoCalGas is one of the companies that made such type of effort. The actions of SoCalGas to achieve its 2045 goals are divided in timeframes. For instance, the firm proposes to conclude five pilot hydrogen projects by 2025 and work to establish state-wide standards of hydrogen mixture in natural gas. By 2030, it aims to deliver 20% of renewable gas and achieve the reduction goals of methane fugitive emissions set by California. Finally, by 2035, it aims to operate a road fleet that is carbon neutral, as well as in the firm's buildings (SoCalGas, 2021).

Similar initiatives are also being deployed by other companies. For example, Enbridge Gas operates the first green hydrogen plant in North America and has partnerships to convert heavy-duty vehicles to NG (Enbridge Gas, 2022). In Brazil, Cegás is the most advanced Brazilian NG distributor in terms of biomethane injection. Currently, 15% of the gas distributed by the company is composed of biomethane sourced from a landfill (Chiappini, 2021).

Results of the Interviews and Workshops: a Roadmap for Decarbonizing the Natural Gas Distribution Sector in Brazil

This subsection brings the main results obtained and specific cases are discussed that reinforce the trends identified. More comprehensive insights on deployment timeframes are presented in the discussion section.

Four main challenges have been identified to decarbonize the gas distribution sector in Brazil: (1) scale-up of biomethane production and its injection in the NG distribution grid; (2) hydrogen production capacity aimed at blending it in gas networks; (3) addressing of hard-to-abate emissions through carbon market (offset) and CCUS alternatives; and (4) increase cogeneration in the Brazilian energy matrix. For each challenge, specific bottlenecks and actions to address these bottlenecks were identified, devising if they involve regulatory bodies and associations, industry and private institutions, and/or research groups. A simplified version of the roadmap is presented in Figure 1, listing challenges and bottlenecks. Due to size constraints, only some main insights are herein provided.

The potential of biomethane production in Brazil is still largely untapped. Germany holds the larger global biogas capacity, although Central and South America has larger production potential than Europe, especially due to crop residues availability (IEA, 2020a). Production and distribution could be fostered by the construction of additional distribution infrastructure. For instance, GasBrasiliano concluded in 2022 a network to transport biomethane obtained from sugarcane mill residues, in partnership with the bioenergy company Cocal (GasBrasiliano, 2022). Tanker trucks (virtual NG pipelines) can also be used to integrate small and medium biomethane producers into existing pipelines. Galileo Technologies is an example of company providing this type of service (Galileo Technologies, 2017).

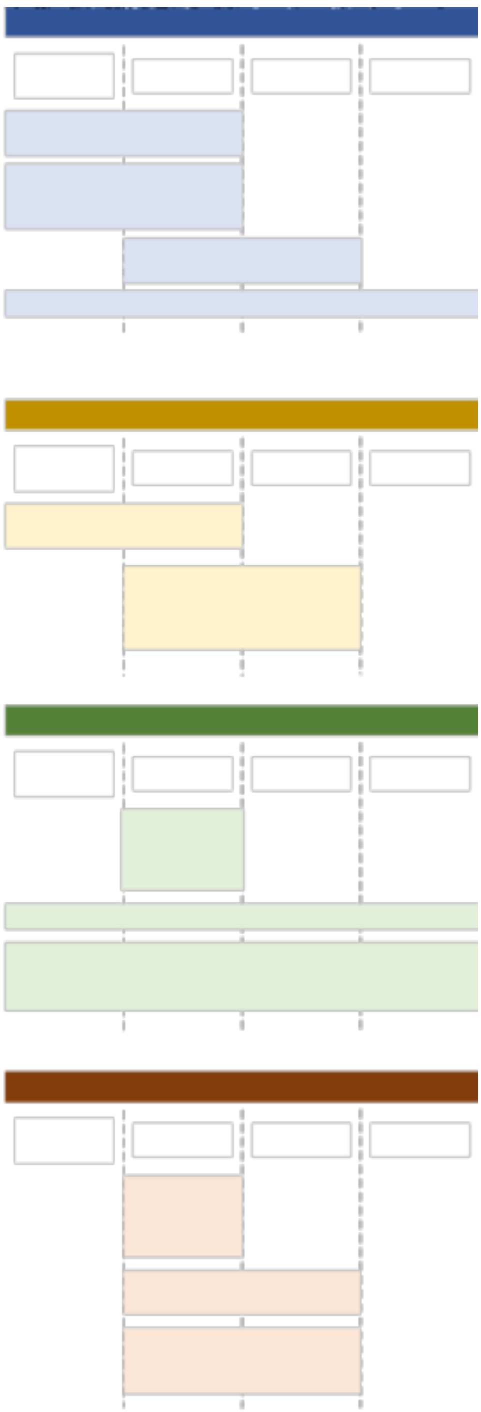

Figure 1. A Roadmap for Decarbonizing the Brazilian Gas Distribution Sector.

Public policies can also play a decisive role to foster biomethane. One example in Brazil is the Federal Government's Zero Methane Program (Programa Metano Zero). It aims to reduce GHG emissions of the agroindustry and landfill managers while turning them into renewable energy producers. The program encompasses initiatives such as credit lines e financing for new biodigesters, biogas purification and biomethane compression systems, and creation of infrastructures for supplying heavy-duty vehicles with biomethane (Brasil, 2022).

The role of hydrogen in Brazil would be as an input for industrial processes, mainly for decarbonizing hard-to-abate sectors (e.g., heavy industries), besides its use for mobility. The relevance of the national production of hydrogen for exports was also pointed out, in agreement with the projections of national and international market studies. Although fossil-based hydrogen is already established, there is a need to consolidate national regulations related to low-carbon hydrogen (e.g., from renewable electricity or biomethane reforming). For example, Bill number 725, from 2022, proposes the obligation of a minimum hydrogen injection of 5% in gas networks by 2032 and 10% by 2050. Yet, it is still not implemented (Chiappini, 2023; Senado Federal, 2023).

Regarding the regulated carbon market, it is expected to be established in Brazil between 2025 and 2030, considering that there are already governmental initiatives to implement an emission trading system. Among the trends that could be driven by the carbon market through the generation of credits, CCU strategies were mentioned, such as the production of synthetic fuels and chemicals. Galp, an integrated energy company that also acts in gas distribution, had seven RD&I projects concerning CCUS by 2022, to name one example of company working in this theme (Galp, 2022).

Finally, the expansion of combined heat and power (CHP or cogeneration) using hydrogen as fuel and chemicals/power cogeneration using (bio)methane are trends identified. As previously mentioned, heat/power cogeneration using methane and biomasses is a reality in Brazil. However, there are important technological bottlenecks to these other alternatives. Although possible to use burn H2 along with methane, it requires adjustments in flow (hydrogen has lower energy content than methane), combustion rate of hydrogen is faster, and hydrogen-fired turbines create more nitrous oxide (a GHG) at higher rates than methane (Clarion Energy Content Directors, 2021). A commercial project was conducted in Brazil by Siemens, which provided a cogeneration unit using hydrogen-rich gas for Braskem. Back in 2019, Siemens disclosed the goal to reach turbines running on 100% hydrogen streams by 2030. In Braskem's project, 60% content (by volume) was reached (Roman Elsener, 2020).

Discussion

From the roadmap developed, it becomes clear that the NG distribution sector in Brazil has many alternatives to significantly reduce Scope 3 emissions. Spurring biomethane is an important venue for development that holds synergies with existing infrastructure. In this sense, short-term initiatives are required to increase the number of producers and deploy cost-competitive technologies for medium-scale biogas upgrading. Additionally, regulations and certifications that create a favorable scenario for these new endeavors and provide security to distributors need to be consolidated. With these movements, it will be necessary to establish new biomethane integration solutions (short- to medium-term). Stimulating value-added applications are crucial from a diversification perspective and different actions are envisioned throughout the horizon of analysis. For instance, in 2021 Comgás established a partnership with Scania to accelerate the deployment of heavy-duty vehicles using NG (Scania, 2021). This is an initiative deemed relevant through the short- to medium-term.

For hydrogen, consolidating regulations and certifications in the short-term is crucial to support market development and hydrogen injection in the NG grid. With these in place, it is expected that efforts to advance and deploy solutions to enable hydrogen injection will be carried until the medium-term.

Regarding carbon offsetting strategies, evaluating quantitative scenarios of the potential impacts of biomethane, hydrogen, and CCUS in a gas distributor's emissions is necessary, which could be carried in the short-term. These would help establishing measurable goals in these fronts. Nevertheless, offsetting emissions by actions in the carbon market will likely be important during the entire timeframe. For this, the establishment of a carbon market in Brazil is key.

In terms of cogeneration, technological limitations need to be addressed and it is expected that technologies will reach sufficient maturity by the medium-term. This timeframe is aligned with the expected establishment of hydrogen-related regulations in Brazil.

Conclusions

This project aimed to generate a roadmap describing main trends impacting the decarbonization of the NG distribution sector in Brazil. The methodology employed proved to be robust for this purpose. A gradual convergence was achieved through the literature review, benchmarks, expert interviews, workshops, and the frequent working meetings with Comgás' team. Regarding new gaseous fuels, such convergence is justified by the possibility of utilizing the infrastructure and competencies already held by the distributors to diversify markets, while contributing to lower emissions. A similar trend is noticed for conversion of heavy-duty vehicles since the know-how related to fueling light-duty vehicles can be utilized. These trends highlight that encountering low-carbon alternatives that are synergetic with the sector's core business is a relevant path to reduce emissions more quickly.

The bottlenecks related to decarbonizing the sector span technical hurdles but also many regulatory constraints, as well as the difficulties to establish new markets (e.g., for biomethane). This insight confirms the complexity associated with transitioning to sustainable energy systems. In other words, decarbonization requires structural changes that may even span national borders, such as harmonizing low-carbon hydrogen certification schemes when considering exports.

This roadmap will be thoughtfully evaluated by Comgás considering its strategic planning, especially for the medium- and long-term horizons. With the roadmap, SENAI also suggested RD&I directions for the company and market/regulatory movements likely impacting Comgás' decarbonization goals. Therefore, the company will be able to effectively direct its resources.

The roadmap herein developed can also support the strategies of other NG distributors in Brazil. Many trends identified are not company-specific, whether considering key technologies being developed or regulatory frameworks. However, adaptations would be required considering each company's strategies and, eventually, local contexts (e.g., lower biomethane production potential in specific Brazilian states).

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SPECIAL TOPICS ON MOT III

May 3rd: 3h10 pm – 5h pm

Chair

Carlai Netto (Federal University of Rio Grande do Sul, Brazil)

Papers

Strategic direction for entrepreneurship support systems: An integrated vision based on strategic and prospective planning

Norly Tatiana Barrera, Fabian Humberto Gómez, Oscar Fernando Castellanos

The personal traits influencing the success of entrepreneurs in Egypt

Mohamed Abbas Gomaa, Mohamed Mamdouh Awny

The Share Fate of Technologies and Supply Chains: From Global to Adaptable Supply Chains

Michel Leseure

Strategic direction for entrepreneurship support systems: an integrated vision based on strategic and prospective planning

Abstract ID#301 | Full paper ID#534

Norly Barrera, Fabian Gómez, Oscar Castellanos (National University of Colombia)

Abstract: This is a strategic direction study that articulates the methods of strategic and prospective planning applied to Fondo Emprender-SENA , (Entrepreneurship Fund), The Colombian National Service for Learning), an entrepreneurship support system of the Colombian government, with the aim to strengthen the services offered by the entity. The study begins with a retrospective analysis of the organization, as well as of the trends in entrepreneurship, to identify 55 critical factors in the entrepreneurial support service. Based on these factors and taking into account the future visions of the organization, a series of strategies are formulated with the participation of the main stakeholders of the system, thus defining the path to be followed in the short, medium, and long term in order to strengthen the entrepreneur support service. In this sense, this study presents 55 critical factors for the evaluation of entrepreneurship support programs, as well as a potentially replicable methodological proposal for similar entities that seek to establish strategies for their direction in an agile and comprehensive manner, articulating their main actors around different visions of the future.
Keywords: Strategic direction, prospective studies, strategic planning, entrepreneurship.

Introduction

Entrepreneurship support systems are public or private initiatives that aim to promote the creation and growth of businesses, based on support strategies such as advice on structuring the business idea, training for entrepreneurs, and funding with initial capital. These programs have a positive impact on business survival rates, as well as on the number of creations of business start-ups, stimulating markets and promoting economic and social development (Cerdán et al., 2013).

The Fondo Emprender-SENA is an entrepreneurship support program created by the Colombian government as a part of its strategy to face the high unemployment rates of the late 1990s and early 2000s (SENA, 2019). Throughout its 20 years of operation, the program has established itself as "one of the most solid allies for the creation of new businesses in Latin America," based on its work with regional, public, and private allies, as well as its efforts to strengthen the national entrepreneurial ecosystem. To date, the program has created 11,203 new companies in the national territory, with seed capital of more than 948 billion Colombian pesos, generating nearly 50,000 new jobs in different regions of the country (SENA, 2022).

However, the Fondo Emprender- SENA, as a public and national entity has been particularly affected by political, social, economic, and institutional changes, which have been exacerbated after the Covid-19 pandemic and its consequences on household income, the productive sector and public finances (DNP, 2021). Considering this, it is imperative for the organization to rethink their structure and objective so that they can face the new challenges resulting from these transformations.

With the participation of the main actors of the entity, the aim of this study is to define adaptation mechanisms and strategies to strengthen the support system for entrepreneurs in the short, medium, and long term. In this sense, this study intent to reflect upon the future direction of Fondo Emprender-SENA, based on the design and application of compact methodologies that articulate different management approaches, such as prospective and strategic planning.

Theoretical Background

The use of strategic direction as a methodological tool for the study of the future is based on the implementation of systematic, logical, and objective techniques, and these results are reflected in the generation of strategies and action plans to guide the organization towards the achievement of its goals (Medina & Ortegón, 2006; Gornostaeva & Sorokina, 2020). In this sense, this research proposes the convergence of the methods of strategic (Akhter, 2003; Bryson, Hamilton, & Van Slyke, 2017), and prospective planning (Godet & Durance, 2007; Rohrbeck, Battistella, & Huizingh, 2015; Hideg, 2007), with the purpose of building together (Weigand, Flanagan, & Dye, 2014) with the main stakeholders of the program, the short-, medium-, and long-term strategies that define the route for strengthening the entrepreneurship support service offered by the Fondo Emprender-SENA. In this section, the conceptual and methodological bases for this purpose are presented, delving into the concepts of strategic direction, strategic planning, and prospective planning. Subsequently, the strategic direction is placed within the future studies, thus demonstrating the potential benefits of articulating said visions for the achievement of the objectives of the entity.

Strategic Direction

Strategic direction is conceived as a process for the effective management of the relations of an organization with its environment (Aguilera, 2010). Based on the analysis of internal and external factors of the organization, it seeks to define the organization's approach "based on its corporate values and projection in the short, medium and long term, to contribute to the construction of corporate identity" (Gutiérrez, Rozo, & Florez, 2019). In this sense, the strategic direction can also be described as an organizational management practice that involves the knowledge and experience of collaborators and stakeholders (Aguilera & Riascos, 2009) to find strategies that drives the efforts of the organization towards the achievement of its objectives in the short, medium, and long term.

Strategic Planning

Strategic planning is a tool that allows the formulation and execution of the organization's policies and action plan, with the main objective of relating and positioning it in its context and achieving its mission goals (Chiavenato & Sapiro, 2016; Reyes, 2012). Authors such as Steiner, Mintzberg, and Glueck (1969; 1987; 1980), present methodological approaches for the development of strategic planning exercises, which are generally composed of four phases (Chiavenato & Sapiro, 2016): a first phase that establishes the baseline of opportunities and challenges of the organization within its environment, a second phase in which the problems are identified and the possible solutions that will constitute the strategic plan of the organization are defined, followed by a phase of implementation of the plan built and a fourth phase that constitutes evaluation process of the performance of the implemented strategic plan.

Prospective studies

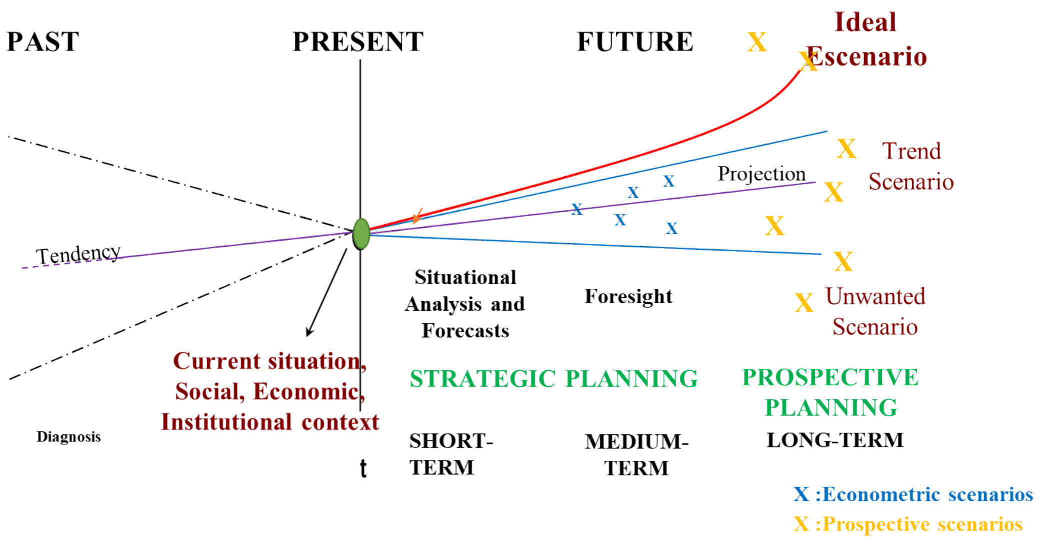
Prospective planning is a discipline that, through the analysis of a desired future, makes it possible to build and act on the present (Mojica, 2010). In this sense, it differs from traditional planning in that it does not project a future derived from the present and the past, but it conceives the best possible future and tries to achieve it through the formulation, construction, and execution of a specific plan (Gastó J. 2005). The methodological approach of prospective studies is characterized by the application of quantitative and qualitative techniques, as well as the participation of stakeholders and its multidisciplinary approach. Within this logic, it is necessary to mention that there is an important variety of techniques for the development of prospective exercises and that the selection of one or another is determined by the specific nature of the topic to be treated, the complexity and scope of the study, the degree of participation of the stakeholders, and the resources and information available (Ortegón & Medina, 2007).

The use of strategic direction is framed within the capacity of this tool to support and demonstrate the competitive advantages and challenges of organizations, as well as the demands of the market in times of uncertainty (Guerrero, 2021). In this regard, various studies have used this approach to contribute solutions for organizations seeking to transform their horizons or have been affected by challenging situations, such as the Covid-19 pandemic. In the industrial y manufacturing sector, recent contributions like González et al, (2022) and Gacha & Hurtado, (2022) present the structuration of strategic plans considering a postpandemic future. Similarly, in the service sector, Avellán & Maliza, and Jackson et al, (2022; 2021) expose the use of strategic direction focused on the assurance and sustainability of companies, and the change in management models.

On the other hand, future studies are based on the analysis of possible and preferable futures and on the perspectives and interests of the stakeholders within the context and topic to be studied (Carrilero, 2017). In this sense, strategic direction as an organizational approach can be included in future studies, as it can benefit from methodologies typical of strategic and prospective planning (Weigand, Flanagan, & Dye, 2014). Figure 1 illustrates this comprehensive approach, in which the techniques of strategic and prospective planning are articulated under the premises of strategic direction, enabling the achievement of the organization's goals.

Figure 1

Articulated approach to strategic direction based on strategic and prospective planning.

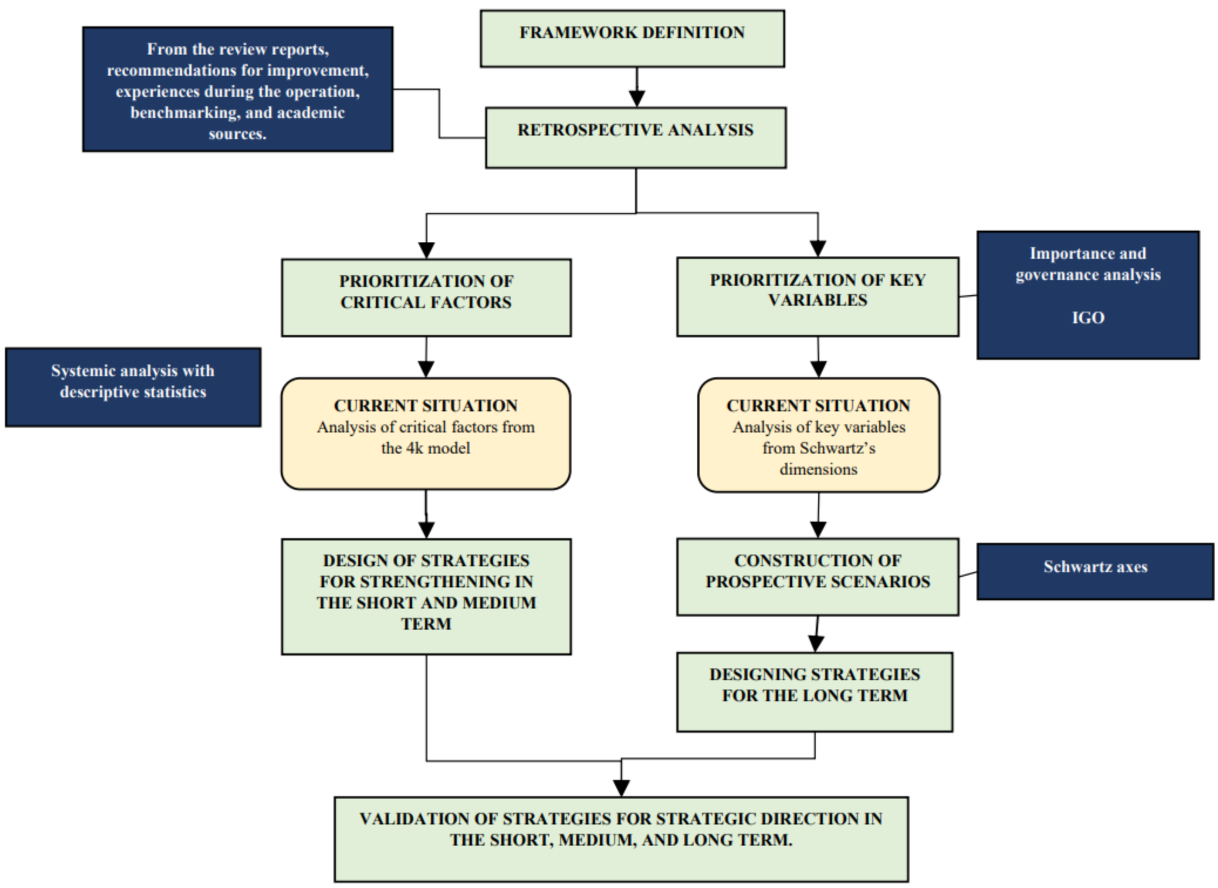


As shown in Figure 1, strategic planning is a method that allows for the generation of shortand medium-term strategies by projecting the current context and situation of an organization. On the other hand, prospective planning allows the generation of future scenarios, considering the long-term visions of the entity. In this sense, the future of the organization is shifted from a trend-based scenario to an ideal scenario, which is achieved through the generation of clear goals and strategies. The articulation of these planning methods results in the implementation of a strategic direction exercise, as the perspectives for the short, medium, and long term of the entity are considered.

Methodological Procedures

The methodological approach for the strategic direction of the Fondo Emprender-SENA articulates the concepts and methods of strategic and prospective planning, which allows the establishment of the institutional direction in the short, medium, and long term. This method has been adapted considering the available resources and actors, as well as the particularities of the organization (Medina & Ortegón, 2006), and is part of the strategic direction initiatives led by the Coordinación Nacional de Emprendimiento - SENA and supported by the Universidad Nacional de Colombia and other operators of the Fondo Emprender-SENA. Figure 2 shows schematically the methodological formulation of this research.

Figure 2
Methodological formulation



Note. Adapted from *Evaluation and Strategic Prospective of Social Relevance and Insertion in Industrial Policy of the Faculty of Engineering of the National University of Colombia*, by Naranjo, Castellanos & Rojas, 2003.

Definition of the context and scope of the study

The objective of the study is the generation of strategies to strengthen the entrepreneurship support service offered by the Fondo Emprender-SENA. In this sense, the main characteristics of the scope are specified as follows:

- Context: User experience of entrepreneurs.
- Output variable: Satisfaction with the service provided.
- Temporality: short-term (1 year), medium-term (4 years), long-term (8 years).

- Participants: Institutional representatives of the Fondo Emprender (SENA) and allied entities (National University of Colombia, Francisco José de Caldas District University, University of Antioquia, EnTerritorio).

Based on the definition of this scope, a retrospective analysis is given.

Retrospective analysis

The retrospective analysis involved three stages: first, 54 critical factors were defined based on diagnoses, recommendations for improvement, and previous reports on the operation of the Fondo Emprender-SENA, as well as the analysis of the academic literature on entrepreneurship support systems. In the second and third stages, the critical factors were submitted for review to two interest groups, the first composed of 13 representatives of the Universidad Nacional de Colombia teams, and the second to a group of 22 institutional representatives of the Fondo Emprender-SENA, including managers and teams from Universidad Distrital Francisco José de Caldas, Universidad de Antioquia, and Universidad Nacional de Colombia. Consequently, the list of factors was validated and adjusted based on the observations of the participants, resulting in a final list of 55 critical factors.

Prioritization of critical factors for strategic planning

During this phase, a face-to-face workshop was held with 13 representatives from the Universidad Nacional de Colombia. For data collection, an instrument was created in Google Sheets® (Table 1) that included the 54 critical factors initially identified. During the application of the instrument, the participants were asked to indicate the degree of incidence of each factor in the satisfaction of the entrepreneur, as well as its categorization within the capitals of the 4K model. The results were statistically analyzed using Microsoft Excel® and PowerBI® software.

Table 1.

Structure of the instrument for the Validation and Prioritization of Critical Factors Workshop

CRITICAL FACTORS THAT AFFECT ENTREPRENEUR SATISFACTION				
NOMINATION	**DEFINITION**	Indicate the current degree of incidence of the critical factor concerning the satisfaction and experience of the FE entrepreneur. **Being 0 = not valid this factor, 1 not at all incidental, and 5 very incidental.**	Indicate the capital associated with each of the critical factors:	**OBSERVATIONS**
		CURRENT INCIDENCE	**4K MODEL CAPITAL**	

Note. Only the structure of the instrument is shown, omitting the list of critical factors.

Prioritization of key variables for prospective analysis: vision 2030

Godet (2000) defines the "key variables" as those essential to the evolution of the system; unlike the critical factors, the key variables are analyzed through the long-term visions of the entity. In this sense, we start from the retrospective analysis to define, based on the 54 critical factors identified, the key variables that, in the long term, will have a positive or negative impact on the satisfaction of the entrepreneur. This prioritization was carried out through the application of the IGO technique (Mojica, 2009), which is a simple tool that allows the evaluation of key variables around two axes: importance and governance.

For the development of the technique, 13 of the most important representatives of the Universidad Nacional de Colombia teams were present, and an instrument was built in Google Sheets® (Table 2) for the collection of information. The results obtained were statistically analyzed using PowerBI® software.

Table 2.

Structure of the Instrument for the implementation of the IGO Technique

<table>
<tr><th colspan="5">KEY VARIABLES THAT WILL AFFECT ENTREPRENEUR SATISFACTION IN THE YEAR 2030</th></tr>
<tr><th rowspan="2">NOMINATION</th><th rowspan="2">DEFINITION</th><td>Indicate the degree of importance of the critical variable concerning the other variables, as follows:
0: Not important
1: Very slightly important
2. Slightly important
3. Moderately important
4. Important
5. Very important</td><td>Indicate the degree of governance of the critical variable, as follows:
0: null
1: Weak
2: Very moderate
3: Moderate
4: Strong
5: Very strong</td><th rowspan="2">OBSERVATIONS</th></tr>
<tr><th>IMPORTANCE</th><th>GOVERNANCE</th></tr>
</table>

Note. Only the structure of the instrument is shown, omitting the list of critical factors.

Generation of strategies for the strategic direction

Generation of short and medium-term strategies based on strategic planning.

The critical factors prioritized and classified according to the 4K model constitute the basis for the design of strategies and action plans to strengthen the entrepreneurship support system in the short term (1 year) and medium term (4 years). For the collection of information, a Google Sheets® instrument was created and applied to the actors mentioned in the previous section. The participants were asked to define short- and medium-term goals and actions for each of the prioritized critical factors. The results obtained were processed and analyzed in Atlas.ti® and PowerBI® software to identify convergence vectors. In this way, the objectives and action plans for the strategic direction of Fondo Emprender-SENA, to be implemented in the short and medium term, were obtained.

Generation of long-term strategies based on the prospective vision for the year 2030.

Based on the IGO technique (Mojica, 2009), the prioritized key variables are obtained, which form the basis for defining the dimensions of the Schwartz axes (Schwartz, 1996). This methodology allows the construction of prospective scenarios, among which an "ideal scenario" is preferred, in which the defined dimensions are positively aligned with the most favorable possible scenario for the entity. Based on this scenario, the long-term strategies for the strategic direction of the Fondo Emprender-SENA are defined.

[The definition of these strategies was developed during a second workshop with the participation of the main representatives of the Universidad Nacional de Colombia teams. The information was collected through a Google Sheets® instrument, in which each participant was asked to propose long-term goals (the year 2030) and strategies to achieve what was proposed according to the ideal scenario. The Atlas.ti® and PowerBi® software facilitated the analysis of the information, thus specifying the actions and strategies to be executed, defining the path to be followed to strengthen the attention and satisfaction of the entrepreneur with a prospective vision towards the year 2030.

Validation of strategies for the strategic direction

The strategies, action plans and goals proposed for the short, medium, and long term were validated and prioritized by the main institutional representatives of Fondo Emprender-SENA and the partner institutions. In this way, the actions to be implemented were prioritized, facilitating the visualization of the path to be followed to achieve the proposed objectives for strengthening the entrepreneurship support system.

For the development of this evaluation, two validation instruments were created in Google Sheets® (Table 3), in both of which each participant was asked to rate the proposed actions according to their relevance and feasibility. The results of these instruments were statistically analyzed using PowerBI® software.

Table 3.

Structure of the instrument for the validation of strategies and action plans for the short and medium term, within the framework of strategic planning.

VALIDATION OF ACTIONS TO BE CARRIED OUT ACCORDING TO THE CRITICAL FACTORS THAT AFFECT THE EXPERIENCE OF THE ENTREPRENEUR (SHORT AND MEDIUM-TERM)					
CAPITAL K	CRITICAL FACTOR	DEFINITION	ACTION PLAN	Indicate from 1 to 5 the degree of relevance of the action to be carried out concerning the critical factor evaluated.	Indicate from 1 to 5, the degree of the feasibility of the action to be taken in relation to the critical factor evaluated.
				RELEVANCE	FEASIBILITY

Note. The general structure of the instrument used for the validation of short and medium-term strategies is shown.

Results and Discussion

The main results are presented below, considering the methodological approach for the short, medium, and long-term direction of the Fondo Emprender-SENA.

Critical factors

The consolidation of 55 critical factors is the result of the retrospective analysis and the iterations and validations carried out with the actors of the Fondo Emprender-SENA ecosystem (Table 4).

Table 4

Critical factors that affect the entrepreneur's experience during the Fondo Emprender's support path

CRITICAL FACTORS					
V1	Entrepreneur's technical and technological skills	V20	Infrastructure for entrepreneurship development	V39	FE alliances and strategic networks
V2	Staff training	V21	Automation & Digitalization	V40	Entrepreneurial culture and soft skills
V3	Business plan formulation methodology	V22	Follow-up and monitoring strategies	V41	Communication channels
V4	Financial model	V23	New entrepreneurship mechanisms	V42	Time dedicated to entrepreneurship
V5	Perception of the contractual responsibility of the entrepreneur	V24	Updating regulations and guidelines	V43	Articulation of the entrepreneurial ecosystem with the national education system.
V6	Business plan evaluation model	V25	Staff sectoral knowledge	V44	Teleworking and working at home
V7	Socialization and appropriation of modernization and change processes.	V26	Technology transfer	V45	Labor informality
V8	Intelligent evaluation feedback	V27	Access and connectivity coverage in rural areas	V46	Regional market positioning
V9	Regulatory procedures	V28	Financial sustainability	V47	Mental health of entrepreneurs
V10	Standardization of digital processes	V29	Staff knowledge of the regulatory framework	V48	Entrepreneurial community and regional alliances
V11	Disbursement times	V30	Sector knowledge of the entrepreneur	V49	Technological surveillance and competitive intelligence
V12	Payment instructions	V31	Differentiated support model	V50	Associativity, distribution, and commercialization of enterprises
V13	Partial payments and accounts payable	V32	Appropriation of the regulatory framework by the entrepreneur	V51	Entrepreneur profiling
V14	Plan-by-plan process	V33	Knowledge management	V52	Public policy on entrepreneurship
V15	Changes in the operational plan	V34	Call deadlines	V53	Portfolio management
V16	Standardization of processes among operators	V35	Conceptual innovation of business plans	V54	Data-driven decision making
V17	Role of the intervener in the start-up process	V36	Support staff workload	V55	Number of financial resources assigned to the business plan
V18	Settlement of business cooperation contracts	V37	Support Staff Rotation		
V19	Service model	V38	Strategies for internationalization		

Note. The total list of resulting factors is shown with their nomination only.

It is important to point out that the validation processes carried out made it possible to unify some factors considering similarities in their description, such as "variety of digital signature operators" and "disarticulation of digital procedures", which are articulated through by factor "standardization of digital processes". On the other hand, some were extended in their definition because in some situations they were extrapolated beyond a single role within the entity, such as the case of "sectoral knowledge of the mentor" and "role of the supervisor in the implementation", which were adjusted to "sectoral knowledge of staff" and "delimitation of staff roles" respectively. Similarly, factors such as "data-driven decision-making" and "public policy on entrepreneurship" were added, considering evidence from the academic literature.

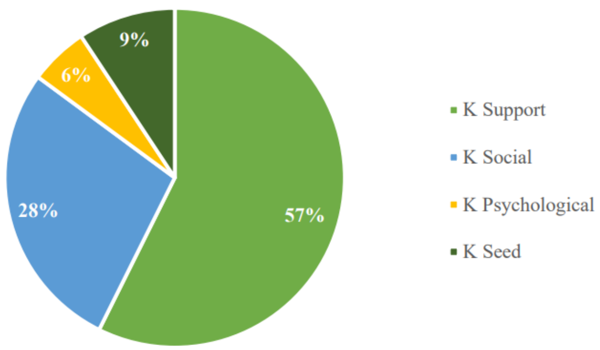
Prioritization of critical factors for the strategic planning

As mentioned in section 3.3, after the first meeting with the participation of the representatives of the Universidad Nacional de Colombia teams, the most important critical factors for the satisfaction of the entrepreneur were obtained, as well as their classification within the capitals of the 4K model. Now, it is imperative to mention that the Fondo Emprender-SENA has developed an institutional platform based on a model called Model 4K, composed of four capitals: psychological, support, seed, and social capital. From this perspective, the strategic direction of the Fondo Emprender-SENA is linked to the strengthening of the model on which it was conceived.

In this sense, the psychological capital includes the set of cognitive and social skills of the entrepreneur that facilitate the successful execution of his business project. This capital includes the training processes offered by the entity for the development of these skills, as well as the promotion of the entrepreneurial culture (SENA, 2019). For its part, social capital is conceived as the real or potential resources derived from being part of a network, community, or group (Bourdieu, 2000), in this case an entrepreneurship ecosystem. The materialization of this capital within the entity is reflected in the different alliances with regional entities for the promotion of entrepreneurship and the implementation of the "Entrepreneurs Network" tool, which enables relationships among beneficiaries, making their products and services known. As for seed capital, this is directly related to the financing offered by the program. Finally, there is support capital, which is conceived as an integral system that supports the entrepreneurial project in the most complex tasks of the entrepreneurship process. This system includes the support network of the Business Development Centers, whose functions include professional advice and assistance (SENA, 2019).

Considering the given conceptualizations, Figure 3 shows the results of the participants' perception and ranking of the critical factors according to the capitals of the 4K model. The capitals Support (57.4%) and Social (27.8%) received higher ranking rates in relation to the capitals Psychological (5.6%) and Seed (9.3%).

Figure 3
Classification of critical factors according to the 4K model



Based on these results, the most incident critical factors were selected for each of the capitals of the 4K model (Table 5). In this regard, it is important to clarify that, due to the differences in the percentages resulting from the classification, they were adjusted according to their proportion, so that the results contribute to the integral strengthening of the 4K model for each of its components.

Table 5

Most incident critical factors according to their classification within the capitals of the 4K Model

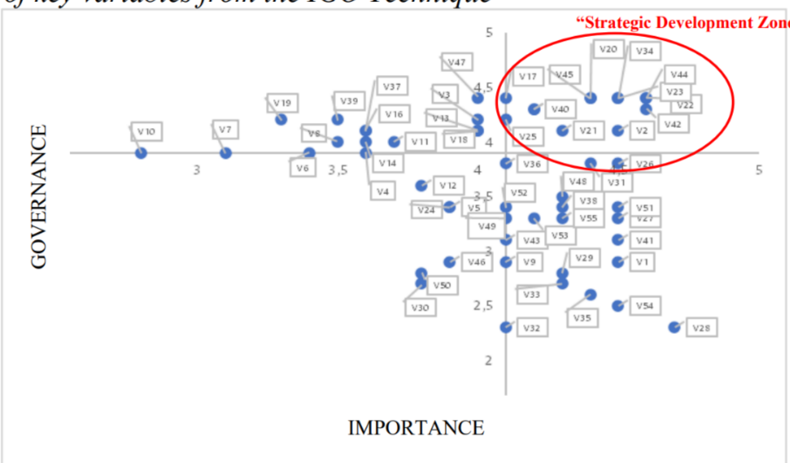
CAPITAL	CRITICAL FACTOR
SUPPORT K	Staff training
	Entrepreneur's regulatory knowledge
	Entrepreneur’s technical and technological skills
	Role of the controller in the start-up process
	Support Staff Rotation
SOCIAL K	FE alliances and strategic networks
	Development of the social capital
	Technology transfer
PSYCHOLOGICAL K	Entrepreneurs' mental health
	Perception of contractual responsibility
SEED K	Payment instructions
	Disbursement times

Prioritization of key variables and construction of prospective scenarios

As mentioned above, the prioritization of the key variables for the foresight process was carried out using the IGO technique, the results of which allow the different variables to be classified into four quadrants. The upper right quadrant is called the "Strategic Development Zone" and the variables included therein have the greatest importance and governance and are prioritized because they are the most decisive for the long-term evolution of the system. Figure 4 shows the prioritization of the key variables and their distribution according to each quadrant.

Figure 4

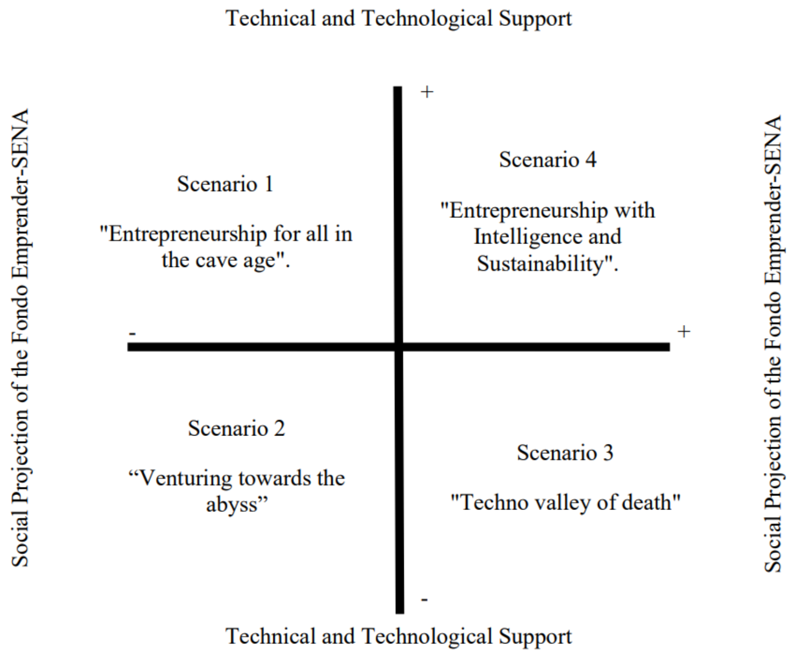
Prioritization of key variables from the IGO Technique



Note. The denominations correspond to Table 4.

The following is an analysis of the key variables of the "Strategic Development Zone" that establishes the Schwartz axes: Technical and Technological Support, and Social Projection of the Fondo Emprender-SENA and its related scenarios.

Figure 5
Schwartz axes



Now, the scenario of greatest interest is the ideal scenario built from the key variables. This scenario is the basis for the generation of action plans and strategies to strengthen the attention and satisfaction of the entrepreneur with a long-term vision. The description of the scenario is as follows:

Ideal scenario: "Entrepreneurship with intelligence and sustainability"

The strengthening of support strategies, the articulation of communication channels and the continuous training of the support team are reflected in the Fondo Emprender's service model. This model articulates the organizational learning processes and the user experience within a service system that integrates processes and actors and considers regional and sectoral specificities along the entrepreneur's path. This service model is based on the automation of internal processes, as well as on a technological platform that facilitates the execution of the business plan and allows the processing and treatment of information. On the other hand, the strengthening of alliances has increased the scope of the organization and the appropriation of the 4K model. In summary, the articulation of technical and technological processes, as well as of the actors within the entrepreneurial ecosystem, has made it possible to develop an entrepreneurship support model that provides the necessary tools based on the regional and sectoral specificities of its beneficiaries

Strategies and action plans for the strategic direction of Fondo EmprenderSENA in the short-, medium- and long-term

This section presents the strategies defined for the strategic direction of the Fondo Emprender-SENA for the short, medium, and long term. Short and medium-term strategies based on strategic planning. The strategic planning allowed the construction of the action plan for the short term (1 year) and medium term (4 years), integrating the 4K model as the articulating system of the support service provided by the Fondo Emprender-SENA. Therefore, based on the identification of convergence vectors and the unification of results, strategies were defined for each of the capitals: support, psychological, seed, and social.

Table 6.

Action plans and short- and medium-term goals for strengthening entrepreneur satisfaction within the framework of the Support capital.

CRITICAL FACTOR	ACTION PLAN	SHORT TERM GOAL	MEDIUM TERM GOAL
Staff training	Develop a training plan that considers competencies for entrepreneurship, implementing evaluations and learning indicators.	Define the strategy and training plan.	100% Counselors trained and evaluated in the defined competencies.
	Articulation with educational entities to strengthen training processes		
Entrepreneur's regulatory knowledge	Implement a regulatory training program for entrepreneurs, developed with the support of control entities.	Establish the scope and appropriation of the regulations required to execute ventures.	Reduction of business plans in progress that require an extension or early termination.
	Develop a digital repository of information related to the regulations applicable to each business plan (guides, manuals, and links of interest) and use didactic methods to socialize the information (videos, shorts, *TikTok's*).		
	Ensure knowledge transfer between outgoing and incoming counselors		

Note. As an example of the results obtained, only two critical factors of the Support capital are shown.

Long-term strategies based on the prospective vision: the year 2030

The strategies and action plans for strengthening the long-term support system for entrepreneurship are based on the definition of the ideal scenario and are built for each of the key variables, prioritized according to their classification within the defined axes. In this way, two main strategies are established, conceived within the axes, "technical and technological support" and "social projection of the Fondo Emprender-SENA, from which a series of goals and action plans are derived (Table 7).

Table 7

Actions and strategies to strengthen the attention and satisfaction of entrepreneurs with a vision to 2030.

DIMENSIONS (AXLES)	KEY VARIABLE	ACTION PLAN	GOAL (2030)	ESTRATEGY
Social projection of the Fondo Emprender--SENA	Differentiated attention: sectoral and regionally	Identify sectoral and regional needs, while maintaining permanent links with territorial entities to generate support strategies.	Implement an integrated support model and a differentiated support route under the economic and sectoral vocations of each region.	Promotion of entrepreneurship through articulation strategies and alliances between entities that allow the appropriation of the territory and the positioning of the entrepreneurial brand fund ventures.
	FE alliances and strategic networks	Identify the capacities of entities in the entrepreneurial ecosystem and structure cooperation agreements to articulate these capacities.	Establish a regional, national, and international institutional articulation model, in which collaboration, knowledge transfer, information, and resources are strengthened.	

Note. As an example of the results obtained, only two key variables of the dimension Social Projection of the Fondo Emprender-SENA are shown.

It is worth mentioning that, in the short and medium term, the action plans are aimed at strengthening and consolidating the 4K model as the basis of the entrepreneurship support system offered by the entity. While in the long term, the proposed strategies focus on the program's mission dimensions, which are technical and technological support, and its social projection at the national level. Likewise, it is important to emphasize that the results of the prioritization of critical factors and key variables, as well as the definition of strategic plans and their validation, should be understood considering the roles, perceptions, and knowledge of each of the actors involved in the methodological development of this study.

Validation of strategies for the strategic direction of the Fondo Emprender-SENA

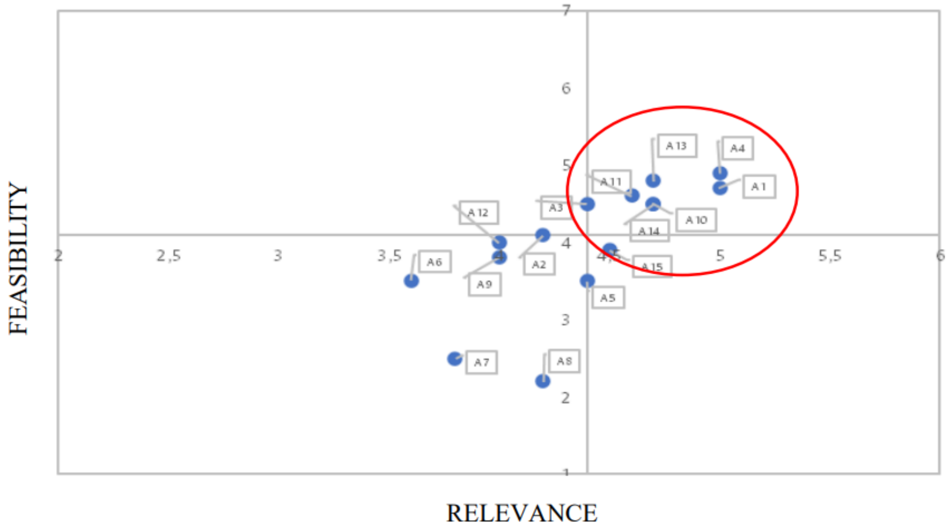
The validation of the strategies made it possible to prioritize the proposed action plans according to their feasibility and relevance, based on the perceptions of the main institutional representatives of the Fondo Emprender-SENA. In this sense, they represent a clear path to achieve the objectives of the entity to strengthen its service in the short, medium, and long term towards the entrepreneur’s satisfaction.

Validation of short and medium-term strategies

The results of the evaluation of the proposed action plans for the short and medium term are shown in Figure 6.

Figure 6

Evaluation of the proposed action plans for short and medium-term strategic planning



Note. The designations correspond to Table 8.

The action plans for the short- and medium-term action plans, validated by the Fondo Emprender's management and the entity's allies, are shown in the upper right quadrant of Figure 6 and detailed in Table 8.

Table 8

Prioritization of short and medium-term action plans

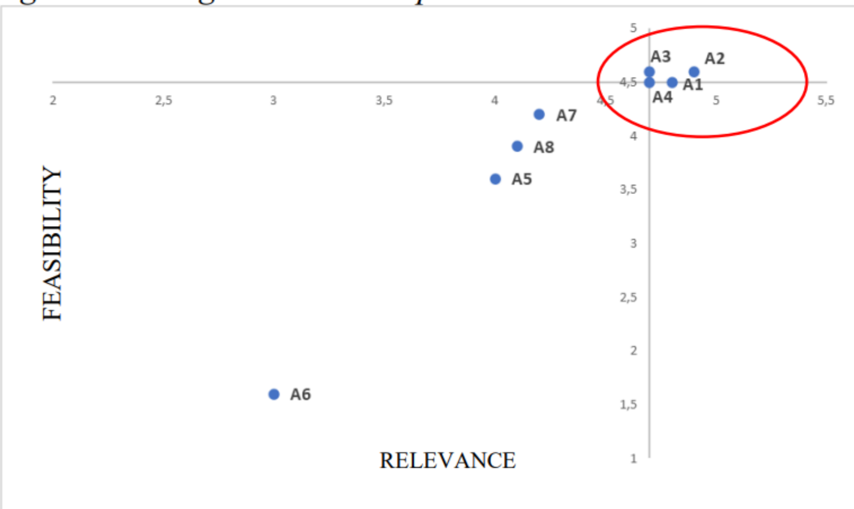
CAPITAL	CRITICAL FACTOR	ACTION PLAN
SUPPORT	Staff training	A1. Develop a training plan that considers competencies for entrepreneurship, implementing evaluations and learning indicators.
	Entrepreneur's regulatory knowledge	A4. Develop a digital repository of information related to the regulations applicable to each business plan (guides, manuals, and links of interest) and use didactic methods to socialize the information (videos, shorts, *TikTok's*).
		A3. Implement a training program on regulations for entrepreneurs, developed with the support of control entities.
SOCIAL	Technology transfer	A11. Continuously develop and promote technology transfer processes
	Entrepreneurial community and regional alliances	A10. Strengthen and position the Entrepreneurs Network Platform.
PSYCHOLOGICAL	Perception of the contractual responsibility of the entrepreneur	A13. Establish and implement methodologies for the transfer of knowledge in relation to the perception of contractual responsibility
SEED	Payment instructions	A14. Review and permanent updating of the instructions and payment platform, with their respective socialization and appropriation evaluated by the entrepreneurs.

Validation of long-term strategies and action plans

The results of the evaluation of the proposed long-term action plans for strengthening the entrepreneur support services are shown in Figure 7.

Figure 7

Evaluation of long-term strategies and action plans



Note. The designations correspond to Table 9.

In this sense, the strategies and action plans identified as the most viable and relevant by the participating stakeholders only relate to the technical and technological support dimension of the Fondo Emprender-SENA, leaving aside the key variables related to the social projection of the entity.

Table 9

Prioritization of long-term action plans

DIMENSION (AXE)	KEY VARIABLE	ACTION PLAN
TECHNICAL AND TECHNOLOGICAL SUPPORT	Service model	A1. Updating, standardization and construction of the FE support model in conjunction with the system's stakeholders.
	Automation and digitalization	A2. Implement modernization and digital transformation processes within Fondo Emprender-SENA, integrating all operational processes, ensuring the articulation of technologies and interoperability.
	Accompanying strategies	A3. Develop and implement new accompaniment strategies, expanding the coverage of accompaniment through technological tools and regional strategic alliances.
	Communication channels	A4. Design an automated communication platform integrating all the stakeholders of the FE, ensuring real-time information processing and continuous attention 24/7.

In this regard, proposals such as the one suggested to strengthen the strategic alliances and networks of the entity are in line with postulates such as the Networked Entrepreneurship Model (González & Gálvez, 2008), which defines that this type of alliance allows the strengthening of entrepreneurial projects by taking advantage of the tools and installed capacity of a broad network of enterprises, without increasing costs or resources, and improving productivity and competitiveness indicators.

Conclusions

The prospective and strategic planning approaches, whose application is usually laborious and extensive, are articulated in this study around an agile and comprehensive exercise with empirically generated results. Likewise, the participation of the actors of the Fondo Emprender-SENA ecosystem in the future visions of the entity and the search for its strengthening within the national and regional entrepreneurial ecosystem is highlighted.

Regarding the 4K model, it has been a bet of the entity towards the definition of an integral structure for the support of entrepreneurship that has hardly been accepted by its main actors. In this sense, the research constituted a reflection exercise to recognize the relevance of the model in the current and future state of the entity and the need for strategies to balance and articulate its capitals.

In addition, the study made it possible to establish strategies for the strategic direction of the entity in the short, medium, and long term, based on the definition of future vectors, prospective scenarios, and the convergence of actors with a common purpose: the strengthening of the entrepreneurship support system.

Finally, for future research, it is recommended to include the perspectives of the program's entrepreneurs. Likewise, it is suggested to delve into those proposed strategies that were excluded from the results due to the convergence analysis, but that may lead to profitable transformation vectors for the entity.

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The personal traits influencing the success of entrepreneurs in Egypt

Abstract ID#144 | Full Paper ID#423

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Abstract: Entrepreneurship is a fundamental driver of growth and development. Hence, governments, in different contexts, have devised means and policies to support entrepreneurship. Startups establishments are politically desired since some of these startups can eventually grow to become market leaders, create jobs, or disrupt the global market The entrepreneur that starts the business, normally, believes in himself has a dream and the passion to achieve it. The lifestyle of this entrepreneur is totally different from other “normal”people. This life might be stressful, unsecured, and risky. Egypt’s National Strategy for Small and Medium Enterprises and Entrepreneurship states thatthe Egyptian Government is committed to creating an effective economy that supports the growth of the private sector that ends up by maximizing the development of the economic potential. If the proper personal characteristics, traits, styles, family life, behaviors, and psychological attitude are identified as potential success factors, Egyptian startups under consideration will be worthy of government support, and financial institutions’ positive responses. This is in addition to the traditional considerations such as the feasibility of businesses and the experienceof the entrepreneurs. This research identifies the significant role of entrepreneurship, which contributes heavily to the economic growth of Egypt. It shows that culture is one of the main motivational factors that drive entrepreneurs to success. In addition, the traits and personal characteristics that affectthe behavior of entrepreneurs pave the way to success. To achieve the main objective of the study, which is to identify the personal traits that contribute to the success of the startup businesses. An in-depth literature review (desk research) is performed for the last 5 years in addition to conducting field research using interviews and questionnaire. The sample approached contains two types: 101 entrepreneurs and 32 eco-system stakeholders.

Keywords: Entrepreneurship, Entrepreneurial traits, Successful entrepreneurs, Entrepreneurial attitude, Start-ups, Entrepreneurial profile, Personal traits.

Introduction

According to the World Bank, entrepreneurship is a fundamental driver of growth and development. Hence, governments, in different contexts, have devised means and policies to support the entrepreneurial spirit in their societies (Lederman, Messina, Pienknagura, & Rigolini, 2014).

Startup establishment is politically desired since some of these startups may eventually grow to become market leaders, create jobs, or disrupt the global market (Mason & Brown, 2014).

Egypt’s National Strategy for Small and Medium Enterprises and Entrepreneurship states that the Egyptian Government is committed to creating an effective economy that supports the growth of the private sector to maximize the development of their economic potential (MSMEDA, 2020).

Experts in the Egyptian entrepreneurship ecosystem have acquired a good part of their expertise from frequent interactions with entrepreneurs. Nevertheless, such expertise has only been in the tacit form pertaining to the limited literature available that codifies ecosystem activities and frequent observations of entrepreneur’s problems, performance, and behavioral patterns

If the proper personal characteristics, traits, styles, family life, behaviors, and psychological attitude are identified as potential success factors, Egyptian startups under consideration will be worthy of government support, and financial institutions’ positive responses. This is in addition to the traditional considerations such as experience and feasibility of businesses proposed by the entrepreneurs.

The research method includes both desk research by literature reviews and field investigations through interviewing several entrepreneurs that have succeeded or failed. Literature data was also acquired from different references such as Global Entrepreneurship Index (GEI 2020) and Global Entrepreneurship Monitor (GEM 2020) about the status of startups in Egypt. These indices set the relative position of Egypt within the countries of the Middle East and North Africa region (MENA). Live data has been also collected from the research. Observations during field investigations and interviews of several stakeholders and entrepreneurs. The objective was to draw a profile of entrepreneur personal characteristics and trait that yields success or failure, in addition to other factors concerning the products or services provided. The research work compares the profiles between successful and failing entrepreneurs

Theoretical background

The Egyptian economy is one of the most diversified economies in the Middle East with different sectors including Agriculture, Tourism, Services, and Manufacturing. All of these sectors are contributing to the Gross domestic product (GDP). The government launched in year 2022 a set of initiatives to support these sectors for the economy to grow. (Silinevicha et al., 2017).

Components of an entrepreneurial ecosystem

The literature reviews showed that there are 6 main different components in the entrepreneurial ecosystem representing the entities that support the entrepreneur to achieve their dreams of starting up succeed and growing with their businesses.

The regulatory bodies represented by the government play a very important role to support the startups' growth through different initiatives affiliated with the government. This role directly affects the economy. (Mason & Brown, 2014)

The components of the entrepreneurship echosystem are presented in figure 3.1 and elaborated on in the following:

I. Policy: The incentives offered by the government such as tax incentives, access to funds, and other incentives encourage entrepreneurs to start their businesses. (Motoyama & Wiens, 2015)
II. Human capital: Human capital is one of the most important components in the ecosystem. It is composed of different sub-components such as networks and labor.They build. The startup enterprise. (Isenberg, 2011).
III. Culture: Culture is the component, which makes the difference between different ecosystems. It reflects the culture of the community that entrepreneurs start their businesses and grow up with them. The right culture may support him to be a successful entrepreneur and encourage him to take the apparent risk involved and vice-versa. Creating, publishing, and spreading entrepreneurial success stories encourage other startups to follow. (Isenberg, 2011)
IV. Support: Different types of support, such as infrastructure, communication, energy,and other essential needs may be offered to help the startups operate efficiently.(Mason & Brown, 2014). Other in-kind supports are also needed such as access to conferences, competitions, and different services like accounting, legal, and administration services. (Launonen & Viitanen, 2011)
V. Finance: Startups need different forms of finance during the different stages of their

businesses. These include quick access to finance through a close zone of family and friends. In addition to other different forms of finance like seed funds, grants, loans, equity, venture capital, or debt venture. Each fund will support different stages in the growth cycle of the startups. (Isenberg & Onyemah, 2016)

VI. Market: Access to the market is a necessary component for any startup as they needto check the ability of their products or services to be successfully commercialized.This also helps to validate their ideas especially in the early stages of business andbefore investing more time, money, and effort in an unmarketableproduct.(Launonen & Viitanen, 2011)

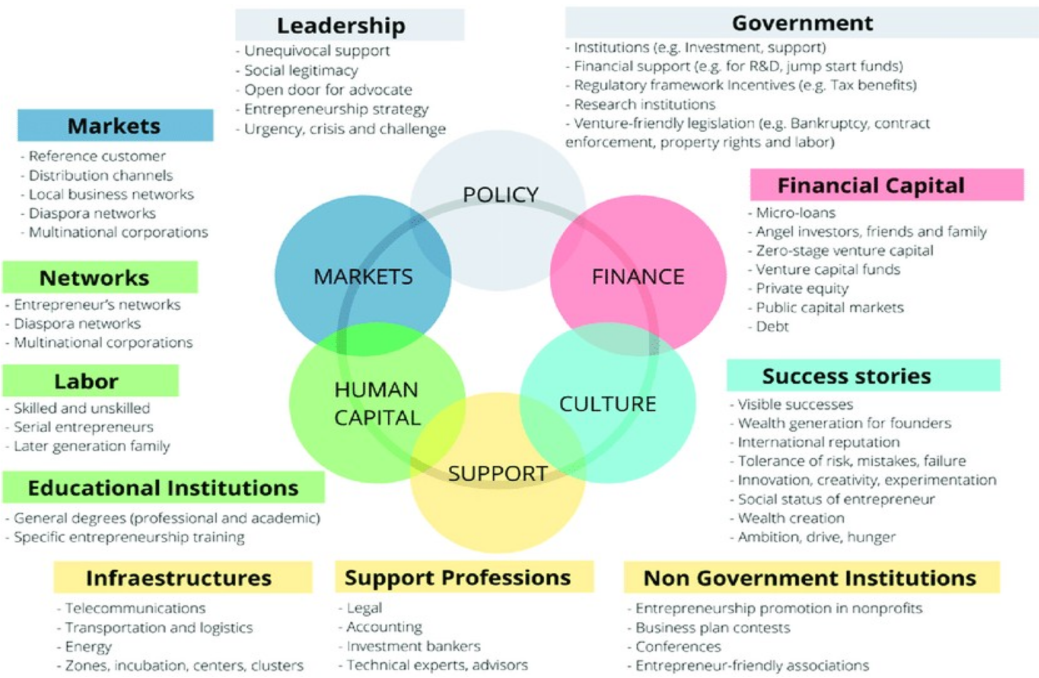

Fig 3.1 Components of the Entrepreneurship Ecosystem, (Source: Isenberg 2011)

Impact of entrepreneurs on the Egyptian economy

Egypt's score in the World Bank's entrepreneurship indicator accelerated to 100 in the bank's 2022 report, up from the 75 recorded in the 2021 report, The report named Egypt among eight economies in the region that scored 100 in that aspect. The report attributed this improvement to the country's enactment of reforms regarding entrepreneurship, including making the access to credit much easier and banning gender discrimination in financial services. (World Bank, 2022)

Ahmad & Abdel-Aziz (2015) showed that entrepreneurship plays a significant role in the economic growth, increase employment level, create new products/services with new demands and new markets. However, start-ups face many challenges to sustain and survive. According to the literature, their failure rate could be more than 90% especially in developing countries such as Egypt. Therefore, it is important for the government in the developing countries to design specific support services for startups to reduce their failure rate and increase their chances for success. (Hung Kee et al., 2019)

Factors affecting the success or failure of the Egyptian startups

There are many factors influencing the Egyptian start-ups success: (European Union, 2018)

1. The choice of the qualified needed innovative product/service
2. The presence of an innovative/committed and right team
3. The design of long-term scalable business
4. The availability of fund
5. The choice of the right timing to go market
6. A suitable level of education, training, and qualifications of the team
7. The presence of a self-motivated entrepreneur with the right personal characteristics.

Recently, the Egyptian government published a list of incentives and decisions to support and enhance the entrepreneurial culture as follows: (WAYA, 2022)

- One stop shop initiative to facilitate the legal establishments of the new startups
- Innovation, science, and technology incentives law to encourage and help researchersto establish businesses based on their research
- New regulation to support the internal processes and timeline of legal registration forthe startups
- New platform to offer list of services and supports for the startups

Linking entrepreneurship to economic growth

Startup establishment is politically desired and encouraged by governments as some of these startups may eventually grow to become market leaders, create jobs, or disrupt global market and hence contributes to the economic growth of the country. The World Bank emphasizes that entrepreneurship is a fundamental driver of growth and development. Hence, governments, at different countries, have devised means and policies to support entrepreneurship. In some areas of the world, governments have been shifting from developing "traditional enterprise policies to growth-oriented enterprise policies" (Mason & Brown, 2014).

A variety of stakeholders such as banks, universities, and regulatory bodies become involved in promoting startups as means to economic growth (Launonen & Viitanen, 2011). These entities are collectively referred to as "Growth Entrepreneurship Ecosystem". (Isenberg, 2011)

The framework for linking entrepreneurship to economic growth shown in figure 3.2 is inspired from Wennekers and Thurik (1999).

It explains three levels of analysis to link the entrepreneurship with the economic growth of any country. These are:

- Individual level: which analyzes the psychological endowments of the entrepreneur within the culture of the institution, which consider the attitudes, skills, and actions of the individual entrepreneurs. (Conditions for the entrepreneurship)
- Firm level: which analyzes the situation from the culture of the firm itself with the business incentives. This is seen at the individual entrepreneur's level as his attitude, skills, and actions he takes. At the firm level which is the entry of the startup into the market with innovations. And at the macro level in the variety of competitions affectedalso by the attitude, skills, and actions taken at the individual level and contribute to thecompetitiveness and economic growth. (Crucial elements of entrepreneurship)
- Macro level: which analyzes from a bigger view reflecting on the competitiveness and economic growth. This considers the realization of the entrepreneur's personal wealth at the macro level and by the competitiveness economic growth.

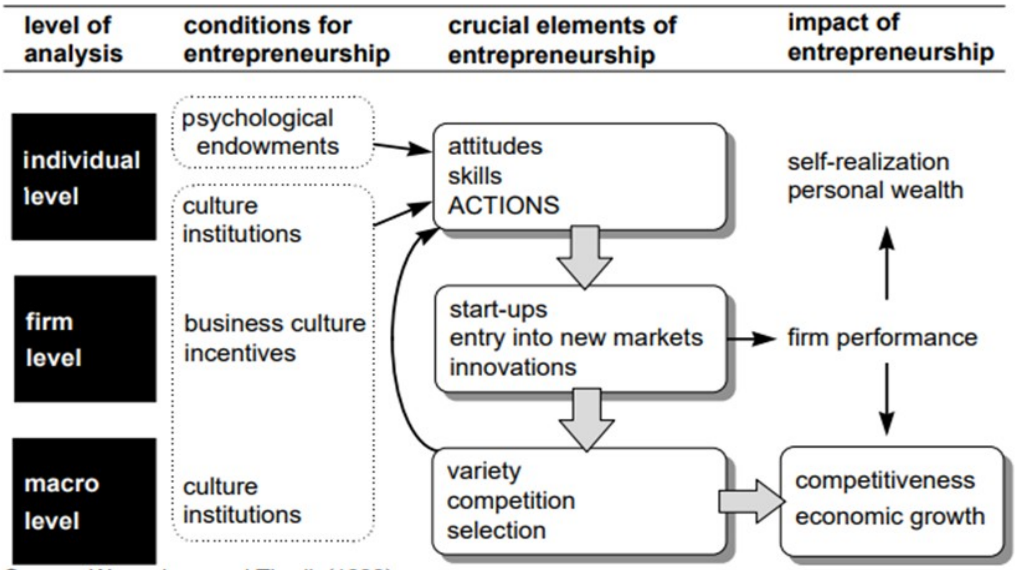

Fig 3.2: Framework for linking entrepreneurship to economic growth (Wennekers and Thurik 1999).

Types of entrepreneurs

The following are the different types of entrepreneurs as identified by Genome, S. (2021)

1. Innovative entrepreneur, who introduce new products, services, and processes to the market.
2. Replicative entrepreneur, who penetrate the existing market with a unique value proposition or unique selling point for a similar product/service.
3. Opportunity entrepreneurs: who are engaging in different entrepreneurial activities to increase their income and become more financially independent. This needs a high levelof skills, education, and experience.
4. Necessity entrepreneurs, who are maintaining the startups income without the need to have skills or education level or have the sufficient experience or knowledge with the regulations.
5. Intrapreneur, who innovate new ideas within his employer's business or company withan access to employer's resources and facilities to support his idea. Many well-known companies have grown and benefited from creating the intrapreneurship culture of their employees.

Psychology of entrepreneurs

Psychometrics is a scientific field concerned with the theory and techniques of assessing personality traits and cognitive ability via different types and models of measurements. (Thomas.co. 2022).

In 2017, the national Bureau of economic research published a review of recent literature for personality traits of entrepreneurs. They showed an extensive literature on the personality traits of entrepreneurs (Kerr et al., 2018)

Ability of future prediction and taking risk is the first step for any potential successful entrepreneur as they identify the business opportunities and start the journey to achieve it

There are mainly 3 types of physiological characteristics of any potential entrepreneur that would affect his success as follow: (Mukherjee, 2016)

- The previous experience effect, whether bad or good experience, possibly gained from previous jobs
- The personal characteristics of the entrepreneur
- The personal qualifications with reasonable age between 25-40 years

Entrepreneurial style

Entrepreneurial style refers to people's different ways of thinking, which affect their approaches and attitude towards transforming an idea or innovation into a business activity. (Samanta, 2021)

The Wadhwani foundation in 2020, established a test to define the entrepreneur's style and role in starting up new business. The test is composed of a set of questions reflecting the cultural issue, personality, traits, and characteristics. They composed a certain situation and checked the response of the entrepreneurs when he is involved with it. They showed that there are five styles as follows (figure 3.3):

- A maker: who has the ability to bring ideas to life through tangible plans and he always sees the big picture and the smallest details and can simplify complex problems
- A merchant: who has the ability to spot a market opportunity, an unmet need. He can match demand with supply. He can improve existing ideas and innovatively apply concepts from other industries.
- A magician: who can take risks that are not always can be calculated accurately. He navigates unchartered territory and stays a head of the market. He is the one who creates the future, surprises his customers and competitors.
- A mobilizer: who has the ability to connect ideas, people, and resources to build a great relationships and high energy teams. He also focusses on the social problems and involve the grass-roots level of team Juniors.
- A master: who is highly skilled and knowledgeable with a great passion for the chosen field. He adheres to high quality standards and expect the same from others.

Psychometric assessment

The Psychometric assessment uses a series of tests designed by qualified professionals (psychologists or psychometrics experts), to assess and measure a wide variety of skills, aptitudes, and traits. These are categorized as follows: (Aschwanden et al., 2017)

A. Cognitive ability: measuring the intelligence, aptitude, and skills, etc., of the entrepreneurs as follows:
    - Intelligence: Measure intelligence in its different forms such as: logical reasoning, spatial thinking, technical reasoning, emotional and social intelligence, introspection, and the like.
    - Aptitude: Evaluate someone's abilities, for example in learning new skills.
    - Skills: Assess specific competencies which can be strictly job-related and related to experience and knowledge, or broader skills, such as communication.

B. Personal traits: measuring the behavior, attitudes, values, interests, etc.., of the entrepreneurs as follows:
    - Attitudes: Evaluate attitudes towards other people, towards new and

unfamiliarsituations, towards challenges, etc.

- Behavior: Evaluate and predict behavior in specific circumstances.
- Values: Measure values that reflect a person's attitude and behavior.
- Motivation: Evaluate different motivators closely related to their proposed workchoices and their willingness to excel.

The design of the questions used in a personality assessment can be normative or ipsative. (Danielle B. 2019)

- Normative assessment: frame their questions as a rating-scale choice. The participant is asked about one statement at a time. The answer is on a scale, to allow him to choosehow much they disagree or agree with the statement. Answers in normative tests are easy to fake.
- Ipsative assessment: frame their questions as a forced choice. The participant must select only one option that best describe himself. This test is difficult to fake unlike normative tests.

The Motivational factors influencing success entrepreneurs

Figure 3.3 shows studies by Sandra King and Kevin Thomas (2010) who focussed and classified the motivational factors that drive the entrepreneurs to realize their dreams of establishing an enterprise, into two main drivers.

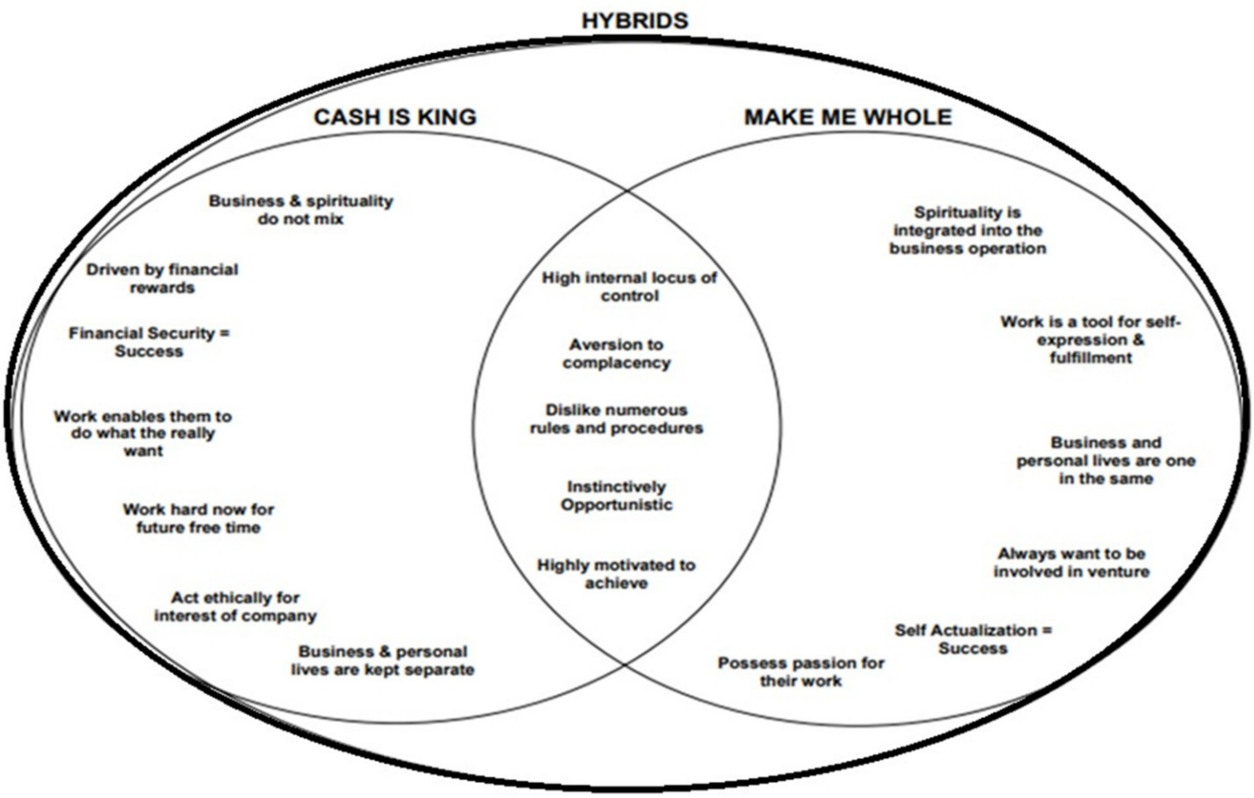

Fig 3.3: "Cash is king" & "Make me whole" drivers. (Kauanui et al., 2010)

The first category is coined "cash is king" factor, where an entrepreneur would be wholly motivated by the potential of gaining a lot of money and becoming financially independent. The second driver is coined "make me whole", where self-fulfilment and success are the main aspiration of a start-up. But there is another type which have a significant mutual motivation driver between the "cash is king" and "make me whole" drivers. These other motivations are : (Kauanui et al., 2010)

- High internal locus of control: The individual's belief that the successes he achieved during his life are the result of his skills, attributes and not due to environmental factors such as luck and fate.
- Dislike numerous roles: He is innovative and risk taker which make him abnormal and always thinking out of the box.
- High motivation to achieve: Have a motivational driver to plan, put a target and go to achieve it.
- Aversion to complacency: He always unsatisfied with what he has already achieved and always looking for more achievements.
- Instinctively opportunistic: Opportunity hunter and always look for the good opportunity and go for it.

The personality traits

ENTREPRENEURIAL TRAITS

Entrepreneurial traits are the typical characteristics, abilities and thought patterns associated with entrepreneurs. While some entrepreneurs are born with these traits, others can develop them.

One of the most popular models showing the personality traits is the big five model described below.

THE BIG FIVE MODEL

The "five basic personality traits" are a theory developed in 1949 by D. W. Fiske (1949) and later expanded by other researchers including Norman (1967), Smith (1967), Goldberg (1981), and McCrae & Costa (1987).

Figure 3.4 shows the multidimensional approach to define the personality through measuring 5 traits as follows: (Kerr et al., 2018)

1. Openness to experience: which is the desire and ability to learn or try new things,
2. Conscientiousness: which is the ability to do tasks with high performance and takeseriously the obligations to do,
3. Extraversion: which is the ability to be interacted socially and emotionally with otherpeople,
4. Agreeableness: which is to be cooperative, polite, kind, and friendly.
5. Neuroticism: which is the tendency toward anxiety, depression, self-doubt, and othernegative feelings.

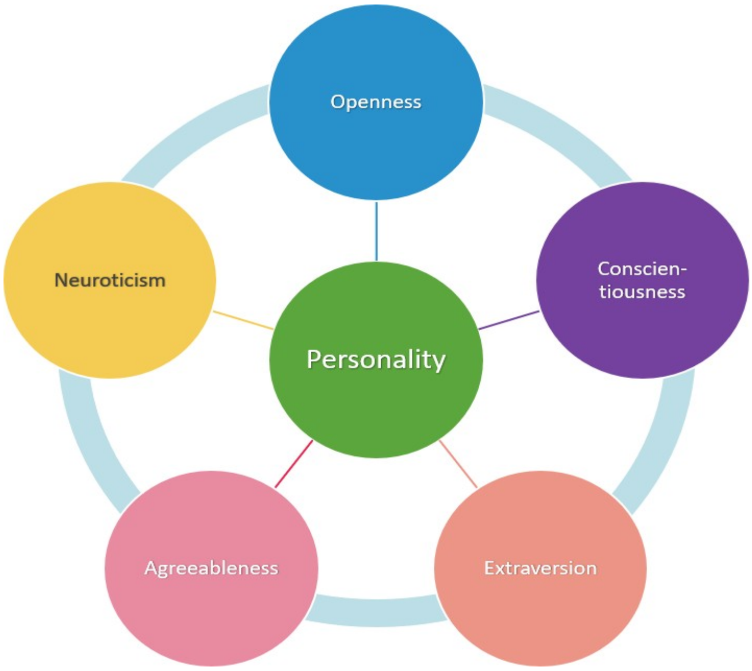

Figure 3.4 - Big-five model (Kerr et al., 2018)

The current situation of entrepreneurship in Egypt

In Egypt, job creation expectations and actual growth rate of population are not well synchronized. In general, the number of the new jobs' opportunities generated is less than the projected one. On one hand, 52.5% of Egyptian early-stage entrepreneurs do not expect to add any new jobs to their business for the first 5 years of their operation. (Ismail, Tolba, Barakat, Meshreki, 2018)

This indicates that a considerable percentage of "self-employment" businesses, are informal micro enterprises (informal sector). On the other hand, 23.7% of early-stage entrepreneurs expect their business to grow by 6 or more jobs within 5 years of their operation. This reflects high growth aspirations among about a quarter of the early-stage Egyptian entrepreneurs. (Ismail, Tolba, Barakat, Meshreki, 2018)

Start-ups at the early stage (i.e. idea generation stage), bear the highest risk and have the highest failure rates. It is hard to claim accurately about failure rate statistics for the early-stage businesses. They do not raise capital from funds or other entities but are funded by the founders themselves, their families, and/or friends. The quoted number globally is that 9 out of 10 start- ups fail as stated in (Start-up Genome project 2020).

As shown in table 3.1 a comparison between Entrepreneurship Ecosystem in the Middle East and North Africa using fourteen pillars describing the entrepreneurial characteristics including entrepreneurial attitudes (ATT), entrepreneurial abilities (ABT), entrepreneurial aspirations (ASP). It shows the rank of Egypt compared with the global average and MENA average. (Faghih & Zali, 2018).

Table 3.1: Entrepreneurship Ecosystem in the Middle East and North Africa (MENA) (Faghih, M. R. Zali, 2020)

	Fourteen Pillars	World	MENA[a]	Jordan	Lebanon	Morocco	Algeria	Egypt
ATT factors (below):								
1	Opportunity Perception	0.41	0.43	0.45	0.18	0.30	0.34	0.23
2	Start-up Skills	0.37	0.40	0.58	0.71	0.14	0.28	0.14
3	Risk Acceptance	0.30	0.30	0.12	0.02	0.33	0.39	0.07
4	Networking	0.39	0.51	0.62	0.49	0.27	0.51	0.09
5	Cultural Support	0.38	0.48	0.62	0.22	0.21	0.32	0.32
ABT factors (below):								
6	Opportunity Start-up	0.40	0.50	0.35	0.38	0.39	0.17	0.16
7	Technology Absorption	0.33	0.32	0.08	0.14	0.23	0.25	0.25
8	Human Capital	0.41	0.58	0.34	0.36	0.13	0.31	0.24
9	Competition	0.35	0.32	0.34	0.43	0.10	0.16	0.19
ASP factors (below):								
10	Product Innovation	0.39	0.43	0.42	0.38	0.44	0.22	0.18
11	Process Innovation	0.37	0.38	0.31	0.41	0.65	0.10	0.45
12	High Growth	0.40	0.58	0.52	0.19	0.25	0.20	0.46
13	Internationalization	0.38	0.38	0.20	0.66	0.16	0.20	0.26
14	Risk Capital	0.37	0.62	0.26	0.37	0.39	0.31	0.50

The Global Entrepreneurial Development Index (GEI) is based on the sum of points assigned to three sets of entrepreneurial characteristics.

Entrepreneurial Attitudes (ATT)

Entrepreneurial attitudes of the startups are estimated by measure of the type of the needed environment to support the entrepreneurs to operate with the list of attitudes and needed skills for them to success (Ismail, Tolba, Barakat, Meshreki, 2018). It has the following pillars:

- Opportunity Perception (0.23): Measures the capabilities of entrepreneur to recognize opportunities.
- Startup Skills (0.14): Indicates the percentage of the population who believe they acquired adequate startup skills.
- Risk Acceptance (0.07): Defining the percentage of the entrepreneurs who do tolerate failure without fear.
- Networking (0.09): Indicating the ability of the entrepreneur to gain personal socialnetwork.
- Cultural Support (0.32): This pillar is a combined measure of how a country’s inhabitants view entrepreneurs in terms of status and career choice, and how the level of corruption in that country affects this view.

The data shows that Egypt is under the world average in the Entrepreneurial attitudes, which in return, reflects the personal skills and characteristics of the entrepreneurs.

Entrepreneurial Abilities (ABT)

Focused more on the qualities and skills of the entrepreneurs themselves, which related to entrepreneurs’ training. It reflects their ability to absorb the technology and increase their opportunity to compete and grow. (Ismail, Tolba, Barakat, Meshreki, 2018)

ENTREPRENEURIAL ASPIRATIONS (ASP)

Focused on product, process of innovation, internationalization, and high growth potential to attract the venture capitals to help them to grow and gain new customers. (Ismail, Tolba, Barakat, Meshreki, 2018)

From the above description for the different entrepreneurial characteristics, It is more clear that the entrepreneurial abilities (ABT) and aspiration (ASP) are related to either the technology, the gained skills through trainings, or any building capacity programs the entrepreneurs had attended. However, the Entrepreneurial attitude (ATT) is more related to the personal traits and characteristics of the entrepreneurs.

Methodological Procedures

To achieve the objective of the study, an in-depth literature review (desk research) is performed for the last 5 years in addition to conducting field research using interviews and questionnaire. The sample approached contains two types: 101 entrepreneurs and 32 eco- system stakes holders as follows:

A. For entrepreneurs:
- Design semi structured questionnaire showing the objective of the research
- Conduct face-to-face interviews for 50 entrepreneurs working in different sectors
- Validate the previous results by distributing online questionnaire with another 51entrepreneurs utilizing the outcomes traits from the previous interviews
- Compare the results from the two groups and use chi-square test to show thesignificance of these results
- Entrepreneurs covered different sectors of the Egyptian economy, number of employees, gender, age, geographical areas, and business current values.
- Both types of entrepreneurs were approached, viz; successful and failed ones.

B. For eco-system stakeholders
- Designing a structure questionnaire
- Send the questionnaire to 32 representatives from the ecosystem stakeholder's i.e. Incubators, accelerators, universities, banks, mentors, government, venture capital,and non-financial support entities

Results

Results and analyses of the start-ups' interviews:

The following shows the results and discussions of the questions raised during the face-to-face interviews carried out with the selective entrepreneurs.

Description of entrepreneurs

AGE OF THE FOUNDER WHEN INITIATED HIS/HER STARTUPS

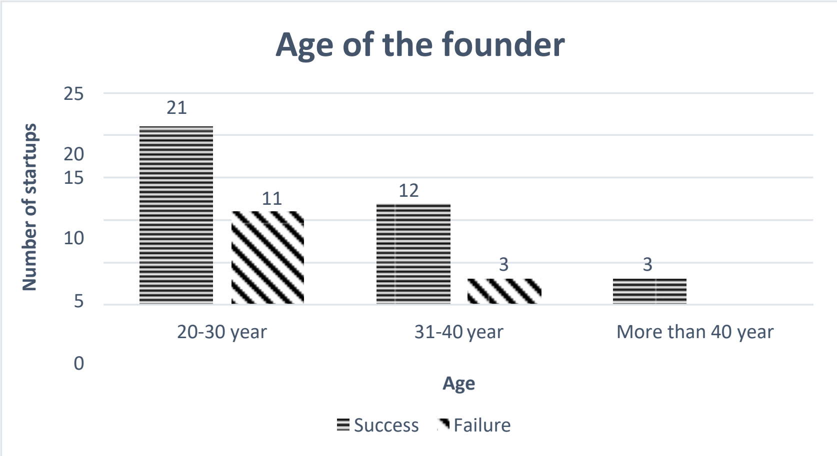

Figure 5.1 Age of the founder

The success rate per age group were:

Age group	Success rate
20-30 year	65.6 %
31-40 year	80 %
> 41 year	100

This shows that there is no age limit to be an entrepreneur and to start one's own successful journey in business. However, the higher the age group the greater their chance to succeed.

BUSINESSES PRESENT WORTH VALUES (IN M$)

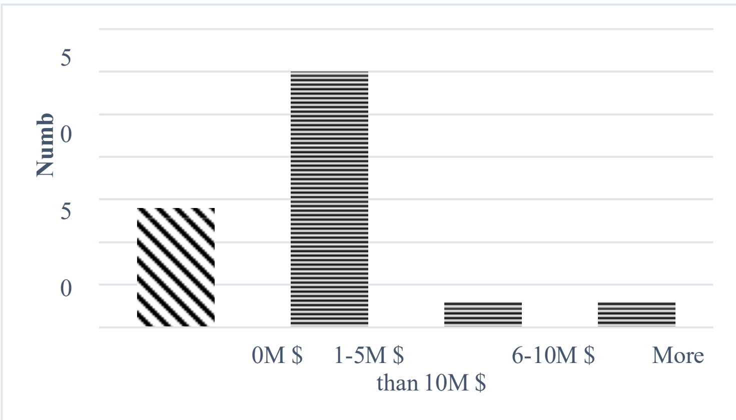

Figure 5.2 Businesses present Values ($)

These valuations range between 0(failed) and 10 M $ divided as follows:

- 0 M$: for the 14 failure case, They worked between one to three years before closingthe business because of they don't have the ability to continue
- 1-5 M$: for 30 start-ups

- 6-10 M$: for 3 start-ups
- More than 10M$: for 3 start-ups

This shows the variety of businesses size in the sample and the value of start-up business

EDUCATIONAL LEVEL WHEN ENTREPRENEURS STARTED THEIR BUSINESSES

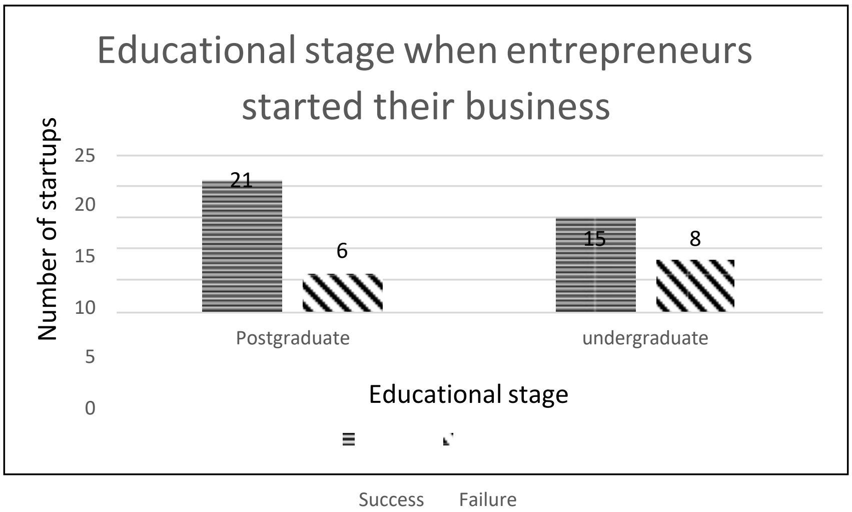

Figure 5.3 Educational stage when they started the business.

The success rate per education level were:

Education level	Success rate
Undergraduate	65.2 %
Postgraduate	77.8%

The results show that post graduate education gives the entrepreneur greater chances of success. However, both undergraduate as well as postgraduate entrepreneurs can be successful.

FIELD OF BUSINESS OF THE STARTUPS

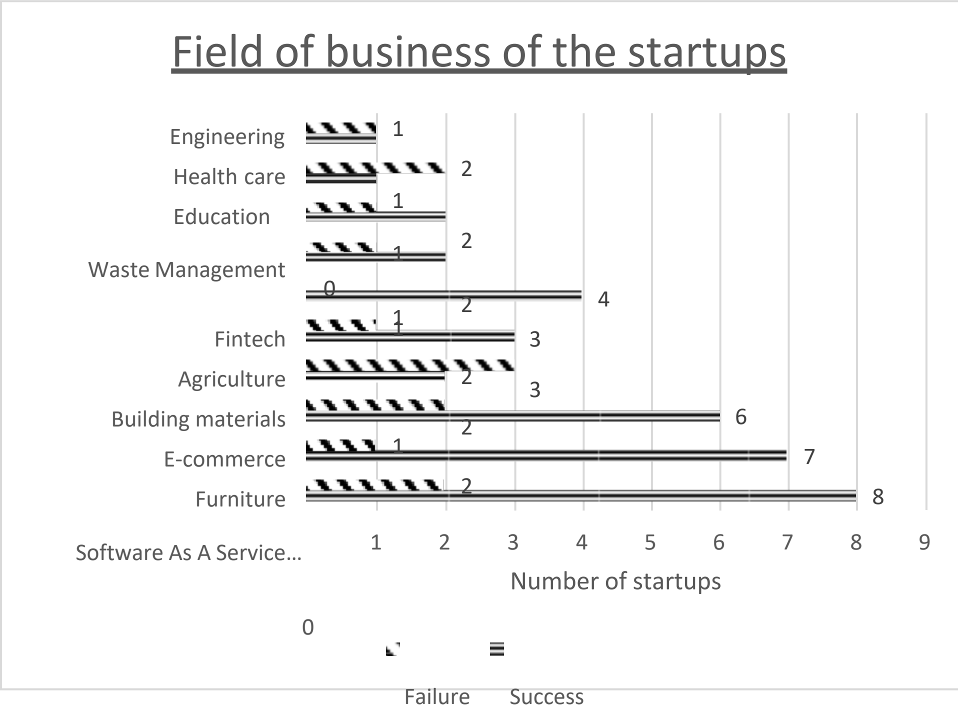

Figure 5.4 Start-up business field

The start-ups businesses represented most of the fields/sectors such as Software As A Service (SAAS), Furniture, e- Commerce, Building materials, Agriculture, Fintech, Education, health care, and Engineering.

Start-up field / sector	Success rate
Engineering	50 %
Health care	33.3 %
Education	66.6 %
Waste management	66.6 %
Fintech	100 %
Agriculture	75 %
Building materials	40 %
E-commerce	75 %
Furniture	87.5 %
Software as a service	80 %

PRIOR EXPERIENCE

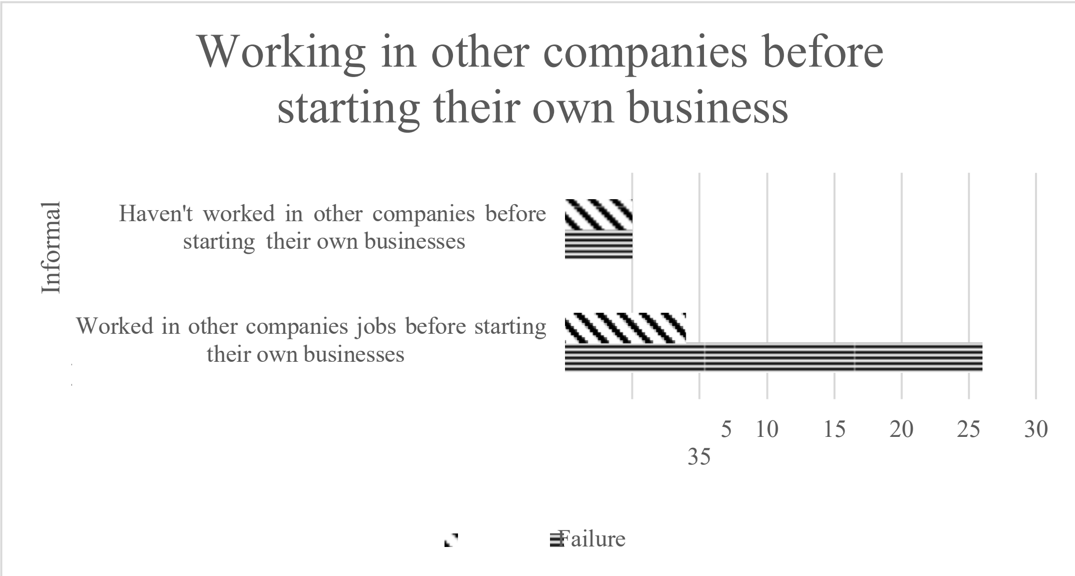

Figure 5.5 Working in companies before starting your own business

More than 70 % of the founders have worked during their studying stage or worked in other companies after graduation before starting their own businesses.

This shows the importance of gaining experience during working within a previous jobs that motivated them to start their own businesses later on.

FAMILY BUSINESS RELATION:

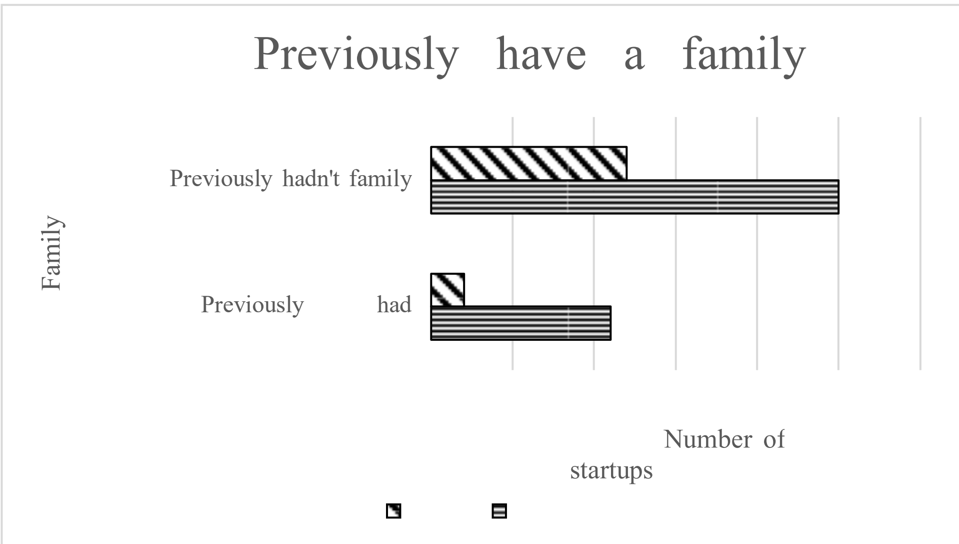

Figure 5.6 Family business relation

More than 60% of the founders did not have any family businesses before starting their own businesses.

This shows that it is not very important to have a previous family business to start a successful own business.

FACTORS AFFECTING THE MOTIVATION OF THE ENTREPRENEURS

The interviews indicated that the most effective factor that motivate many entrepreneurs to start and continue their businesses are:(as in figure 5.7)

The most effective factor affecting the motivation to start own business are seen as:

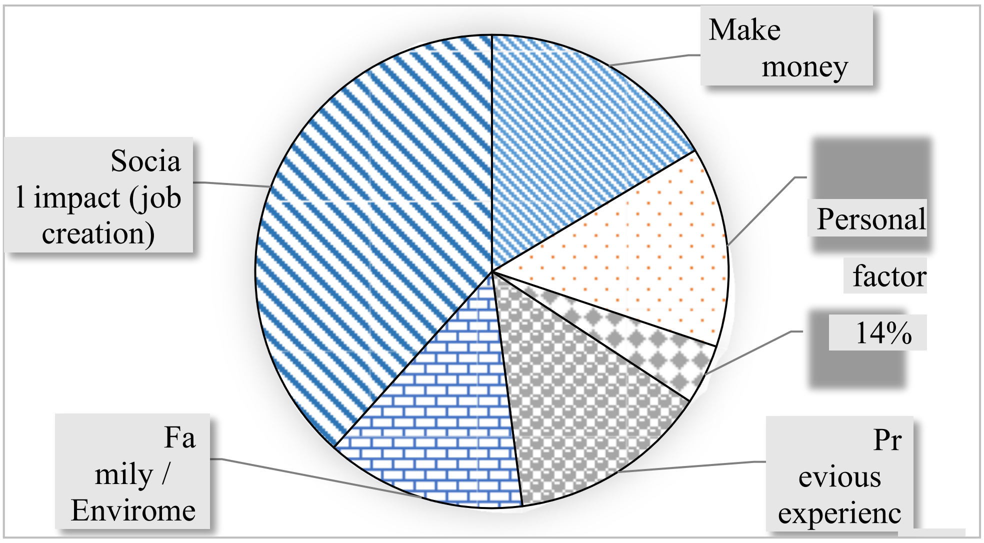

Figure 5.7 The most effective factor affecting the motivation to start own business

- Social impact prospective: by creating job for others in the community. (38%)
- Family / Environment: The living environment of entrepreneurs or their families' traditions of taking responsibilities at the earlier age. (16%)
- Personal factor: which create their own careers and achieve their dreams at their own decision. (14%)
- Previous experience: having a good experience in a certain field and they want to take advantage of that. (14%)
- Making money: That is, aiming at gaining good financial returns in shorter time byestablishing new successful businesses. They may also had the chance later to sell them to investors. (14%)
- Others: This mean that these particular entrepreneurs have none of the above motivations to start their own businesses. This sample is subject to fail. (4%)

The analysis showed that 66% of the chosen factors have almost, equal effect on the entrepreneurs (between 14% and 16 %). However, it was surprising to notice that most of the interviewees have started their business derived from their desire to support the community through offering social activity through the generation of new job opportunities (38 %).

Also, 4 % of the interviewed showed that they had no motivations to start their own businesses, but just came by luck. This might be one of the major causes that made them to fail.

SOCIAL FACTORS SUPPORTED THE ENTREPRENEURS TO START OR CONTINUE THEIR BUSINESSES

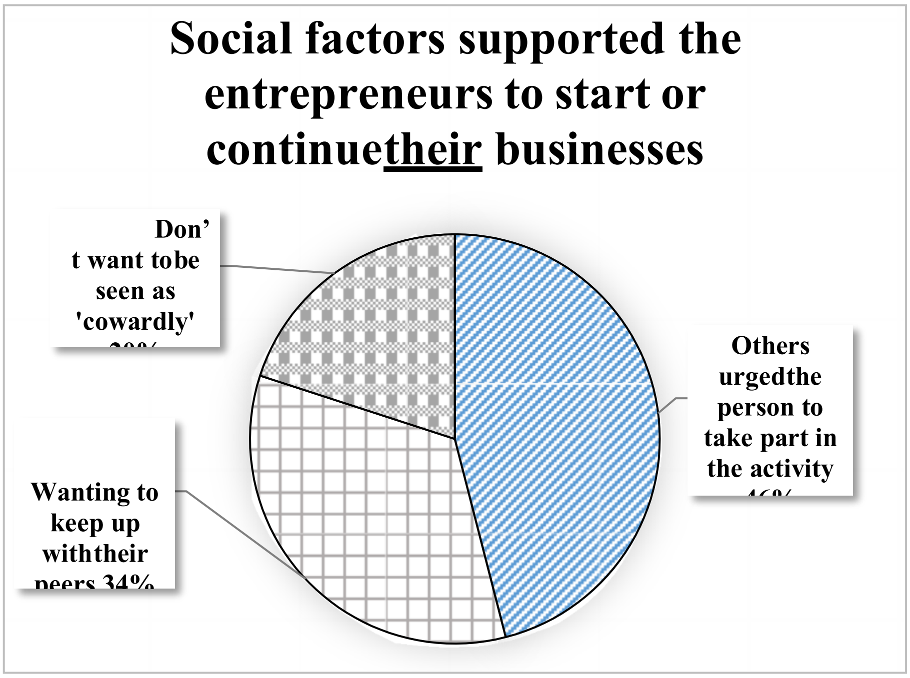

Figure 5.8 Social factors supported the entrepreneur to start or continue their businesses

As illustrated in figure 5.8 there are social factors which encourage the entrepreneurs to start and continue with their start-up enterprises. The interviews showed that there are three main social factors in that sense as follows:

- Others urged them to succeed: Their families or network urged them to be successful entrepreneurs who encouraged them to continue even though they may figure out it is too hard to do so. (46%)
- Wanting to keep up with their peers: They always looking for their peers and challenging themselves to be more successful. (34%)
- Don't want to be seen as 'cowardly': Most of them related this to the above factorswhich means they failed in their challenge because they are afraid of failure. (20%)

This shows that the start-ups need a motivation to start his own business even if it is a mental or psychological motivation or culture motivation

The interview showed variation in the responses of the samples whether for causes of successes or failures cases. The most obvious responses were about the risk attitude and networking importance.

a- Risk attitude

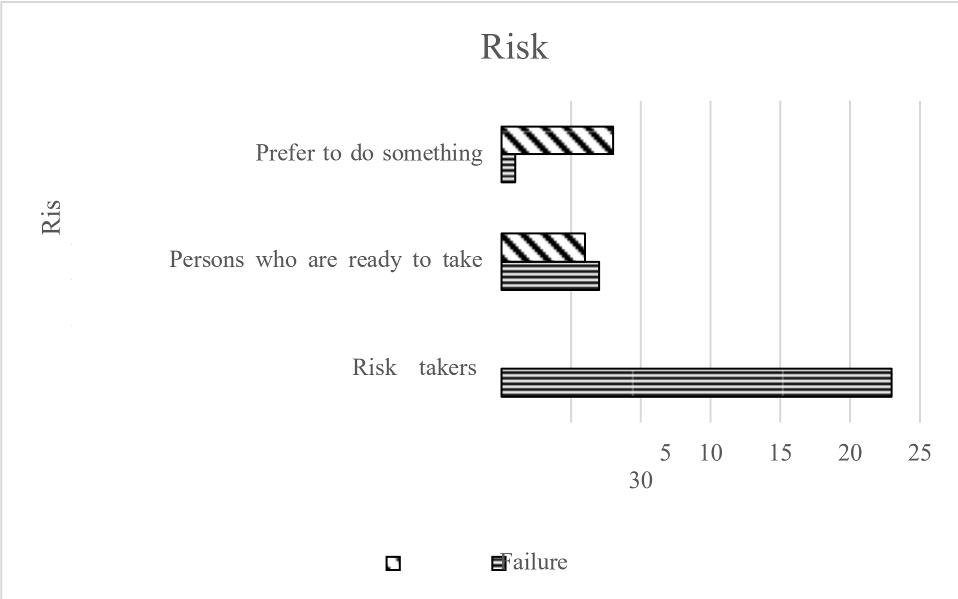

Figure 5.9 Risk attitude

One of the most important traits for entrepreneurs is the ability to take a risk. The interviews showed that there are three option to measure the risk attitude at the start of the business as follows:(the above figure 5.9)

The success cases: (36 start-up) were very clear with their responses regarding this subject, as 77.8 % of them chose "they are a risk takers at any cost", 19.5% chose "ready to take some risk", and 2.7% chose "Prefer to do something less risky".

In the failed cases: 42.9% chose between "ready to take the risk" and 57.1% chose "prefer to do something less risky.

Which shows that risk attitude is one of the main traits for a successful entrepreneur.

b- Networking skills

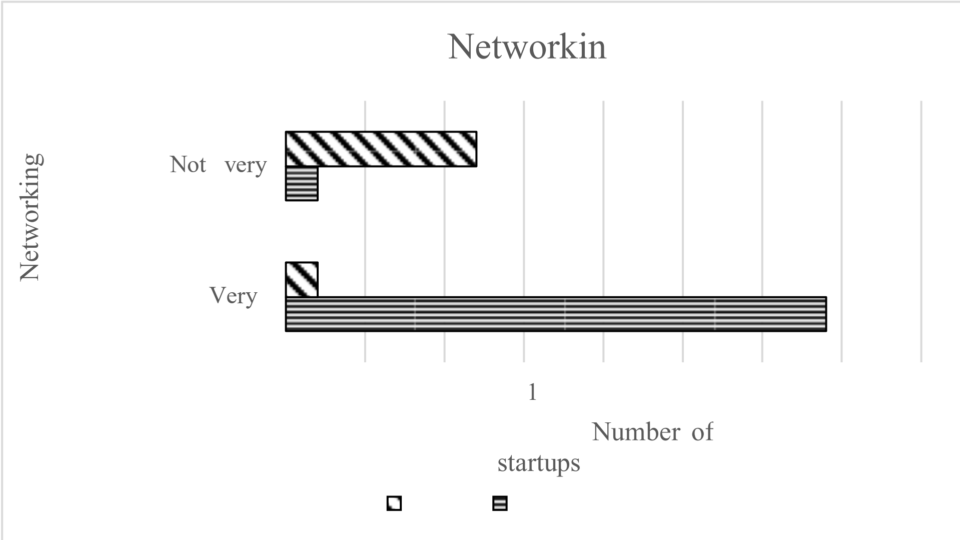

Figure 5.10 Networking skills

In the questions regarding their ability to build a social network to scale up or sustain the growth of their businesses by partnering with others, figure 5.10 illustrates the results.

In the success cases 36 start-ups 94.4 % of them chose “networking is very important” On the other hand, 85.7% of the failed cases chose “networking not very important”

Which shows that networking is very important traits contributing to the success.

GEOGRAPHICAL DISTRIBUTION OF THE ENTREPRENEURS

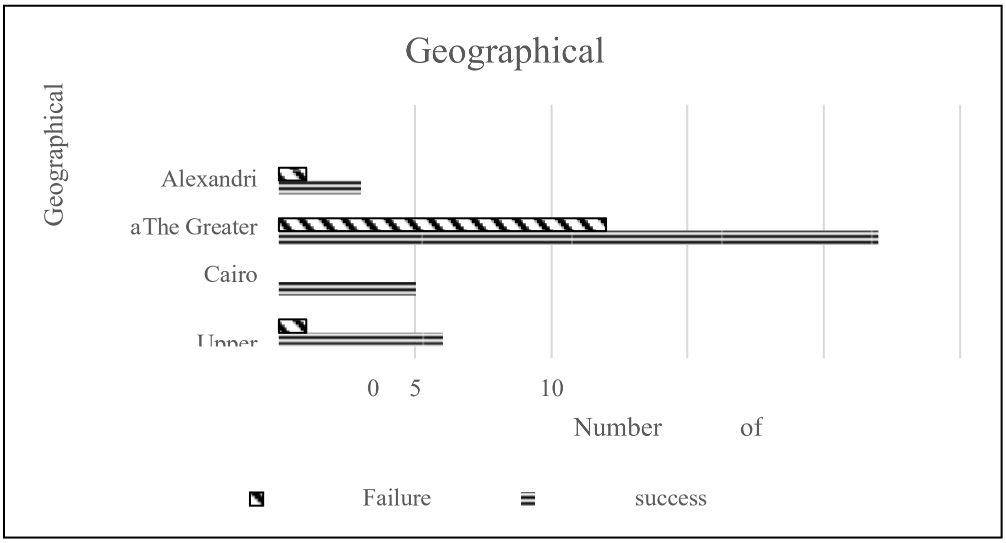

Figure 5.11 Geographical distributio

As illustrated in figure 5.11 different geographical areas have been covered, namely Delta, Upper Egypt, greater Cairo and Alexandria as follows:

Governorate	**Success rate**
Alexandria	75 %
The greater Cairo	64.7 %
Upper Egypt	100 %
Delta	85.7%

This shows that the geographical area may affect the success or failure of the business regarding the cultural factor of the geographical area.

GENDER DISTRIBUTION

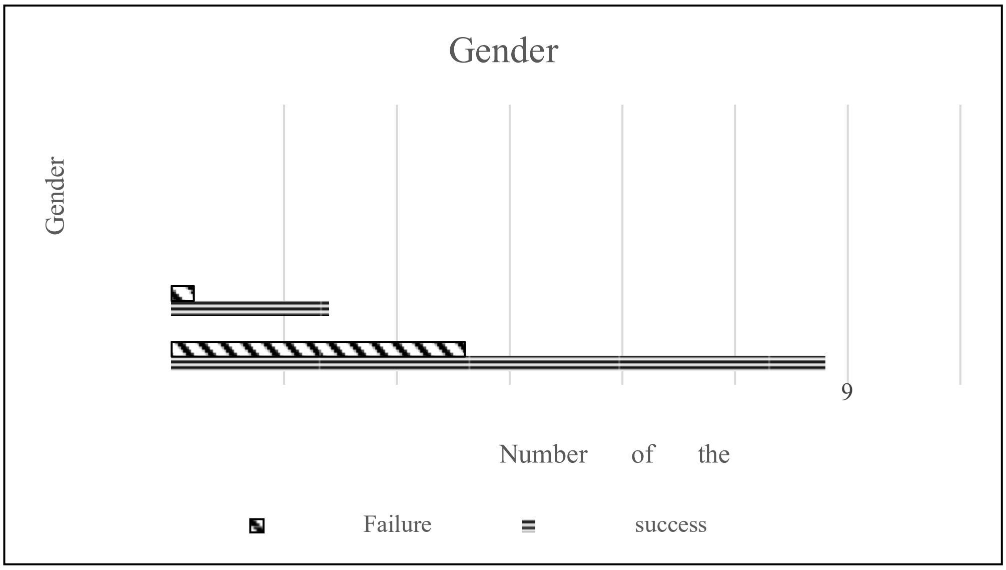

Figure 5.12 Gender distribution

Gender	Success rate
Female	87.5 %
Male	69

This is significant, hence we need more support to be offered to the female entrepreneurs as they have a high rate of success comparing with the male entrepreneurs

NUMBER OF EMPLOYEES WORKING IN THE STARTUP BUSINESSES

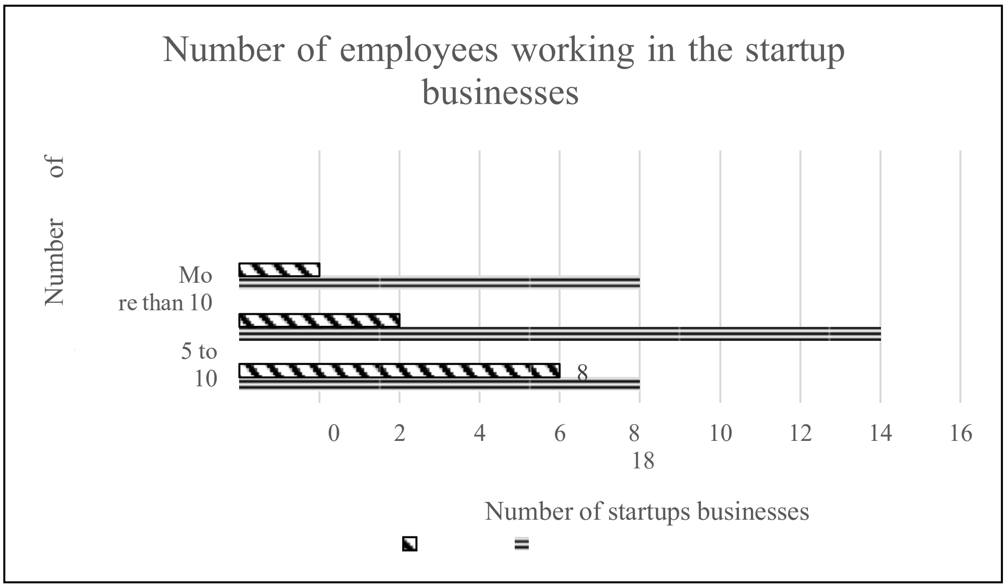

Figure 5.13 Number of employees working in the start-up's businesses.

As illustrated in figure 5.13 the number of employees is different from startup to another as follows:

Number of employees working in the start up	**Success rate**
1 - 5 years	55.6 %
5 - 10 years	80 %
>10 years	83.3%

This shows that the start-up is not considered as a job creator for the first 5 years but they can offer more opportunity after scaling in the market

The traits of the first sample of entrepreneurs

- The main personal characteristics and traits associated with entrepreneurs as deducted from entrepreneurs' points of view.

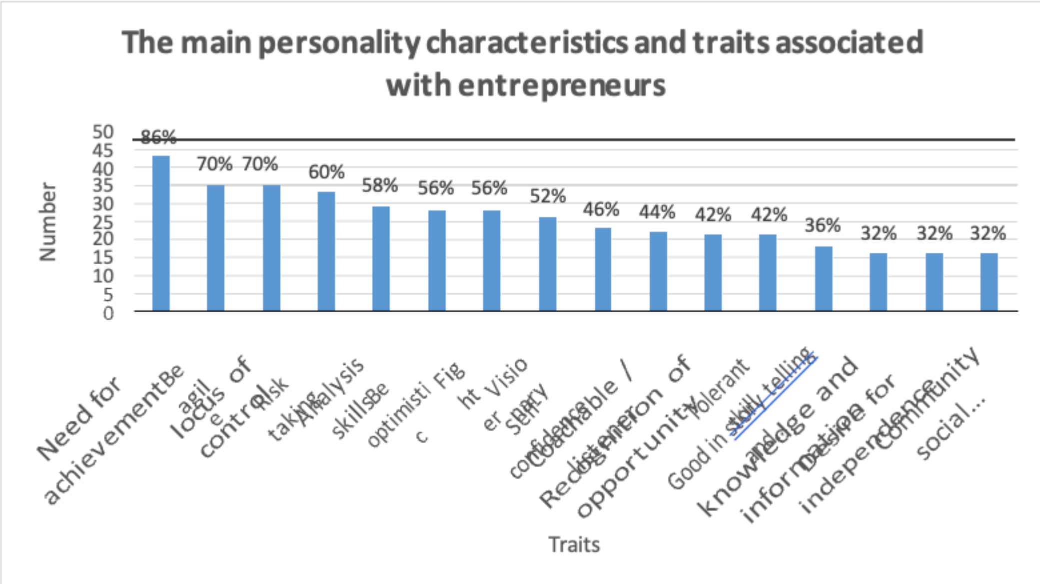

Figure 5.14 The main personal characteristics and traits associated with entrepreneurs' point of view

As illustrated in figure 5.5 there are around sixteen traits and characteristics, which affect the personality of the potential entrepreneur and encourage him to succeed. The highest one chosen by 86% entrepreneurs is the need for achievement. The lowest one with 32% entrepreneur in community social responsibility CSR skill.

Results of the stakeholders' questionnaire:

The followings show the results of the questions raised through the questionnaire given to representatives of the Egyptian entrepreneurship ecosystem.

Description of the stakeholders

STAKEHOLDERS' CLASSIFICATION

Figure 5.15 Stakeholders' classification

As illustrated in figure 5.6 the researcher met a variety of stakeholders representing the entrepreneurship ecosystem in Egypt, as follows, and shared their views.

Stakeholders representatives	Number
Incubator	8
Accelerator	2
Venture capital	2
Mentor	6
Non-financial support entities	6
Banks	2
Governmental entities	4
Angel investor	2

Findings of stakeholders discussions

STAKEHOLDERS' VIEWS ABOUT SUCCESS FACTORS

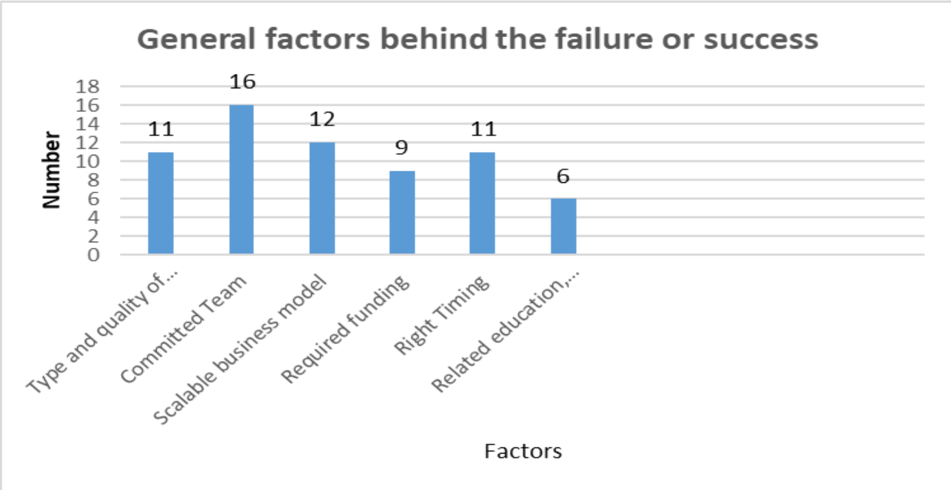

Figure 5.16 The general factors behind the success (stakeholders)

As illustrated in figure, 5.7 responses revealed that there are general factors affecting the success or failure of the startups as follows:

- Type and quality of Innovative product/service:
- Committed Team
- Scalable business model
- Required funding availability
- Proper timing of product introduction
- Relevant education, training, and qualifications

This shows the general factors affecting success or failure of the start-up and that the highest factor is the "committed team".

II. All stakeholders have unanimously stated that the entrepreneurs' traits and characteristics are very important for the success of the startup

III. The traits or characteristics of the founders which affect the failure or success

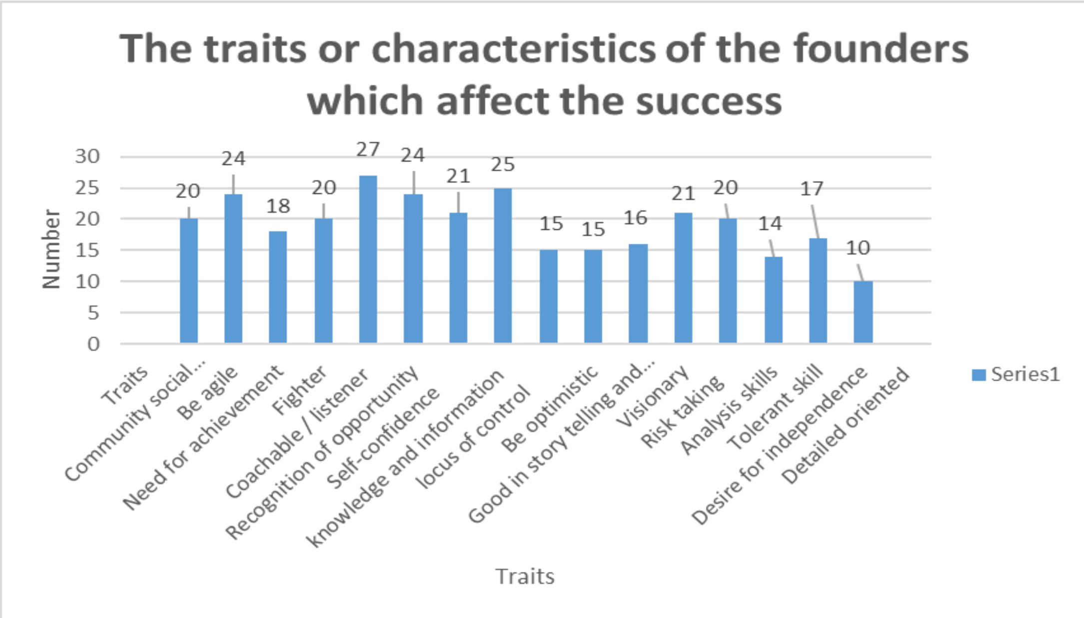

Figure 5.17 The traits that affect success (stakeholders' point of view)

As illustrated in figure 5.8, stakeholders showed the traits that achieved the high scores which was found that they match the entrepreneurs' point of views as in figure 5.5

Discussion

The Chi-square test was applied to compare between the importance of the traits in the sample and the validation group. A sample of 50 entrepreneurs in the test sample and 51 entrepreneurs in the validation sample were conducted. It was concluded that with a 95% confidence level, Risk-taking, Optimism, Fighter, Analysis skills, Visionary, Self- confidence, Recognition of opportunity, Good in storytelling and communication skills,

"Tolerant", "Community and Social Responsibility", and "Desire for independence" are the traits that both groups of entrepreneurs, the test, and the validated samples, agreed on.

In the traits "Knowledge and information", "need for achievement", "locus of control", "agile", and "Listener and Coachable", the sample of entrepreneurs thought that they are not important while 95% of the validation group thought that they are important.

Two entrepreneurs in the validation sample added one trait that was not in the test sample. The trait was "Social Intelligence" which may be important too, as it refers to a person's ability to understand and manage interpersonal relationships with others.

The comparison between the sample and the validation groups responses are tested statistically to validate the outcomes of the sample responses.

Conclusion

The importance of this research topic reflects the pressing needs of the Egyptian start-up businesses' community to identify the proper traits of Egyptian potentially successful entrepreneurs. This is because in Egypt, a considerable number of startup businesses fail and the community stakeholders suffer from investing in the wrong persons.

The dissertation covers several diverse topics: definitions of the most popular terminologies for entrepreneurship, the components of the entrepreneurial eco-systems, the framework for linking entrepreneurship to economic growth, and the integration of entrepreneurship with the global economy. It focuses on the types of entrepreneurs, their psychology and their expected roles in the Egyptian society and economy. The opportunities and challenges facing the entrepreneurs, their personal characteristics, and traits are identified showing examples from other countries.

It is noticeable that the Egyptian educational and social systems do not encourage the entrepreneurial thinking. The role of entrepreneurship and innovation to be side by side, is not emphasized

It is concluded that there are two different groups of factors affect the success or failure of startup businesses. The first group is addressing the business itself such as: type and quality of innovative product/service, the presence of a committed team with entrepreneurial spirit, scalable business model, suitable funding, right timing, related education, training, and qualifications. No previous research in Egypt has tackled the psychological features of entrepreneurs themselves such as: personal needs for achieving a breakthrough and success, internal locus of control, ability to take risk, tolerance for ambiguity, and proper behavior. These are addressing the personal merits, characteristics, and traits of the entrepreneurs. These are the second group of factors and have been discussed in this research work.

Statistical analyses were carried out to compare between the results of responses of the sample and the validation group. This showed that eleven traits were unanimously agreed upon by both groups as mentioned in results section.

As in table 7.1 below, the outcome of this research work is a list of sixteen traits influencing the success of Egyptian entrepreneurs some of these traits are collected from the literature. The rest of the traits are the outcome of this research work.

Table 7.1: The personal traits influencing the successful entrepreneurs in Egypt

No.	The personal traits influencing the successful entrepreneurs in Egypt	Literature outcomes	Research additional outcomes
1	Need for achievement: always looking to achieve something for themselves or for others	x	
2	Locus of control: Believe that the achievements they got intheir businesses are the result of their skills, attributes and not due to luck	x	
3	Risk taking propensity: Willing to take risks to achievetheir dreams.	x	
4	Self-confidence: Confident with what they are doing and whatever the results they achieved	x	
5	Tolerant skill: Be able to tolerate uncertainties and acceptsthe results	x	
6	Knowledge and information: Have knowledge and hold experiences from their previous works	x	
7	Desire for independence: That is, entrepreneurs do not liketo work in a hierarchy of posts, or working for others, but they are looking to have their own businesses.	x	
8	Recognition of the opportunity: Main skill to recognize the opportunity through the noticed problems or needs	x	
9	Community Social Responsibility (CSR). Obviously, they like to avail new job opportunities and innovate new products, both to support and serve the community. This reflects the unique culture of the Egyptians to help their neighbors and the community as part of the motivation factors to start their own businesses.		x
10	Coachable / Good listener: This is also a part of the Egyptian family culture of the members listen carefully to their parents and older persons. This means that they takethe advises from others into considerations.		x
11	Agile: This is by having insights to convert the problems they meet during their businesses into new opportunities fornew businesses.		x
12	Good in storytelling & Communication skills: This reflectsthe Egyptian culture of storytelling reflect the gained culture during their early ages with elder people of the family		x
13	Analysis skills: One of the important trait and skill most ofthe interviewees mentioned are the need and ability to analyze the problems they face to be able to learn and gainmore experience and benefit from the opportunities they face in their start-ups journey.		x
14	Visionary skill: This is normally needed after analyzing their situation to be ready for the next stage in their businesses.		x
15	Fighter / persistence skill: They face many obstacles and problems which may let them fail easily but they need persistence skill to be able to continue.		x
16	Optimistic skill: In case of challenges this skill is a MUSTto continue since the only one who mostly believe on the person is the person himself and hence he must be optimistic to be able to continue and succeed		x

The importance of these traits was judged by a group of entrepreneurs, and then validated by a different group. Moreover, stakeholders were also approached and confirmed the results

Significance and outcomes of the research work

Identifying the personal traits influencing the successful entrepreneur can guide investors, banks, government, educational institutions to define type of support / services that can be offered to the potential entrepreneurs.

Research outcomes:

- The output of this work can be utilized towards several actions/projects directedtowards the Egyptian entrepreneurship ecosystem.
- Aptitude tests to be carried out by different entrepreneurship support organizations to forecast the possible success of their investments.
- Team building activities or training plans to be designed according to the resultsof identifying the proper characteristics that should be possessed by the entrepreneurs to succeed.
- Recommendations for Egyptian educational system to build required skills andurges certain behaviors.

These Outcomes can positively:

- Enhance entrepreneur's success rate.
- Support the Egyptian economy

This research work provides a guide for government authorities, financial institutions, investors and community at large in supporting the entrepreneurs to start and grow their businesses.

Research limitations

There are some limitations for this research as follows:

- Access to personal traits for the Egyptian entrepreneur's data
- All the cost of the research covered by the researcher which make the possibility ofcommercialized the results into a psychometric assessment tool is difficult.

Future work

Psychometric assessment needs to be developed to be tested by the stakeholder's representatives before offer any type of support to reduce the failure rate of the startups.

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The share fate of technologies and supply chains: from global to adaptable supply chains

Abstract ID#324

Michel Leseure (University of Portsmouth, UK)

This paper argues that two key theories have shaped the modern context in which technologies are developed, commercialised, and achieve success.

The first theory is that of global value creation (Gerefii and Lee, 2012) which explains why outsourcing and offshoring practices have been so successful. The root principle was the idea that firms do not compete with one another; instead supply chains do (Christopher 1992). The cost benefit achieved by either consolidating manufacturing facilities to achieve economies of scale or/and benefitting from lower labour cost was such that global supply chains principles would prevail, and this despite the potential impact on lead times (Christopher et al, 2006).

Michael Porter's 1998 theory of the new economics of competition, where he introduced the concept of clusters, is the second theory. Over the years, the idea of investing and nurturing clusters expanded to the point of becoming the sole focus of policy making. The concepts of smart specialisation (Foray, 2014) and Technology Innovation Systems (Bergek and Jacobson, 2003) continue this tradition. Instead of focusing on cost advantages and distribution networks, smart specialisation focuses on the requisite environment for the creation of unique entrepreneurial networks that can develop a core technology which is unique enough that a co-ordinated proactive local cluster can become the central node of a global supply chain, even in the absence of local cost advantages.

Combining the two theories together provide a simple way of designing the supply chain for a new product. If the underlying technology is basic (e.g. requiring labour intensive practices), it is likely that the product should be relying on a global supply chain for commercial success. Low cost become the barrier to entry. It is only in the case where the underlying technology is difficult to transfer or acquire that a cluster can emerge, with global value creation being concentrated in that local cluster.

By combining these two theories together, it is easy to explain technology success and to predict the ability to deliver high quality products at a low cost to consumers. As a result, the fate of technologies and supply chain have become inextricably linked.

The volatility, uncertainty, and strategic ambiguity experienced by supply chain in the last 5 years has been unprecedented. It challenges the decision to rely on global supply chains as the best model to commercialise (or transfer) technologies. The paper develops a typology of supply chains by using supply chain risk and the extent to which a smart specialisation advantage can be developed at the technology development stage. Case studies are used to provide illustrations of three commonly used types of supply chains: local integrated supply chains, global cost leaders, and "smart" supply chain (i.e. based on cluster). Case studies include the success of Koutoubia, which introduce a new meat product in Morocco by focusing on developing a full supply chain from scratch, the textile supply chain, the windsurfing industry, offshore wind supply chains, and the Taiwanese chip industry.

The paper shows how industries previously described as resounding success are failing today and cannot be described as being sustainable any longer (often against all three dimensions of sustainability). The lack of performance in the face of increased volatility echoes the work of other researchers arguing that smart specialisation may not be, in the end 'so smart' (Weller and Rainnie, 2021). Whereas global supply chain researchers called for the need to avoid a "one size fits all" stereotypic view of global supply chains (Cohen and Malik, 1997; Christopher et al, 2006), this did not happen and instead poor performance is reinforced by path dependency, i.e. the inability of supply chains to adapt away from a set model.

In order to complete the typology, we argue that since the fate of technologies is tied to supply chains, we need to redefine high performance supply chains as adaptable supply chains, using the definition of adaptability proposed by Katayama and Bennett (1996, 1999). This recommendation is illustrated with a scenario analysis of future car technology for the UK's plan to ban sales of internal combustion engines in 2030 and 2035 for hybrid vehicles. The decision to focus on electrical vehicles seems an unlikely scenario as supply chain challenges are enormous (but support a future market in which electrical vehicles are niche products). The fuel cell scenario is more promising as it relies on adapting an existing supply chain.

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INNOVATION CAPABILITIES IV

May 3rd: 3h10 pm – 5h pm

Chair

Anthon Botha (University of Pretoria, South Africa)

Papers

High digital growth: Essential capabilities and the research agenda
André Luiz Damasceno, Cristiano Morini, Edmundo Inácio Jr

Innovation capabilities in manufacturing firms: New evidence from Brazil
Nathalia Pufal, Denise Barbieux, Guilherme Camboim, Paulo Antonio Zawislak

Innovation Capability: A Systematic Review of the Chinese Industry
David Mayorga, Jorge Tello-Gamarra, Martín Hernani-Merino, Julio Zevallos

Paths of Innovation in the São Paulo Industry
André Alves, Nathália Pufal, Denise Barbieux

The Industry 4.0 technologies as motivators to the adoption of Circular Economy in foodtechs: An analysis in the stakeholders perspective
Tiago Hennemann Hilario da Silva, Simone Sehnem

High Digital Growth: Essential capabilities and the research agenda

Abstract ID#236

André Luiz Damasceno, Cristiano Morini, Edmundo Inácio Jr (Unicamp, BR)

Purpose

The research aims to investigate the capabilities essential for high digital growth.

Literature Review

Entrepreneurship plays an essential role in the economic growth and development of countries and their subregions (Cantner & Wolf, 2018). In this scenario, high-growth companies stand out as the major responsible for strengthening economies (Acs, 2011). Recent research efforts have analyzed the determinants of success or failure of digital businesses (Allegretti, Seidenstricker, & Kasseckert, 2018; Alroaia & Baharun, 2018), indicating the need to make efforts to understand the essential capabilities that induce high growth. Growth and evolution are desired goals for most organizational leaders and managers. At the same time, companies need to expand their capacity to generate revenue, profitability, and wealth by entering new markets, formalizing processes, and attracting and retaining talent. In the view of Gerhardt et al. (2021), high digital growth develops based on the following elements: (i) adoption of a lean structure from the beginning; (ii) scalability; (iii) replicability of processes, products and services; (iv) innovation; (v) ability to operate in an uncertain environment; (vi) development of favorable relationships with relevant players and agents; (vii) effective adoption of Industry 4.0 technologies; (viii) communication; and, (ix) ability to use venture capital. Fostering knowledge is critical for any business ventures, but "it is especially so for startups that expect high growth rates. In the "fauna of high-growth entrepreneurship" (especially of digital businesses), it is mandatory to address 'three animals' of note: gazelles, unicorns, and dragons, which make up part of a taxonomy widely adopted in the literature. For didactic reasons, the terms will be used in this section. In an investigative study on the participation of firms in U.S. economic growth, the concept of gazelle firms was introduced. Gazelles are young businesses, less than five years old, which employ more than ten workers and exhibit annual growth of more than 20 percent per year over a period of at least three years. These businesses generally have a greater capacity for long-term survival and job creation. The high-growth theme also includes unicorns, companies that are valued at more than US$ 1 billion in market value. More than 1,000 companies reached this level in February 2022. Unicorn companies comprise a part of the entrepreneurial ecosystem called "ambitious entrepreneurship." These companies explore opportunities for new goods and services aiming for maximum added value, with accelerated growth and market value. This leads to a higher probability of achieving growth, innovation, and internationalization of their companies.

Methodological Procedures

A systematic literature review was performed using the Scopus and Web of Science databases to generate a bibliographic portfolio of 139 articles on the key topics. The bibliographic portfolio formed subsidized the other stages of the research.

Findings

The proposition of a summary table containing the identified core capabilities of the startup, growth and expansion stages, and a research agenda for high-growth digital businesses.

Implications

The literature on digital business entrepreneurship has advanced significantly, having contributed in a relevant way to the understanding of the theme. In this research, the authors sought to offer an analysis of these studies, at the moment of recognition of the 1,000th company-unicorn, analyzing the bibliography that deals with the theme to identify the capabilities needed to stimulate the high growth of organizations. With this, we arrived at a framework, which offers an organized vision in 3 stages and 5 dimensions. In this holistic perspective, the authors considered the incremental assimilation of capabilities, since moving to the next stage does not require the abandonment of the capabilities of the previous stage; on the contrary, at each stage advancement, high growth companies are challenged to deepen and adapt the capabilities already acquired, according to the organizational environment, decreasing the risks of failure. The study can be enhanced by developing and applying techniques to empirically verify the validity of the framework and the presence - or absence - of the capabilities. Following the paper, we proposed some questions that may support future research. The list, although not exhaustive, is intended to support the advancement in scientific understanding on the topic of high growth, subject little explored in the literature. The questions proposed by the study address issues at different stages; the phenomenon of high growth involves the ecosystem, the entrepreneur, and the organization at various stages of the life cycle. The analysis is intended to be a starting point, supporting researchers in developing approaches and perspectives for developing a theory of high growth.

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Innovation capabilities in manufacturing firms: new evidence from Brazil

Abstract ID#314

Nathalia Pufal, Denise Barbieux, Guilherme Camboim, Paulo Antonio Zawislak (Federal University of Rio Grande do Sul)

Purpose

The aim of this study is to analyze the innovation capabilities of Brazilian manufacturing firms.

Literature Review

Brazil is a country where the low level of knowledge circulation and the low technological base generate a product profile with limited market penetration – either because they can be easily copied or because they are technologically outdated. In both situations, the remaining strategy is to compete for price, given the homogeneity of the products, which tends to generate lower levels of profit for firms and, therefore, a small potential of GDP growth (Reichert et al., 2015; Alves et al., 2017). This configuration, combined with the prevalence of small-scale production, puts Brazil far behind leading countries. The key factors for gradually narrowing the gap vis-a-vis leading countries are learning and building innovation capabilities (Fan, 2006; Lee and Malerba, 2017). It is from the applied knowledge to new solutions offered in the market as goods and services by firms, that sectors and countries advance to higher levels of technological development. Therefore, it is important to know which capabilities lead to higher innovative performance. Expanding on the idea that solely the technological capabilities, those related to product and process, will lead any firm to achieve innovative performance (Dosi, 1988; Lall, 1992; Bell and Pavitt, 1993), Zawislak et al. (2012) propose an innovation capabilities model that encompasses both technological and non-technological capabilities: development, operations, management, and transaction. In this paper, we analyze these four capabilities in Brazilian manufacturing firms.

Methodological Procedures

We conducted an innovation survey in 2021 that focused on understanding the innovation capabilities in Brazilian manufacturing firms. The survey received 1,304 from senior managers or owners of firms. The questionnaire was based on the Innovation Capability Model proposed by Zawislak et al. (2012), relating to the four innovation capabilities. Descriptive statistics, mean and regression analyses were used to assess how are the innovation capabilities arrangement of manufacturing firms in Brazil. We also analyzed specific firms' characteristics.

Findings

Results show that Brazilian manufacturing firms act mostly in low technology and medium low-technology industries, representing 80% of the sample. Descriptive analyses show that the main determinant of decision-making by such firms is strategic planning, followed by knowledge developed internally, recent performance, information provided by customers, information obtained from suppliers and, finally, information observed in competitors. The predominant management system is to be run by the family, followed by professionalized family, professionally and by corporate governance. Prices are mostly set based on costs, followed by market prices, intended margin, perceived quality, brand reputation, and lastly, prices determined by the customer. The main sales channel used by firms is their own physical point of sale, followed by their own website, intermediary representation, direct sales to retailers, direct sales to other firms, direct sales to wholesalers, a third-party physical point of sale and, finally, a third-party website. Most of the production schedule is made according to placed orders, followed by sales forecast, installed capacity and the pace dictated by sales. The main factors that trigger development in these firms are customer requests, improvement of existing product and increase in product portfolio. Development is mostly carried out based on formal project activity, informal resolution activity, and formal and continuous activity. Mean analysis reflects what the firms perceive as more relevant to achieve better performance. Therefore, results show that firms focus on operations capability at most, followed by management, transaction, and development capabilities. However, when we look at the impact on performance, results are different. Regression analyses aimed to identify the best capabilities arrangements for innovation performance. Whereas management, transaction and development capabilities appear as the three capabilities responsible for firm performance, in this respective order of importance, operations capability does not appear as significant for the model. In sum, manufacturing firms in Brazil still rely on production and efficiency, rather than on product development and commercialization. Firms focus on the capability that does not impact significantly on performance, i.e., operations capability. To improve their performance over time, manufacturing firms in Brazil should focus on developing strategic management and new business models, differentiated products with high added-value and new ways of going to the market.

Implications

By showing new evidence with empirical micro-level data, this study contributes to the analysis on innovation capabilities in developing countries, which is still scarce. This paper enlightens the discussion for innovation in manufacturing firms and effective strategies to develop their capabilities over time. This study may also contribute to the design and implementation of industrial innovation policies by elucidating that actions should focus on management, transaction, and development capabilities, rather than promoting operational efficiency. As for managers, they could benefit from the proposed discussion to conduct changes within their arrangements of capabilities towards innovation and competitive reconversion.

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Innovation Capability: A Systematic Review of the Chinese Industry

Abstract ID#235

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Purpose

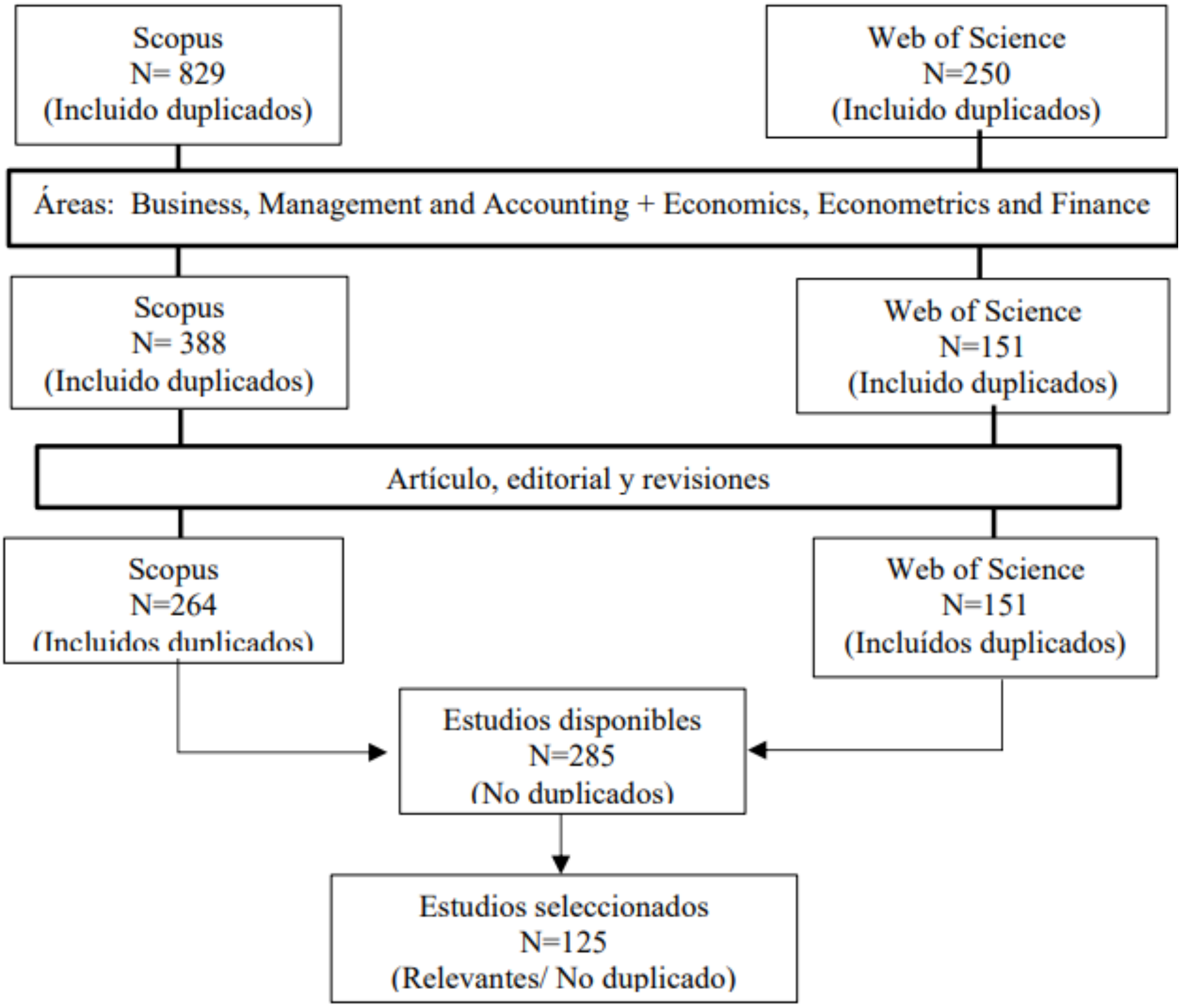
Innovation capability is a broad and complex construct. In the literature, systematic reviews on innovative capability have attempted to understand this complexity. Despite these advances, systematic reviews of the literature on innovation capability are still scarce and do not address specific contexts. Consequently, taking the context of the Chinese industry, the objective of this article is to broaden the understanding of the capability for innovation.

Literature Review

Innovation capability is a meta-capability composed of a set of capabilities. At the beginning of the century, Lawson and Samson (2001) described the capability for innovation as the ability to continuously transform knowledge and ideas into new products and processes. Later, Guan and Ma (2003) indicated that the capability for innovation is a special asset on the part of the firm, closely related to its internal activities. Later, Yam et al., (2011) mention that the capability for innovation is the set of characteristics that drive strategies for the benefit of technological innovation. Given the scope of the capability for innovation, it is a complex task to study it. For example, there is no clear consistency on the elements that make up the capability for innovation, these vary from organizational aspects (Le and Lei, 2019), relationships with thirdparty agents (Romijn and Albaladejo, 2002), among others. Likewise, in the literature, innovation capability is called in various ways: 'innovation capability' (Lawson & Samson, 2001), 'innovative capability' (Guan & Ma, 2003), 'technological innovation capability' (Yam et al., 2011), 'business innovation capability' (Perdomo-Ortiz et al., 2006), etc. Consequently, some systematic literature reviews began to emerge trying to give some order to the complexity that underlies the capability for innovation, these being the studies by Saunila (2019), Mendoza-Silva (2020) and Daronco et al., (2022). Despite the importance of these contributions, systematic literature reviews on innovation capability in the context of a region or country are scarce; therefore, there is a need to cover this gap in the literature.

Methodological Procedures

To achieve the objective of this study, we conducted a systematic review of the literature on innovation capability in Chinese industry following the methodology proposed by Trandfield et al., (2003). For this purpose, we follow three stages. First, using the scientific databases, Scopus and Web of Science (WoS), we conducted a search for the term “innovation capability”, among others; in the title, abstract, and keywords. Second, we filter according to areas of interest and types of articles. Third, we identified all articles without duplicates from both databases and evaluated them based on explicit exclusion criteria. We reached a number of 125 relevant articles, which are used for the dissemination of the results (Fig. 1).



Findings

The results provide four findings. First, we look at how the definition of innovation capability has evolved from a technology approach to a multi-capability approach. Second, we identify that, according to technological intensity, there is a presence of innovation capability in the technological intensity strata based on the OECD classification (2007). Third, we propose three perspectives on the capability for innovation for the Chinese industry, these being: multidimensional, technological, and non-technological. Fourth, we provide a framework for innovation capability in Chinese industry that considers institutional factors, background, dimensions, and performance.

Implications

We present theoretical and practical contributions. In the theoretical implications, the study aims to be a guide to study, assimilate and replicate the path of accumulation of innovation capability in the context of emerging countries. Regarding the practical implications, these can be about management and public policy. On managerial implications, we suggest that managers consider investing in managerial and transactional capability, this encourages learning and strengthens the firm's reputation. Finally, those responsible for public policy must create an atmosphere that encourages knowledge and technological development, promoting the collaboration of actors related to innovation.

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Paths of Innovation in the São Paulo Industry
Abstract ID#271

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Abstract: Economic growth and prosperity results from the dynamics of firms and markets. Whilefirms have previously been described as a "production functions", the evolutionary view of the firm highlight the role of knowledge and capabilities in creating this dynamic. However, understanding what are the key features that drive some firms and countries to be more innovativethan others remains a challenge in both literature and practice. Based on a capability-view of the firm using industrial firms as the main unit of analysis, this project aims to answer the following question: what is the influence of different innovation capabilities on the economic performance of firms? A survey with 131 companies was conducted. Preliminary results on small industrial firms in Brazil confirms the strength of the innovation capability model. For the current sample, transaction and management capabilities present the highest influence of innovation performanceof companies. This is coherent with intrinsic characteristics of the sample, mostly composed of low and medium-low-tech firms. Results also highlight the importance of overcoming the innovation paradox of latecomer countries in enhancing managerial capabilities in order toinnovate.
Keywords: innovation capabilities, development, operational, management, transaction capability, innovation performance.

Introduction

Innovation is widely recognized by academics and policy makers as the engine of economic development as well as the main source of sustainable competitive advantage for business firms. However, innovation is far from being an easy task. It depends on the ability of firms to build specific configurations of 'knowledge, experience and skills' (capabilities) to leverage technological and market opportunities. This poses challenges for both companies that often do not have a clear view how to begin their innovation efforts, and for policy makers who often create misleading incentives detached from the actual innovation possibilities of firms given their capabilities' levels.

To define priorities and help government and firms to set a common and coherent agenda for innovation, it is necessary to identify and measure the levels of capabilities of industrial firms. This project aims to access and identify the different paths for innovation in the São Paulo. Based on innovation and dynamic capabilities literature e methodology, this research expands on previous efforts to measure firms innovation capabilities in Brazil. An exploratory phase will be followed by a major survey with industrial companies in the State of São Paulo. Findings will contribute to pushing an innovation agenda for the State and companies.

Innovation Capabilities: An Assessment Model

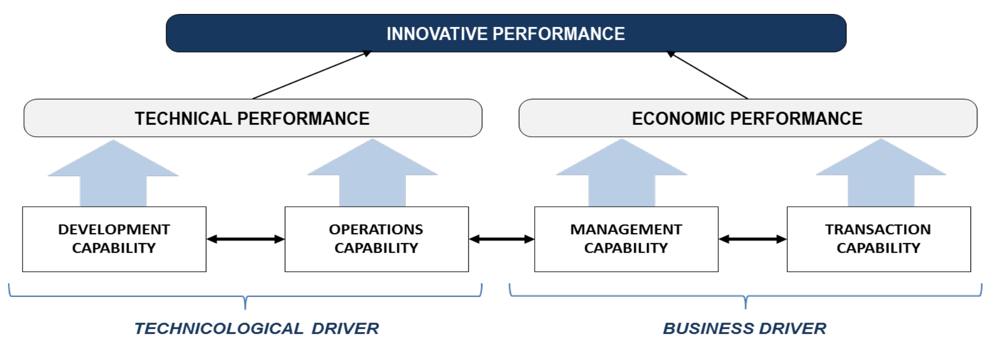
Regional and National Economic dynamism is reliant on the health and capabilities of firms that operate in them (Teece, 2017). While innovation is recognized as a key process for economic development (Schumpeter, 1912; Sollow, 1956) and competitiveness (Cantwell, 2005), assessing the main features that allow some companies and countries to be more innovative than others remain a challenge. Much of the discussion, has majorly focused on technological-based issues of firm capabilities. This is mostly the case of seminal work made by Dosi (1988), Lall (1992) and Bell and Pavitt (1993).

Previous research has shown that using technological capabilities or R&D measures to account for the innovative performance of firms does not provide a complete picture as many companies innovate without R&D (Bradke et al, 2009). The growing complexity of knowledge application and its outputs as well as the uprising new business models are shedding light over a new issue: the role of non-technological capabilities for innovation (Yu et al., 2013; Teece, 2014; Lee and Yoon, 2015). Exploiting market opportunities require the coordination and capabilities that are complementary to the technological ones (Tello-Gamarra and Zawislak, 2013).

On the one hand, technological capabilities emphasize R&D and operations, while business capabilities highlight the importance of strategy, management and marketing (Dutrénit, 2000). Innovation capabilities have a direct relation to dynamic capabilities (Teece et al., 1997). However, advances as dynamic capabilities still lacks empirical tests and validation (Ambrosini & Bowman, 2009; Arend & Bromiley, 2009; Barreto, 2010).

This research builds upon the "innovation capabilities model" (ICM) developed by Zawislak et al (2012) which measures four main capabilities of the firm: development and operations capabilities (technology driver) and management and transaction capabilities (business driver) (Figure 1). Innovation capabilities of the firm are inherently a multidimensional construct (Wonglimpiyarat, 2010; Forsman, 2011) that involves knowledge and learning, skills and R&D; operations and processes; planning, organization, management, resource, capital, decision and strategy; marketing and communication (Guan and Ma, 2003; Wang et al., 2008; Cheng and Lin, 2012).

Figure 1. A capability-based model of firm's innovation



Source: Based on Alves et al. (2017)

By encompassing, the main dimensions of the firm, the ICM allows the observation of the different configurations of firms as well as a clear understanding of the firms ordinary and dynamic capabilities (Alves et al. 2018). Such assessments are of specially importance for developing countries that often lack some more basic capabilities (such as operations and management) (Bloom and Van Reenen, 2007) that prevent companies for achieving higher innovation goals. The lack of such basic capabilities creates an 'innovation paradox' obstructing the possibilities of realizing the full dynamic potential in these countries (Cirera & Maloney, 2017).

Measuring innovation capabilities

Measuring innovation capabilities is a key challenge for innovation studies Mendoza-Silva (2020). Innovation capability measurements come in many forms such as: assessment tools (Guan and Ma, 2003; Rush et al. 2007; Alves et al. 2017), maturity models (Essman, 2009; Esterhuizen et al. 2012; Corsi and

Neau 2015; Arends, 2018). Innovation is the result of a variety of factors and can be observed in a variety of ways. Since Schumpeter (1934) described innovation as “new combinations” in terms of products, processes, markets, sources of supply and industry organization, recent approaches (including the Oslo Manual (OECD, 2005) have characterized types of innovation in very similar terms: product, process, organization and marketing. Recently, the Olso Manual (2018) have divided these types into two main categories: technology/Product innovation and business process innovation. Interestingly, this division of innovation types is very similar the innovation capabilities proposed by Zawislak et al (2012). Firms innovate as the provide new valuable solutions to the market. To do so, firms must rely on certain capabilities to bring this solution about as a result of an intended action (Dosi et al, 2010). Capabilities are the set of routines based on knowledge, experience and skills that bring firms to life (Richardson, 1972; Nelson and Winter, 1982, Winter, 2003;).

Therefore, measuring capabilities must take into account methodologies that can assess these the level of specific routines that, in combination, form the specific capabilities of the firm. Zawislak et al 2012; Reichert et al 2014; and Alves et al 2017 have proposed, tested and validated an innovation capability model based on for capabilities defined and presented in table 1.

The technological driver of firms is composed of development capability and operational capability. These two, express de ability firms have to create and master as specific technological base. The business driver of the firm is composed of management and transactional capabilities which are the capabilities need for firms to orchestrate internal and external resources efficiently and transact in the market. The exercise of these capabilities in combination will lead to lower or higher innovation performance in various ways.

Table 1. Capabilities of the firm, Innovation and measurement items

Driver	Capabilities Definition	Previous measurement items	New (additional) Measurement items	References
Technology	**Development Capability (DC)** The ability that any firm has to interpret the current state of the art, absorb and eventually transform a given technology to create or change its operations capacity and any other capability aiming at reaching higher levels of technical-economic efficiency.	✓ *Original design of products* ✓ *Monitoring technological trends* ✓ *Use of formal project management methodologies* ✓ *Adaptation of technologies* ✓ *Prototyping of products* ✓ *Use of scientific knowledge* ✓ *Launch own products*	✓ *Development of own product design* ✓ *Preparation of new products for production* ✓ *Use of digital technologies for product development*	Lall (1992); Bell and Pavitt (1995); Iammarino, Padilla-Pérez and Von Tunzelmann (2008); Teece, (2017); Rajapathirana and Hui (2018)
	Operations Capability (OC) The ability to perform the given productive capacity through the collection of daily routines that are embedded in knowledge, skills and technical systems at a given time.	✓ *Formalization of production planning and control (PPC)* ✓ *Updating of machines and equipment in use* ✓ *Use of statistical methods* ✓ *Adequacy of stock to the production process* ✓ *Avoids of rework* ✓ *Compliance with delivery deadlines* ✓ *Avoid return* ✓ *Flexibility of capacity*	✓ *Use of quality management tools* ✓ *Use of digital technologies in the production process* ✓ *Maintenance of machinery and equipment*	Hayes and Pisano (1994); Wart et al. (1998), Chandler (1990); Skinner (1969), Slack and Lewis (2008); Teece, (2017); Rajapathirana and Hui (2018)
Business	**Management Capability (MC)** Is the firm's ability to transform the technological outcome into a coherent operational and transactional arrangement.	✓ *Formalization of strategic objectives* ✓ *Integration of sectors with information technology* ✓ *Standardization and formalization of different work procedures* ✓ *Updating of management techniques, tools and practices* ✓ *Staff training* ✓ *Updating of techniques in financial management*	✓ *Monitoring of goals and management processes* ✓ *Carrying out business planning over the years* ✓ *Use of digital technologies for decision making*	Penrose (1959); Barnard (1966), Mintzberg (1973), Chandler (1977), Zawislak et al. (2011, 2012); Bloom an Reenen (2007); Bloom et al (2013); Teece, (2017); Rajapathirana and Hui (2018)
	Transaction Capability (TC) Is the ability to reduce its marketing, outsourcing, bargaining, logistics, and delivering costs, in other words, transaction costs.	✓ *Market monitoring* ✓ *Imposition of negotiation conditions to suppliers* ✓ *Imposition of company prices on the market* ✓ *Imposition of your trading conditions on customers* ✓ *Use of formal criteria for selecting your suppliers*	✓ *New product sales planning* ✓ *Creation of advertising pieces* ✓ *Own logistics processes (storage and transport)* ✓ *Use of digital technologies to sell products* ✓ *After-sales service*	Coase (1937), Williamson (1985, 1999, 2002); Argyres (1996, 2011), Madhok (1996); Langlois and Foss (1999), Cannon and Hamburg (2001), Kotabe (2002), Mayer and Salomon (2006), Zawislak et al. (2011, 2012); Rajapathirana and Hui (2018)
Innovation	New products, new processes and equipment, new organizational forms, new commercial approaches to the market that leads to extraordinary profits.	✓ *Increase in sales* ✓ *Increase in Market-Share* ✓ *Increase in profits*		Schumpeter (1934), Bessant and Francis (2005), OECD (2005)

Everything the firm does (new product developments, new processes, new managerial arrangements or commercial relations) is intended to improve economic performance (increase in sales or reduction in costs, in order words, increase in profits). This is analogous but relatively broader version to Schumpeter's idea of "extraordinary profits" that result from innovation efforts.

The expected equation for measuring the innovative performance of firms is the following:

$$IP = \beta_0 + \beta_1 DC + \beta_2 OC + \beta_3 MC + \beta_4 TC + e \quad (1)$$

Methodological Proceedings

Model description: The Innovation Capability Model highlights four features of innovation that can be verified in different firms. They are: development capabilities, operation capabilities, management capabilities and transaction capabilities. This model provides an integrative and coherent view on the interplay of technology and business that allow each company to exist in its single way. To measure these capability levels, it is necessary to develop a robust scale for each dimension.

Sample Selection and Data collection

This research was done through a survey questionnaire conducted by phone by professional interviewers related to the Center for Studies and Research on Administration (CEPA) of the Federal University of Rio Grande do Sul. Interviewers were instructed to call selected firms from an industrial database obtained on Orbis from Bureau Van Dijk. The Oribs database was The list was generated by filtering industrial (mostly manufacturing) firms from the State of São Paulo, with at least 16 employees.

The goal is to have a representative sample able to capture the different industrial sectors and sizes. As the research involves understanding a broad secretum of the firm's capabilities, interviewers were asked to reach out to specific interviewees with sufficient knowledge of the firm. Ideally, research should be conducted with the firm's owner, president, directors or higher managers.

Questions involved dichotomous and likert-type scales. Blocks were divided as follows: block one had questions related to each of the four capabilities; block two are questions about performance; and block three with general information. The full length of application of the questionnaire was around 40 minutes.

Given the unprecedent situation of the current Pandemic that hit the whole economy. Interviewees were asked to base their responses considering the pre-pandemic scenario. Additional questions on the impact of the pandemic on the company were added at the end of the survey.

Pre-test and Survey

Pre-test was conducted in Rio Grande do Sul using the updated version of the questionnaire developed in 2014. To measure capabilities, the full questionnaire involved two sets liker scale questions. The first set used the exact questions tested and validated in the 2014 survey in Rio Grande do Sul. The second set involved an updated version that aimed at enhancing the model. A pre-test with 20 companies was run in RS to account for necessary refinements on the clarity of questions being made.

Sample Characteristics

The São Paulo survey is currently being conducted. So far, 131 responses have been obtained. 14.5% composed of micro size firms with revenues bellow R$ 360 thousand reais, 68,7% of the sample is composed small size firms with revenues between R$ 360 thousand and R$ 4.8 million. 21% of Medium sized firms with revenues between R$ 4.8 million and R$ 300 million. Data collection continues and is expected to reach 300 companies including large companies.

Table 2. Company size

	Frequency	Percent	Valid Percent	Cumulative Percent
Revenues less than or equal to R $ 360 thousand – MICRO	19	14.5	14.5	15.3
Revenues greater than R $ 360 thousand and less than or equal to R $ 4.8 million – SMALL FIRM	90	68.7	68.7	84.0
Revenues greater than R $ 4, 8 million and less than or equal to R $ 300 million – MEDIUM FIRM	21	16.0	16.0	100.0
Total	131	100.0	100.0	

The average age of the main decision maker of firms was 42 years old and 11 years working in the company. For this sample, respondents were also mainly partially or main decision makers of the company in about 60% (Table 3). In terms of education, 57% of the respondents replied that the main decision maker of the company has completed higher education.

Table 3. Main decision maker profile

Descriptive Statistics		**N Statistic**	**Minimum Statistic**	**Maximum Statistic**	**Mean Statistic**	**Std. Deviation Statistic**
Age		129	21	76	42,17	11.474
Years in the Company		130	1	54	11,76	10.137
	Education	**Frequency**		**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Missing	5		3,8	3,8	3,8
	Incomplete Elementary School	1		0,8	0,8	4,6
	Complete primary education	2		1,5	1,5	6,1
	Complete high school	22		16,8	16,8	22,9
	Incomplete Higher Education	20		15,3	15,3	38,2
	Complete Higher Education	75		57,3	57,3	95,4
	Specialization	2		1,5	1,5	96,9
	Master's	2		1,5	1,5	98,5
	Doctorate degree	2		1,5	1,5	100
	Are you the main decision maker of the company?					
	Yes	20		15,3	15,3	16
	No	52		39,7	39,7	55,7
	Partial	58		44,3	44,3	100
	Total	131		100	100	

Analytical procedures

All statistics were first run using all variables contained in each construct. After running the factor analysis, variables were grouped together and reduced in smaller groups. The same statistics with the new variables were produced to check of improvements in the analysis. The results are showed in the next section. All tests were done using the IBM SPSS Software version 25.

The ICM can be assessed using different analytical tools. Descriptive statistics will allow for an overview of the overall of characteristics of companies (e.g Annexes). The previous model has been validated in Alves et al. 2017. The new model followed similar methodology as new variables have been added. After testing constructs reliability, a confirmatory factor analysis was run in order to validate the capability dimensions of the framework.

Regression analysis was used to identify the capabilities that have a higher impact in the innovative performance of firms defined by increase in sales, profits, market share and new products. The results of this study will be compared to the ones obtain in the State of Rio Grande do Sul up until now to check for differences in state firms' capabilities.

The study will also compare differences in the capability levels of firms from different sectors to identify patterns and potential deficiencies that might deserve attention from decision and policy makers.

Preliminary Results

In this section we present the preliminary results as the data collections is still being conducted. Table 4, brings a cross sectoral averages for capabilities scores and innovation performance.

Table 4. Sectors of companies and capability score averages

Sectors	Count	MC	TC	OC	DC	IP
Food and drinks	7	4,18	3,83	4,60	3,64	3,24
Automotive	4	4,13	3,65	4,25	4,08	3,25
Leather and Footwear	2	3,25	3,00	3,50	3,50	2,83
Electric Equipment	3	4,17	3,60	4,13	4,17	3,11
Pharmaceuticals	1	5,00	5,00	5,00	5,00	4,67
Instruments and Tools	2	3,88	3,40	3,60	3,67	2,67
Graphic	9	4,03	3,11	4,58	3,57	3,19
Computing	1	3,75	3,80	4,40	3,67	4,00
Medical instruments	2	4,88	4,50	4,40	4,42	4,00
Machines and equipment	24	4,13	3,64	4,33	4,12	3,29
Furniture	5	4,15	3,52	4,40	3,90	2,33
Other manufacture	4	3,81	3,35	4,20	3,12	3,50
Paper And Cellulose	2	3,75	3,70	4,40	3,17	3,83
Plastics and Rubber	16	3,92	3,49	4,23	3,56	3,21
Wood Products	2	3,88	3,90	4,20	3,75	3,33
Metal Products	23	3,86	3,57	4,10	3,69	3,61
Chemical	5	4,20	4,12	4,36	4,17	4,00
Textile	8	4,16	4,08	4,43	4,29	3,83
Clothing	3	4,17	3,00	4,33	3,83	3,33
Glass products	2	3,38	2,70	4,00	2,58	2,00
#N/A	6	3,88	3,57	4,13	3,61	3,17
Grand Total	131	4,01	3,60	4,28	3,80	3,34

Internal consistency

Internal consistency was verified on both (old and new questions) for each of the five main constructs, named Development Capability (DC), Operations Capability (OC), Management Capability (MC), Transaction Capability (TC) and Innovative Performance (IP); and of the entire model (Table 5) composed by these five elements.

Table 5. Reliability Statistics

	Cronbach's Alpha (OLD)	N of Items	Cronbach's Alpha (NEW)	N of Items
MC	0,885	4	0,920	9
TC	0,877	5	0,898	11
OC	0,834	5	0,913	13
DC	0,879	6	0,929	10
IP	0,898	3	0,898	3

Cronbach's alpha coefficient was used to verify the reliability of data used as dimensions of the innovation capability model. The lowest alpha coefficient was found in the operational capability (0.834), which is already greater than the suggested threshold values of 0.6 (ranging from 0 to 1) (Hair et al., 2005; Malhotra, 2006) or 0.7 (Kline, 1998) for an acceptable level of reliability.

Table 6 and 7 present the averages and standard deviations from the former and new innovation capabilities assessment model.

Table 6. Previous capability measurement items

	Descriptive Statistics Your enterprise...	N	**Minimum**	**Maximum**	**Mean**	**Std Deviatio**
Management Capability	15. Formalizes strategic objectives	131	1	5	3,98	0,9
	16. Updates your management techniques, tools and practices	131	1	5	3,97	0,8
	17. Empowers staff	131	2	5	4,2	0,8
	18. Uses current financial management techniques	130	1	5	3,9	0,8
Transaction Capability	34. Conducts formal research to monitor the market	131	1	5	3,16	1.2
	35. Imposes its negotiation conditions on suppliers	130	1	5	3,65	0,9
	36. Imposes its prices on the market	131	1	5	3,66	1.0
	37. Imposes its trading conditions on customers	130	1	5	3,68	0,9
	38. Uses formal criteria for selecting its suppliers	131	1	5	3,85	0,9
Operations Capability	55. Maintains adequate stock for the production process	122	1	5	4,19	0,8
	56. Comply with production schedule	131	1	5	4,36	0,7
	57. Establishes a productive routine that avoids rework	131	2	5	4,31	0,7
	58. Delivers products on time	131	2	5	4,43	0,6
	59. Manages to make installed capacity more flexible	131	2	5	3,94	0,7
	60. Can you guarantee the process to avoid returning	131	2	5	4,34	0,6
Development Capability	77. Designs your products in an original way	130	1	5	4,01	0,9
	78. Monitors the latest technology trends in the industry	130	1	5	3,93	0,998
	79. Uses formal project management methodologies (Stage-Gate, PMBOK, Funnel of Innovation, etc.)	131	1	5	3,5	1.119
	80. Adapts and applies new technologies to your needs	130	1	5	4	0,9
	81. Prototyping your products	131	1	5	3,83	1.1
	82. Launches its own products	131	1	5	3,55	1.2

Table 7. New capability measurement items

	Descriptive Statistics Your enterprise...	N	Minimum	Maximum	Mean	Std, Deviatio
Management Capability	2. Formalization of strategic objectives	131	1	5	3,83	0,929
	3. Updating of management techniques, tools, and practices	131	1	5	3,9	0,802
	4. Updating of techniques in financial management	131	1	5	3,76	0,802
	5. Staff training	131	1	5	4,11	0,917
	6. Integration of sectors with information technology	131	1	5	3,53	1.002
	7. Standardization and formalization of different work procedures	131	1	5	3,84	0,84
	8. Monitoring of goals and management processes	131	1	5	3,96	0,948
	9. Conducting business planning over the years	131	1	5	4,01	0,941
	10. Use of digital technologies for decision making	131	1	5	3,66	1.021
Transactional Capability	19. Use of formal criteria for selecting your suppliers	131	1	5	3,88	0,903
	20. Imposition of your negotiation conditions with suppliers	131	1	5	3,65	0,911
	21. Conducting formal research to monitor the market	131	1	5	3,17	1.296
	22. Imposition of company prices on the market	131	1	5	3,72	0,963
	23. Imposition of your negotiation conditions with clients	131	1	5	3,75	0,947
	24. Performing integration with customers	131	1	5	4,01	0,78
	25. Conducting sales planning for new products	131	1	5	3,57	1.089
	26. Performance in the creation of advertising pieces	131	1	5	3,29	1.218
	27. Own performance in the logistics processes (storage and transport)	131	1	5	3,89	0,883
	28. Use of digital technologies to sell products	131	1	5	4,01	0,988
	29. After-sales service	130	1	5	4,07	0,99
Operations Capability	39. Compliance with production schedule	131	1	5	4,26	0,76
	40. Establishment of a productive routine that avoids rework	131	2	5	4,24	0,814
	41. Compliance with product delivery deadlines	131	2	5	4,34	0,697
	42. Use of formal quality management tools	130	1	5	4,2	0,839
	43. Formalization of production planning and control (PCP)	131	1	5	3,97	0,902
	44. Use of statistics to monitor the production process	131	1	5	3,66	1.093
	45. Process management to avoid return	131	1	5	4,26	0,828
	46. Adequacy of the stock to the production process	131	1	5	4,24	0,833
	47. Flexibility of installed capacity	131	2	5	4,01	0,76
	48. Use of digital technologies in the production process	131	1	5	3,65	1.095
	49. Updating of machines and equipment in use	131	1	5	3,85	1.034
	50. Maintenance of machinery and equipment	131	1	5	4,31	0,785
Development Capability	61. Monitoring the latest technological trends in the sector	131	1	5	3,8	1.041
	62. Adapting and applying new technologies to your needs	129	1	5	3,85	0,977
	63. Use of formal project management methodologies (Stage-gate, PMBOK, Funnel of Innovation, etc.)	131	1	5	3,44	1.138
	64. Original design of your products	131	1	5	3,98	1.011
	65. Development of own product design	131	1	5	3,83	1.165
	66. Product prototyping	131	1	5	3,75	1.166
	67. Preparation of new products for production	131	1	5	3,85	1.089
	68. Performance in the launch of its new products	131	1	5	3,5	1.273
	69. Use of digital technologies for product development	130	1	5	3,72	1.143
	70. Use of scientific knowledge in the development of your Products	131	1	5	3,56	1.137

Preliminary Factor Analysis

For these preliminary results, given the relatively small sample and irregular results, the factor analysis was done using only Innovation Capability Model which had been validated in the past in Alves et al 2017. To verify the adequacy in using factor analysis, we found a KMO = 0.876 of sampling adequacy (very good correlation according to Pestana and Gageiro, 2003). The Bartlett's test was significant ($p<0.001$), indicating the data is fit to factor analysis (Table 8).

Table 8. For previous model

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.876
Bartlett's Test of Sphericity	Approx. Chi-Square	[illegible]
	df	190
	Sig	.000

A factor analysis using unweighted least squares, clustered variables into for factors (Table 8). However, the limited size of the sample didn't allow for the confirmation of the model. The results were even more difficult to obtain on the new model which has more variables. These results should improve as the sample size increases.

Table 8. Factor Analysis for questions in the original model

Rotated Factor Matrix[a]

	Factor 1	2	3	4
36. Imposes its prices on the market	.778			
35. Imposes its negotiation conditions on suppliers	.753			
37. Imposes its trading conditions on customers	.734			
34. Conducts formal research to monitor the market	.677			
16. Updates your management techniques, tools and Practices	.538			
38. Uses formal criteria for selecting its suppliers	.453			
59. Manages to make installed capacity more flexible	.414			
58. Delivers products on time		.840		
56. Comply with production schedule		.814		
60. Can you guarantee the process to avoid returning		.694		
57. Establishes a productive routine that avoids rework		.691		
17. Empowers staff			.754	
80. Adapts and applies new technologies to your needs			.629	
18. Uses current financial management techniques		.	.531	
79. Uses formal project management methodologies (Stage-Gate, PMBOK, Funnel of Innovation, etc.)			.521	
78. Monitors the latest technology trends in the industry			.502	
15. Formalizes strategic objectives				
82. Launches its own products				.823
77. Designs your products in an original way				.690
81. Prototyping your products				.647

Extraction Method: Unweighted Least Squares. Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 5 iterations.

Regression analysis requires that the expected factors cluster together so independent factors can be created and turned into variables to be used in the regression model. Given this impossibility, independent factors were created considering solely the variables of each construct. Although not ideal, this strategy was chosen by assuming and trusting that the model had been previously validated in the past using a much larger sample. Next section presents the preliminary results for the regression analysis.

Regression Analysis

Using stepwise regression, the model's level of explanation is represented by the coefficient of determination R2, which is a measure of adjustment for the regression line, i.e., the proportion of the variation in the dependent variable that is explained by the set of explanatory variables. For the Innovation

Capability Model the adjusted R2 was 0.284. Considering a social science study, this value for the ajusted R2 is acceptable (Churchill, 1977) other authors have presented innovation capabilities models with R2 values lower than 0,210 (Guan and Ma, 2003; Yam et al, 2004). Once the adequacy of the regression model has been tested, the following equation was defined:

Table 9. Regression Results for São Paulo

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.554a	.307	.284	.80804635

ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34.469	4	8.617	13.197	.000b
	Residual	77.700	119	.653		
	Total	112.168	123			

a Dependent Variable: IP_Fac

b Predictors: (Constant), DC, OC, TC, MC

Coefficientsa

Model		Unstandardized Coefficients		StandardizedCoefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.013	.073		-.181	.857
	MC	.225	.134	.218	1.672	.097
	TC	.305	.114	.294	2.666	.009
	OC	.032	.098	.031	.327	.744
	DC	.090	.120	.089	.750	.455

a Dependent Variable: IP_Fac

Based on the equation, it is possible to affirm that the dependent variable Innovative Performance (IP) can be positively explained by the four capabilities of the Innovation Capability Model at an explanation rate of 28% of the total variance of the variable IP. This result confirms our hypothesis that all capabilities impact innovative performance.

The transaction capability is the one that influences the innovative performance the most in the current sample of small business firms. The operations capability got the lowest beta value. On the other hand, transaction, followed by management capability, is the one that influences the firm innovative performance the most. Interestingly, Development capability is the second lowest score for the current sample. This could indicate the low level of development capability of these firms.

Comparison with the Rio Grande do Sul's Results so far

The current project includes a comparison of the results between São Paulo industrial firms and Rio Grande do Sul. As data collection is still ongoing, results still lack robustness. The RS sample size, however, has 355 responses. In the stepwise regression, the model's level of explanation is represented by the adjusted R2 was 0.275. The regression model for the RS firms, highlighted Transaction and Development Capabilities. The RS sample for this research, used the same list of companies that participated in the 2014 research. Many companies in this list, do not exist anymore. So far, the results highlighting these to capabilities could indicate that the companies that still operate tend to have a higher innovative capabilities. This assumption still needs to be confirmed.

Table 10. Regression Results for Rio Grande do Sul

Model Summary

Model		R	R Square	Adjusted R Square	Std. Error ofthe Estimate
	1	,524	,275	,266	,72802

ANOVAb

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	70,388	4	17,597	33,201	,000
	Residual	186,035	351	,530		
	Total	256,423	355			

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,698	,395		1,764	,079
	DC_2020	,258	,068	,209	3,789	,000
	OC_2020	,009	,085	,005	,107	,915
	MC_2020	,018	,069	,014	,258	,797
	TC_2020	,493	,069	,381	7,127	,000

Final Remarks and Next steps

If innovation conducted by firms lead to wealth generation and general life improvements, understanding what the necessary capabilities are that national firms must develop is crucial for both firms and policy making purposes. This research advances in this direction by providing a capability-based model of the firm to assess how companies innovate and seek competitive advantage, as well as what are the main gaps for Brazilian firms. This research is improving in the previous model by providing an updated and more complete version of the assessment tool, as well as, broadening the range of the analysis by incorporating industrial firms from the State of São Paulo. We expect that this research will provide key insights on key features and nuances of different Brazilian regions in terms of the innovation behavior of firms.

These results are preliminary as data is still being collected during the months of December and January aiming at a more significant and representative sample including Medium and Large Firms of the State of São Paulo. However, important results and more conclusive analysis are expected with a rich database that is being built. In addition to the innovation capability measures, the instrument is also gathering others relevant aspects of the firm's profile such as: innovation triggers and sources, additional factors and characteristics of firms capabilities as well as the impacts of Covid-19 on firms (see Annexes). Key insights are expected for both academic purposes as well as policy and decision making.

Acknowledgement

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The Industry 4.0 technologies as motivators to the adoption of Circular Economy in foodtechs: an analysis in the stakeholders perspective

Abstract ID#354

Tiago Hennemann Hilario Da Silva, Simone Sehnem (University Of Southern Santa Catarina)

Purpose

This study has the objective of analyzing Industry 4.0 technologies as motivators to Circular Economy, in startups foodtechs, through the most relevant stakeholders. Based on this objective, this article offers three research questions:

RQ1: How are Foodtechs startups inserted in the context of Circular Economy?

RQ2: How can the Industry 4.0 technologies support Circular Economy in startups from the Foodtechs sector?

RQ3: Which are the most relevant stakeholders for startups in the processes of Circular Economy?

Literature Review

The Circular Economy (CE), which has as main objective the maintenance of products, components and materials in its highest level of usefulness and worth in all the cycle of life, distinguishing between technical and biological cycles (Ellen MacArthur Foundation, 2015). Thus, CE seeks to find in Industry 4.0, which are a group of technologies, gadgets and processes with the capacity of operation in an integrated form (Beltrami, Orzes, Sarkis & Sartir, 2021) generate a supporting base to its due using in the organizations (Sehnem, Provensi, Silva & Pereira, 2021).

Feeding is directly linked to human existence and culture, for we need it in order to survive. The current system in which we live has given livelihood to a population in fast growing and has also accelerated the economical development and urbanization. However, productivity gains have come with an onus, since this model is more appropriate to fulfill the needs in a long term. So, the transition to a circular economy of food presents itself as a necessary model with economical, environmental, and health benefits, in all value chain and as well as society, in a general way (Ellen MarcArthur Foundation, 2019). Based on this reality, many stakeholders, from different sectors, understand the importance of this challenge and are moving towards a more sustainable economy. (Agrawal, Wankhede, Kumar, Upadhyay & Garza-Reyes, 2021).

Methodological Procedures

This study is characterized as a qualitative exploratory research, based on multiple case studies. We make it clear in this study that our research findings should not be generalized and also that they cannot replace conclusive quantitative research with robust hypothesis testing and scale validation. As main data collection technique in-depth interviews were used, being conducted via online meetings on Google Meet and also in person. Added to the documentary analysis and secondary data, the qualitative analysis is carried out, based on the analytical phases of compilation, decomposition, recomposition, rearrangement, interpretation and conclusion described by Yin (2010).

Findings

The results show that: (i) the I4.0 technologies are fundamental in the practices adopted by the foodtechs; (ii) the CE being internalized, supported by I4.0; (iii) CE is made possible by gathering sinergy and co-participation from stakeholders which are strategic and relevant to foodtechs; (iv) innovation factor is present in the adoption of I4.0, in the operationalization of the practices of CE and in the production of synergy among the stakeholders relevant to foodtechs; (v) the creation of new markets is also a consequence of the adoption of I4.0, the adoption of CE and the articulation of stakeholders in the context analyzed; (vi) virtualize and regenerate are the most strengthened strategies at the sphere of the analysed foodtechs; (vii) IoT, Big Data and integration of ubiquitous and intelligent components in supply chains are the highlighted artifacts in the making of CE practices at foodtechs levels; (viii) foodtechs of food producers have shown a greater synergy and articulation of stakeholders to the success of CE supported by I4.0.

Implications

The practical contribution is the validation of the three research constructs in the context of foodtech startups. This market sector, despite already having the concepts of the Circular Economy well used in its processes, still has a vast field of implementation, having in its main pathway the Industry 4.0 technologies.

The theoretical contribution of this paper is the intersection between two constructs and an already grounded theory applied in the context of Brazilian companies, which still needs more depth. It also contributes with an empirical study that correlates with the current literature.

The social contribution of this study is the intention of bringing to light, even if in embryonic form, the possibility of small companies, in the case of this study, startups, of using Industry 4.0 technologies to maximize the Circular Economy.

As suggestions for future studies, first is the possibility of analysis from the prism of circular supply chain management (Farooque, et al. 2019), as the main stakeholders cited are managers, suppliers, customers, and investors, verifying the main technologies of Industry 4.0 already listed above. A second suggestion, on the other hand, would be to focus on only one niche market of foodtechs startups, such as, for example, food producers.

The limitations of the study are firstly associated with the research object in only one sector, since the results cannot be generalized. Another limitation is that, although this study is supported by a theory already consolidated in the academy, the two constructs (CE and I4.0) still lack further empirical studies. And finally, the bias of researchers in qualitative research, which would tend to be minimized in a quantitative study.

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INNOVATION ECOSYSTEMS III

May 3rd: 3h10 pm – 5h pm

Chair

Renato Garcia (University of Campinas, Brazil)

Papers

Innovation policy and entrepreneurial ecosystems: A dose-response analysis of a SME R&D Grants Program

Renato Garcia, Veneziano Araujo, Sarah Ferreira

Government funding and the development of innovation and entrepreneurship ecosystems

Karen E F Pinto, Sérgio R R Queiroz, Bruno B Fischer

Orchestration competence in urban innovation ecosystem

Lisiane Machado, Kadigia Faccin, Bruno Anicet Bittencourt

Factors influencing talents' perception to take over an urban innovation ecossystem

Cristian Rogério Foguesatto, Mathaus Freitag Dallagnol, Bibiana Volkmer Martins, Kadígia Faccin, Alsones Balestrin

Knowledge Flows for Rural Businesses: Evidence from Medellín's Innovation Ecosystem

Camila Coletto, Leonardo Caliari, Dércio Bernardes de Souza, Daniela Callegaro de Menezes

Innovation policy and entrepreneurial ecosystems: a dose-response analysis of a SME R&D Grants Program

Abstract ID#216

Renato Garcia, Sarah Ferreira (University of Campinas); Veneziano Araujo (Federal University of São Paulo)

Purpose

This paper evaluates the main effects of a R&D grants program for SME policy in the Brazilian state of São Paulo. Policy supporting R&D expenditures represents a very suitable field for evaluating the effectiveness of a local-based, SME-oriented R&D policy.

Literature Review

Public policies to support private R&D are usually justified by their purpose to foster the increase of firms, especially SME, R&D expenditure. Firms' difficulties related to the appropriating returns from R&D expenditures are usually pointed out as a reason for public policies. In addition, policies could be associated to more strategic goals linked to building innovative capacity in specific technologies, sectors, or regions. In both cases, the main goal of R&D grant policies is to support the increase of private innovative expenditures that, on the long run, will lead to innovation and upgrading in business performance. The key rationale for providing public support for private R&D and innovation is the potential impact on knowledge and value creation (Vanino et al., 2019). Public policies for innovation can take different formats and can use different instruments. In many countries, general subsidies to firms R&D expenditures, frequently through the tax system, have been considered as a key component of the policy innovation (Edler & Fagerberg, 2017). Previous analyses have shown that such subsidies may have important positive effects on firms' R&D investments, particularly in small firms (Castellacci & Lie, 2015). To evaluate the effectiveness of the R&D grants program usually involves the analysis of the factors that affect firms' participation in R&D programs (David et al., 2000; Wu et al., 2020). Some studies focus on assessing whether public policies were able to increase R&D expenditures by beneficiary firms. Other studies have focused on the effects of support policies on performance variables, such as innovation outputs, patents, and the main effects on exports or on firm productivity.

Methodological Procedures

We use a rich and unique database that covers all policy expenditures over a long period, from 1999 to 2020, from the PIPE-FAPESP. PIPE-FAPESP is a public program that grants funds for scientific and technological R&D in micro, small and medium-sized firms in the State of São Paulo. Its main objective is 'to promote technological innovation, business development and increase the competitiveness of small businesses'. PIPE's first grant was issued in 1997. Since then, the total budget of the program has increased from US$ 6.3 million between 1999-2001 to US$ 31.4 million in 2017-2019. The number of granted firms also increased in analysed period, reaching a peak of 799 in 2017-2019. The average annual expenditure per firm is US$ 36,629.48 and each benefit's duration is 3.7 years on average. Our methodological strategy involves applying the propensity score matching approach, and difference-in-difference (DiD-PSM), followed by a counterfactual dose-response regression model, in which we perform an evaluation exercise of policy targets on SME innovation. Our analysis evaluates the impact of R&D grants on patenting activity at the firm level. To do that, we design a dose–response approach, since firms receive different grants amounts. By doing this, we can overcome limitations of a binary treatment variable, allowing the observation of the average effect.

We also implement a lag structure for our control variables (Cerulli et al., 2022), due to the time lag for R&D expenditures generate innovation outputs.

Findings and implications

The results of the comparative statistical analysis using DiD-PSM approach show that, after the treatment period, the granted firms present a better innovative performance, in comparison to the control group. Granted firms present an average difference of 0.110 patents in their stock of patents after they receive the R&D grants. Although the effect may seem small, it is important to consider that few SMEs hold patents, since the average amount of patents among small firms before the R&D grant was 0.108 patents. After receiving the grant, beneficiary firms almost doubled their number of patents on average, since the effect corresponds to a growth of 101% in comparison to the control group. In order to strengthen these positive results, we run a dose-response function. By estimating a dose-response function, we can assess the effect of an additional dose of treatment on the results of individuals. In this way, we can assess the effect of each additional dollar granted for the individual SME on its innovative performance. Our dose intensities are represented by values ranging from 0 to 100 after standardization and the maximum value granted is around US$ 900,000 by year. As usual, to evaluate the effectiveness of the policy, it is interesting to know the 'shape' of the dose– response function. Our results show an inverted U-shape curve for the dose–response function, in convergence to previous studies (Cerulli et al., 2022; Dai et al., 2020; Heijs et al., 2022). The inverted U-shape curve suggests that intermediate doses are more effective, and we can find the optimal dose. Our results show that the effect on innovative performance decreases when the grant for individual firm is too large or too small. The estimated results for these doses can be used to speculate on their likely effects and their implications. Our focus is not on the estimated coefficients in the models but rather on the size of the policy effect presented in the dose-response function graphs. In general, the effect of the dose starts around zero and increases quickly, reaching a maximum around a dose of 52%, where the effect begins to reduce reaching again the zero around the top of the dose (81%). Converting the dose in dollars granted by year, this optimum point occurs with the grant on US$ 496,000 which is around 13.5 times greater than the average. Individual SMEs that receive this amount of grants presents a better innovative performance, measured by 0.214 more patents after 3 years, or around 6 times higher than the average effect found by the DiD-PSM approach.

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Government funding and the development of innovation and entrepreneurship ecosystems

Abstract ID#237

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Purpose

Access to funding is known to be critical for the emergence and consolidation of new innovative ventures. There are several studies mentioning funding as one of the pillars on which Innovation and Entrepreneurship Ecosystems (IEEs) are based, although there is still a lack of systemic knowledge about funding sources and their effects on ecosystems (Frimanslund et al., 2022). Although there are several types of private funding, such as venture capital and business angels, here focus on discussing the role of government funding for the development of ecosystems, since public funding dedicated to support scientific research - either applied research aiming at innovation directly, or more basic research - functions as trigger for innovation and the creation of new knowledge-intensive companies. Thus, the purpose of this article is to show how non-reimbursable funding from public sources affects the dynamics of IEEs, particularly in the context of emerging economies, where other sources of funding tend to be scarcer.

Literature Review

It is important to distinguish between the two groups of grants from public research support agencies that promote the development of IEEs. The first, direct, consists of programs aimed at applied research that focus on innovation, such as the Small Business Innovation Research (SBIR) in the US and Fapesp's Innovative Research in Small Businesses (PIPE) in Brazil. Such initiatives are based on two fundamental principles: (i) the existence of market failures in the process of funding entrepreneurship and innovation; and (ii) the expectation of socialization and economic gains arising from the success of the companies supported. In these cases, public sources of funding not only generate liquidity for the ecosystem (Autio & Ranniko, 2016) but also act as indicators of the potential of selected projects. The relationship between knowledge-based firms and public research institutions can increase their innovative potential, which reinforces the role of public institutions as relevant agents in the entrepreneurial ecosystem. Also, public research funding improves the systemic conditions of IEEs, as it provides early-stage funding for technologies that will be the basis of new products and services. The second group, indirect, involves all support for scientific research, including basic research, which eventually may translate into the generation of innovation and new ventures. The prerogative of this group is supported by the knowledge spillover theory of entrepreneurship, which identifies the production and circulation of knowledge as assets that are strongly attached to territorial spaces and support the development of entrepreneurial and innovative activities. The approximation of new and existing enterprises with universities fosters gains in terms of technological capabilities (Audretsch et al., 2020). Furthermore, academic research itself can create opportunities for economic exploration, making universities relevant cradles for the emergence of new innovative ventures (Fischer et al., 2019). In both cases – direct and indirect – the role of public funding in ecosystems in incipient stages has a more relevant relative weight. This is due to the lack of maturity in the configuration of the IEEs, in which the presence of private capital still falls short in achieving traction.

Methodological Procedures

The methodology is divided into two fronts: 1) Literature review. The research envisages carrying out a literature review on public funding and the development of Innovation and Entrepreneurship Ecosystems (IEEs). The search was carried out in Scopus and Web of Science, selecting scientific articles from 2015 to 2022. The search occurred by topic, ordered by relevance. From the initial list of articles identified, the most relevant ones were selected according to the research objectives. 2) To advance in the development of methods, metrics, and indicators for the analysis of public funding in IEEs, we proceeded with the following steps. a. Develop an approach for the specific case of Unicamp. b. Work with Unicamp's licensing and technology transfer data. Licensing cases: Connect companies with supporters by crossing the name of inventors/technologies/dates with Fapesp's global base. Spin-offs: Connect companies with supporters by crossing the name of inventors/technologies/dates with Fapesp's PIPE base. Data gathered from companies in the science park: Check the relationship between companies in Unicamp's Science and Technology Park and Fapesp's support. We carried out a survey and subsequent triangulation between the unstructured data provided by the Unicamp Innovation Agency (Inova) with the structured data provided by Fapesp. This enabled the analysis of the direct and indirect connections between public funding and IEEs.

Findings

This article contributes to academic research and literature in two different ways. First, the confirmation of the gap identified in the literature concerning the lack of studies focused on the role of government funding for the development of innovation and entrepreneurship. Second, our analysis demonstrates the relative centrality of public funding within the context of an IEE embedded in a developing country. This will allow us to developed a more nuanced picture of the role played by public sources dedicated to research in shaping the dynamics of such ecosystems.

Implications

This article brings a few important lessons. First, we came to the conclusion that it is important to strengthen government funding to promote both applied research aiming at innovation and basic research capable of generating new ideas. Second, it is critical to assess the role of public funding in generating new ventures in selected IEEs through mechanisms capable of measuring this effect; for such, we recommend the assessment of licensing and technology transfer data, university spin-offs, and companies located in science parks.

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Orchestration competence in urban innovation ecosystem

Abstract ID#299

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Innovation is widely recognized as one of the foundations for promoting economic development and quality of life. In a scenario of open and collaborative innovations, the concept of innovation ecosystems emerges (Granstrand & Holgersson, 2020). In cities, global movements, organized in recent decades as urban development strategies, such as 22@Barcelona projects in Spain, Ruta N, in Colombia and, in Brazil, Pacto de Inovação de Santa Catarina, in Santa Catarina (SC) and Pacto Alegre, in Porto Alegre (RS) (Audy et al., 2022), constitute urban innovation ecosystems (Autio & Thomas, 2022). In these projects, communities of interdependent, but hierarchically independent, heterogeneous participants collectively generate an ecosystem value proposition, which generally emerges through collective action, in which ecosystem members interact with each other and with the external environment (Thomas & Ritala, 2021), articulated by the quadruple helix (Carayannis & Campbell, 2009), in thar cities have faced several problems and socioeconomic difficulties (Camboim et al., 2019).

The city as a political actor promotes agreements and associations, being central in the articulation between civil society, the private sector, and the different instances of the State (Castells & Borja, 1996). This articulation takes place in the collective and joint action of the various actors and promotes the creation of innovation ecosystems at the city level (Thomas et al., 2020; Mignoni et al., 2021; Visnjic et al., 2016) where to manage the processes innovation is a complex and multifaceted task (Pikkarainen et al., 2017). This complexity requires the mobilization of actors through orchestration aimed at the development, management, and coordination of the urban innovation ecosystem, articulated by an orchestrator (Dhanaraj & Parkhe, 2006; Ritala & Blomqvist, 2009).

The orchestration of the innovation ecosystem is linked to the definition of roles and activities of the orchestrator (Hurmelinna-Laukkanen & Nätti; 2018; Pikkarainen et al., 2017), with the logic of prescribing tasks and attributions prevailing. Orchestrators play a key role in managing the plurality of networks through orchestration, which opens a space for network research, related to the orchestrator skills and capabilities (Reypens et al., 2021). However, it is highlighted that there is an essential ecosystem competence that is needed by all actors in an ecosystem, regardless of their position, the ability to manage dynamic strategic interactions related to innovation (Valkokari et al, 2017).

In this context, it is argued that there is a difficulty in articulating and orchestrating the actors inserted in the ecosystem - which are orchestrated by individuals who are part of the ecosystem with a focus on relationships and innovation processes - identifying as a research gap the need to advance the theoretical field promoting the expansion of the orchestration model of networks and ecosystems addressing the perspective of orchestration competence of this orchestrator (individual) (Valkokari et al, 2017; Reypens et al., 2021). It is also argued that the development of orchestration competence makes it possible for existing work practices in urban innovation ecosystems to be directed towards more effective management, considering the strategies adopted and the involvement of the actors. Thus, we seek to answer the research questions: What is individual orchestration competence? What are the attributes of the orchestration competence for orchestrating urban innovation ecosystems? In this theoretical paper, considering the field and theoretical evidence, the thesis is defended that orchestration is a dimension of innovation competence (Keinänen & Kairisto Mertanen, 2019). A specific orchestration competence is necessary, consisting of a set of attributes associated with knowledge, skills, and attitudes of the orchestrator to articulate and orchestrate the constituent actors and all actions that involve an environment and/or context of innovation to create and extract value of the urban innovation ecosystem. Therefore, considering the orchestration dimensions (orchestration practices), the attributes of individual orchestration competence emerge from the orchestration processes (practices and actions) associated with the orchestrator role (function) and the orchestration activities (work practices) to promote the urban innovation ecosystem.

Search by keywords was used (“orchestrator” OR “facilitator” OR “articulator” OR “conductor”) AND "innovation" OR "network*" OR "ecosystem*") AND ("competenc*" OR "skill*) OR "habilit*" OR "capabilit*" OR "characteristic*" OR "role*" OR "activit*"), in the title, abstract and keywords of the articles, in the period 2006 to 2022, for the construction of the theoretical framework, considering the article by Dhanaraj, & Parkhe (2006) as a theoretical-conceptual frame, in Scopus and Web of Science databases. Classical articles and books were also used, as well as recent articles and references cited in the selected articles.

The results, as theoretical contributions, promote the expansion of the theoretical model of orchestration in networks and in innovation ecosystems organized from the perspective of orchestrator roles and activities for an orchestration competence approach, with the proposition of defining this competence and its main attributes, considering the dimensions of the orchestration, in the context of urban innovation ecosystems. In these relationships, we perceived that the different orchestrators roles are intertwined and emerge from the relationship between the individual and the action to be performed. In other words, the different orchestrator roles influence the dynamics and formation of the urban innovation ecosystem associated with the attributes of orchestration competence when an orchestrator (individual) acts in a situated context. Furthermore, the identification of the attributes of the orchestration competence enables the constituent actors of the urban innovation ecosystem to organize and design qualification and training programs and to create learning spaces for its members for the development of orchestration competence, the which can be designed using methodologies and technologies and learning theories.

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Factors influencing talents' perception to take over an urban innovation ecosystem

Abstract ID#194

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Purpose

Urban innovation ecosystems have been recognized among academics and policymakers as important for the development of a region through collaboration among a set of partners such as universities, private organizations, government, among others. To ensure the development of these ecosystems, it is necessary attracting and retaining talented people. The quality of life of a region is important to this need. Following Winters (2014), in this paper we consider as talents students from STEM (Science, Technology, Engineering, and Mathematics) programs. Talents have interpersonal skills that are relevant for creating knowledge and innovation. Using constructs from environmental quality of life literature, this study aims analyze the factors influencing talents' perception to stay and foster the urban innovation ecosystem of Porto Alegre, in the southern of Brazil.

Literature Review

Urban innovation ecosystems are pivotal for technological development, which is associated with creation of knowledge and innovation (Audretsch and Belitski, 2016). Talent is considered as a critical factor in ecosystems (Davies et al., 2017). Moreover, universities have the potential to influence on developing talents to feed new ideas in ecosystems (Rocha et al., 2022). Studies demonstrates that those talents have a positive influence in technological innovation inside an ecosystem (Zhang et al., 2021). Thus, we define 'talents' as skills and competences developed and demonstrated by an individual (Berger and Berger, 2004). To be considered as an attractive innovation ecosystem, the collaboration among authors must transform the region as attractive to top talents fostering programs, partnerships with universities and companies making those activities attractive to those talented individuals (Robaczewska et al., 2019), this collaboration must include political government initiatives to strengthening the relationships between all actors (Hong et al., 2019). However, there are several critical factors to an ecosystem maintain attractive and retain new talents (Hu et al., 2020). There are a set of indicators that measure how people perceived in urban residential environment. Bonaiuto et al. (2015) provides a set of constructs in this regard, including green places, recreational services, welfare services, and safety of city. Similarly, Macke et al. (2018), analyze community integration, environmental well-being, material well-being, and the sense of safety.

Methodological Procedures

To meet the proposed objective, a survey using a structured questionnaire, and data collection took place in 2019. We analyzed 263 students from three of the country's important universities (one public e two private) located in the city of Porto Alegre – a relevant urban innovation ecosystem of Brazil. Using the software Statistical Package for the Social Sciences (SPSS) v. 26 we performed a logistic regression analysis to attain the purpose of this study. We also used descriptive statistics to provide general information about the students analyzed.

Findings

The main results show that recreational services (e.g., the city is well equipped with sports courts), environmental quality (e.g., this city is not polluted), the safety of the city (e.g., I can go out at night without worrying about muggings or violence), and education quality (e.g., the education offered in this city is of quality) influenced positively the talents' perception to stay in the city and foster the urban innovation ecosystem. R^2 Negelkerke and R^2 Cox and Snell were 0.194 and 0.131, respectively.

Implications

Given the importance of talent for creating knowledge and innovation, understanding how they perceive a given region is important for devising strategies to attract and retain them. The present study contributes to this direction.

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Knowledge flows for rural producers: evidence from a regional ecosystem

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Abstract: This study aims at analyzing how knowledge flows occur between rural producers and the regional ecosystem of Medellín. Based on the case study method, 26 interviews were carried out, being 10 rural producers and 16 actors of the regional ecosystem of Medellín, besides the documental analysis and direct observation, in order to complement the triangulation of the evidence sources. In the results, it was possible to map knowledge flows, identifying the actors of the ecosystem that interact with the rural producers of low technological incorporation, highlighting the actions proposed by the University of Antioquia. The present study contributes with a knowledge flow model to be replicated, in which a framework can be structured, to be investigated in other regional ecosystems, as well as its interactions with productive chains.
Keywords: Regional Ecosystem, Knowledge Flows, Rural Producers, Medellín, University

Introduction

The emerging paradigm in the 21st-century economy is focused on innovations, technologies, and knowledge, the latter of which is considered the most valuable economic asset for regional development. Thus, the capacity of a city or region to convert knowledge into development will depend on the actions established by the agents that generate and apply knowledge, as it provides a favorable environment for innovations to flow (Audy, 2017; Zawislak et al., 2017; Pique et al., 2019; Taxt et al., 2022).

Regarding knowledge and innovations development, the ecosystems approach is highlighted (Scaringella & Radziwon, 2018; Granstrand & Holgersson, 2020; Autio & Thomas, 2022; Fischer et al., 2022). In general, ecosystems refer to organic constellations of organizational actors that collectively co-create results at the ecosystem level (Autio & Thomas, 2022). In the context of a city, ecosystems arise to coordinate and consolidate the relationships of different actors, based on the logic of the quadruple helix, in favor of innovations and regional development (Pidorycheva et al., 2020; Santos et al., 2021). The geographical proximity among actors and the search for alignment contribute to the results of innovation at a territory level, being relevant the understanding of local dynamics in each region (Miranda Oliveira et al., 2019).

Academic research regarding regional ecosystems focus primarily on developed countries (Visnjic et al., 2016; Oomens & Sadowski, 2019; Piquet et al., 2019; Rehm et al., 2021). However, studies focused on emerging countries begin to be evidenced (Surie, 2017; Arenas et al., 2020; Bittencourt et al., 2021; Santos et al., 2021; Thomas et al., 2021). These publications highlight that exploring the phenomenon of ecosystems in different contexts contributes to the advancement of the theory. Despite that, a gap in studies focusing on rural producers can be noticed, mainly on those of low technological and how they can be involved in the dynamics of ecosystem relations in developing countries. It is understood that, in these contexts, there may be actors that drive, support, or are simply beneficiaries of the actions developed in the regional ecosystems, constituting a knowledge flow that can present mechanisms of formal and informal transference.

Among regional ecosystems in developing countries, it is worth highlighting the ecosystem of Medellín, city declared Special District of Science, Technology and Innovation (organic law 043 of 2021), and considered, in 2013, the most innovative city of Latin America (Medellín Cómo Vamos, 2013). Medellín is the second largest city in Colombia, capital of the Department of Antioquia, located in the Aburrá Valley, the central region of the Andes Mountain, in South America. In the last decades, Medellín adopted a series of initiatives for the development of technology, science and innovation, in order to solve problems of public security, job, income generation, infrastructure, and environment, among others.

The actions proposed in Medellín are in line with the UN's sustainable development goals, especially with regard to making cities inclusive, resilient and sustainable. It also includes objectives related to sustainable transport and infrastructure, as well as objectives aimed at rural development that highlight disparities and gaps between the urban and rural sectors (United Nations, 2023).

The initiatives of Medellín developed based on public policies established throughout the years, such as Science, Technology and Innovation Strategic Plan (STI) 2011-2021; Innovation and Social Entrepreneurship Policy (2015); Public Policy for Economic Development of 2017; National STI Policy 2022-2031; and the Development Plan "Medellín Futuro 2020-2023", which proposes strengthening of the ecosystem of Medellín.

In the state of Antioquia, rural producers have an important role in the economy, highlighting the agro-food chains of avocado, banana, cocoa, coffee, sugar cane, beef cattle, dairy cattle, fish farming, and swine (Plan Departamental de Extensión Agropecuaria 2020- 2023 - Unidos por la Vida, n.d). In this way, actions aimed at the rural sector reiterate the goals of the Post-2015 Development Agenda, specifically regarding the expansion of investments in infrastructure, agricultural research, extension services, development of technologies and genetic advances, with international support and cooperation. Such objective of this Agenda seeks to intensify the productive capacities in the agribusiness of developing countries, particularly the least developed countries (United Nations, 2023).

In this sense, it can be understood that rural producers of low technological incorporation can be accessing knowledge provided by ecosystem actors, such as universities located in Medellín, with projects that comprehend the whole state of Antioquia, and other actors, either by means of formal or informal mechanisms, being relevant to identify this process. In developing countries, the pre-eminence of innovation, the technological transfer and the knowledge flows for the agricultural productivity and competitiveness is widely acknowledged (Rambe & Khaola, 2022). In view of this, the study has as a research question: How does the flow of knowledge between rural producers and the regional ecosystem of Medellín occur?

Considering the economic relevance of this sector for the state of Antioquia and the promotional actions to the regional ecosystem of Medellín, the present study has as its objective **to analyze how the knowledge flow occurs between the rural producers and the regional ecosystem of Medellín**. Analyzing the context of a developing country in Latin America allows identification of the contributions that the regional ecosystems can provide, enabling a better understanding of the dynamics and interactions among the main actors that interact with the agricultural context.

The paper is structured in six sections: after the first introductory section, the second section presents a theoretical discussion dealing with knowledge flows in regional ecosystems. The third section presents the methodological path, detailing the data collection and analysis process. The fourth and fifth sections describe the results obtained and discuss them based on the literature, respectively. Finally, the sixth section provides conclusions, highlighting contributions and avenues for future research, followed by references.

Knowledge flow in Regional Ecosystems

Ecosystems correspond to a group of organizational actors that co-create innovative results at an ecosystem level, differing from other theories such as clusters, networks, and supply chains due to four inherent features: results at the system level, interdependence among actors, heterogeneity of participants and coordination mechanisms (Autio & Thomas, 2022). In the economic interactions among actors, researchers have considered knowledge and value flows as essential elements of ecosystems. On the one hand, researchers define an ecosystem as a network of multi-actors in which value flows generate a result at a system level (Adner, 2017; Jacobides et al., 2018). On the other hand, researchers consider the base of knowledge shared among the ecosystem actors, taking advantage of advances in technology and infrastructure (Autio et al., 2018; Spigel, 2017).

Prior to the emergence of the term "ecosystems", studies used the understanding that innovation systems were determinant for knowledge flows (Lundvall, 1992; Jacobson & Johnson, 2000; Edquist, 2010). In these systems, knowledge flows produce externalities that benefit the actors co-located in a territory, favoring exchange of knowledge. At the same time, they integrate the government that aims at stimulating innovation activities and inspiring local parties interested in establishing social connections for regional development of emerging economy (Scaringella & Radziwon, 2018; Trivedi & Srivastava, 2022). Conceptually, knowledge flow refers to a passage of knowledge between knowledge assets of a regional context through its rules and principles. The flow begins and ends with a knowledge asset that enhances the emergence of innovations in a regional innovation system, completing a cycle of knowledge socialization (Labiak Junior, 2012).

However, due to the static feature of innovation systems, innovation as a dynamic process needs to be analyzed from an ecosystem perspective, contrary to the top-down approach adopted from innovation systems (Mercan & Göktas, 2011; Cai & Huang, 2018; Pidorycheva et al., 2020). Thus, ecosystems comprehend evolutive features in the interactions among actors, as well as in innovative activities and their relations with the macroenvironment, since it is always changing its structure based on new objectives and circumstances (Mercan & Göktas, 2011). The responses to the environment are consequences of bottom-up interactions, without a hierarchy or central control, where small changes generate large results at an ecosystem level (Jucevičius & Grumadaitė, 2014).

Geographical roots are central in this process, as access to (tangible or intangible) resources is important to reach goals at an ecosystem level. Besides that, emphasis is placed on the regional and national geographical scope, because at this level the governmental actors contribute to the institutional and regulatory framework essential for the emergence of innovations (Cobben et al., 2022).

The actors of a regional ecosystem are not hierarchically related (Autio & Thomas, 2022) and have different profiles, based on the quadruple helix (Santos et al., 2021; Thomas et al., 2021; Arena et al., 2022; Carayannis & Campbell, 2022). The academy contributes to the qualification of human capital and in the production and dissemination of knowledge; "business" contemplate startups, large companies, incubators, accelerators, scientific and technological parks, investors, and commercial banks, contributing to the development of innovative products and knowledge application; the government is composed of governmental and regulatory agencies, as well as public development banks, responsible for the institutional conditions of the ecosystem; and the civil society consists of both individuals and organizations that benefit from innovations and those that contribute to their accomplishment, such as professionals supporting innovation and entrepreneurship, users, etc.

When the actors in an ecosystem establish cooperation and pursue shared business goals, interdependencies develop and become visible, enabling the reduction of risks and uncertainty. However, only by means of the exchange of knowledge and externalities innovative products and services can be created. Interactions allow co-evolution and cocreation of value at a level in which actors cannot create individually (Scaringella & Radziwon, 2018). In this sense, in order to establish vibrant flows of knowledge, it is essential to improve communication between actors and reduce geographical, cultural (languages and values), technological and social distances (Huang et al., 2007), since the greater the distances, the smaller will be the flows of knowledge (Allen & Cooney, 1973).

It is understood that the more science-intensive the productive sector is, the more frequent the interactions between the actors of the ecosystem and the stimulus to the flow of knowledge will occur according to the technological level of the actors (Dalmarco et al., 2015). In this way, this article focuses on rural producers with a low level of technological incorporation, seeking to understand their role in the regional ecosystem, whether it be an active company or just a beneficiary of the promoted actions.

It is noted that knowledge flow and ecosystem literature have not yet been interconnected, and knowledge flow studies have been more directly investigated in University-Company Relations (Zawislak & Dalmarco, 2011; Dalmarco et al., 2015) and Regional Innovation Systems (Labiak Junior, 2012), as highlighted. Therefore, this article seeks to contribute to the mapping of knowledge flows in regional ecosystems, since, as highlighted, systems and ecosystems are correlated theories (Mercan & Göktas, 2011; Jucevičius & Grumadaitė, 2014; Cai & Huang, 2018; Scaringella & Radziwon, 2018; Pidorycheva et al., 2020). The next section presents the methodological procedures of the research.

Methodological Procedures

Based on the qualitative research (Flick, 2014), with transparency and replicability criteria (Aguinis & Solarino, 2019), a case study was carried out in-depth in the regional ecosystem of Medellín. The choice for the case took place due to his relevance, as a reference in innovation in Latin America, being a dynamic and competitive economy stimulated by public policies at a national, state, and municipal level. The actions carried out in the ecosystem might directly or indirectly benefit rural producers in the whole state of Antioquia, being relevant to characterize this knowledge flow. For such, multiple sources and evidence will be employed: semi-structured interviews, document analysis, and direct observation.

Due to the characteristics that involve the operationalization of the case study, the research was conducted by an outside researcher (Griffith, 1998), without a pre-existent relationship with the study participants. To select the participants, the snowball sampling technique was employed (Patton, 2002), involving a process that simultaneously collects data, analyzes information and searches for new respondents based on the most relevant conclusions obtained by previous respondents. Upon meeting similar patterns in the data, the principle of saturation/redundancy emphasized by Glaser and Strauss (1967) was applied, that is, repetition and recurrence of the data collected as a criterion for closing the collection. With that, the theoretical saturation was met and the interviews were interrupted (Solarino & Aguinis, 2021).

A total of 26 interviews were performed, following a semi-structured script based on the literature, addressing the following topics: *i*) partnerships with ecosystem actors directed to agricultural context; *ii*) business opportunities and knowledge exchanges in the region; *iii*) knowledge sources; and *iv*) formal and informal mechanisms of knowledge transfer. The interviews took place in person, in the period September to December 2022, and were recorded to allow transcription and analysis. Figure 1 defines the actors interviewed.

Figure 1 - Systematization of the actors interviewed

Actor	Interviewee (abbreviation)	Interviewee
RUTA N	**R1**	Business Acceleration Program Coordinator
	R2	Project Coordinator for the Awareness and Culture Strategy for Innovation
Rural producers	**P1**	Coordinator of the Antioquia Milk Initiative - Chamber of Industry and Commerce of Medellín
	P2	Dairy products company
	P3	Milk producer
	P4, P5, P6	Coffee producers
	P7, P8, P9 e P10	Fruits and vegetables producers - *Mercado Campesino*
University	**Uni1**	Director of the Agro-Biotechnological Development Center for Innovation and Territorial Integration (*CEDAIT*)
	Uni2	Professor of the research group at the Faculty of Agricultural Sciences
	Uni3	Professor of the research group at the Faculty of Economics
	Uni4	Professor of the research group at the Faculty of Agricultural Sciences and coordinator of the Territorial Laboratories
	Uni5	Business Developer, Financial dimension of Parque E
	Uni6	Operations and projects manager (*CEDAIT*)
	Uni7	Economic sustainability professional (*CEDAIT*)
	Uni8	Projects director (*CEDAIT*)
	Uni9	Director of Biofactory (*CEDAIT*)
	Uni10	Innovation Director of the University and CUEE Coordinator
	Uni11	Extensionist of the project "Territorial Laboratories"
Government	**Gov1**	Innovation Director of the state of Antioquia - Secretariat of Agriculture
	Gov2	Science, Technology and Agricultural Innovation Director - Secretariat of Agriculture
	Gov3	State Government Platform Coordinator

Source: Elaborated by the authors

The data collection started at Ruta N in order to identify actions aimed at the rural producers. After that, the research was directed at the perception of the rural producers of Medellín regarding the knowledge flow and collaboration with other actors of the ecosystem. The interviews with the producers were carried out during technical visitations, which enabled direct observation of the production activities.

Both the interviews at Ruta N and the interviews with the producer served as the first exploratory phase, in which was identified a need to expand the interviews with actors of the university and the state government. During data collection at the university, actors involved in projects directed at the agricultural sector and that act directly with the rural producers were interviewed. Regarding interviews with the government actors, it was possible to understand the interactions and financing made available to the sector.

Some interviewees used drawings to represent the interactions, being complemented by documents available or provided in the data collection. Figure 2 systematizes the different strategies for documenting interactions.

Figure 2 - Systematization of the data collection procedures

Actor/Sector	Collection Procedures / Documents
RUTA N	• Internal documents, books or chapters produced by the interviewees, papers and theses published by researchers, and internet reports;
Rural producers	• Slides presentations used in conferences, internet reports, and technical reports by the State government; • Pictures and 5 technical visits.
University	• Documents and technical reports by specific sectors of the university; • State and federal legislations; • Drawings to represent the research setting; • Publications of the research groups (papers, books, and videos); • Participation in the CUEE meetings;
Government	• Documents and technical reports by the state government; • State and federal legislations; • Drawings to represent the research setting;

Source: Elaborated by the authors.

The data analysis aimed at the triangulation of the sources of the pieces of evidence, identifying key relationships that unite the first order actors in a narrative, allowing to identify pieces of evidence that represent the theoretical patterns discussed in the literature. To do that, the content analysis technique was used, which allows to carry out the material preparation and exploration, content categorization, and results treatment (Bardin, 2010). The analysis categories were defined after the event, when it was decided to group the pieces of evidence based on the "profile" of the actors interviewed.

Results

Ruta N and Rural Producers

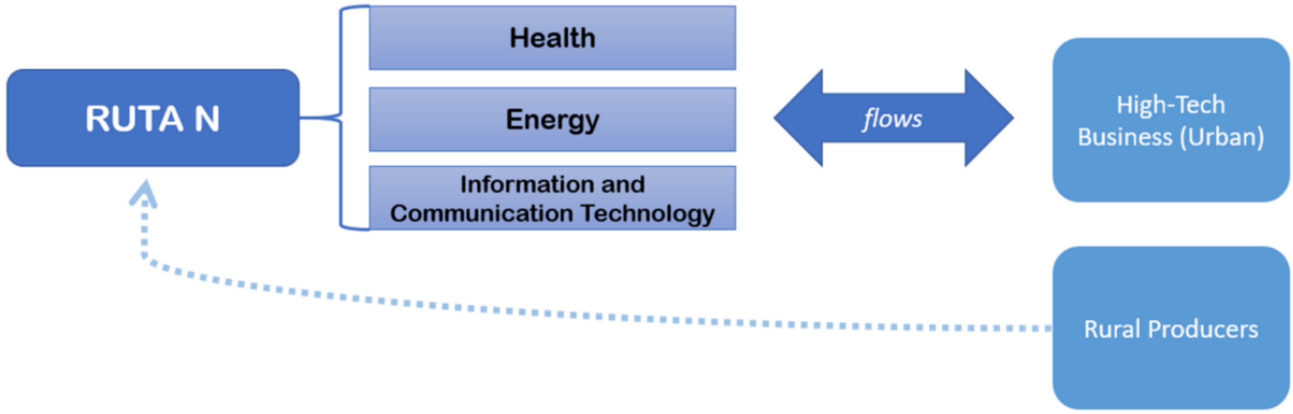
Set in 2009, Ruta N connects the ecosystem, promoting the collaboration among the actors from Science, Technology, and Innovation to coordinate and articulate policies and local institutions for regional development. The actions address three sectors: Information and Communication Technology, Energy and Health (Arenas et al, 2020; Ruta N, 2022). With the ecosystem's maturity, Ruta N has been rethinking its acting focus, not considering as one of its objectives the traditional productive sector, urban as well as rural (R1).

In Ruta N's awareness and culture activities, there is no control of who are the participants (R2), although the rural producers of the region may be benefiting, even though they are not the target audience. In this way, Ruta N's projects do not have specific direction for the rural, supported by R1 which highlights that *"they do not offer follow-up and specific resources for traditional enterprises, let alone the rural sector"*.

In the interview it was mentioned the coffee producers' case, highlighting its process of adding value and tourism activities. Ruta N did not directly influence the coffee sector's actions, because the sector development departs from the cooperative organization and the Coffee National Institute (P5). However, P4 related that, by their own initiative, participated in a tourism-related activity from Ruta N and that it contributed to their rural property. This report highlights that there may be isolated interactions between Ruta N and rural producers.

Fruits and vegetable producers related that the sector development initiatives arise from the city hall's projects and actions (P7; P8; P9). The milk sector, in turn, is self-organizing for the consolidation of a cluster of dairy products in Antioquia, focusing on the product's quality and the sector development, whose actions and projects are led by the Medellin's Board of Industry and Trade (P1; P3). Figure 3 summarizes the results obtained in this section.

Figure 3 - Summary of the results regarding the relation between Ruta N and Rural Producers



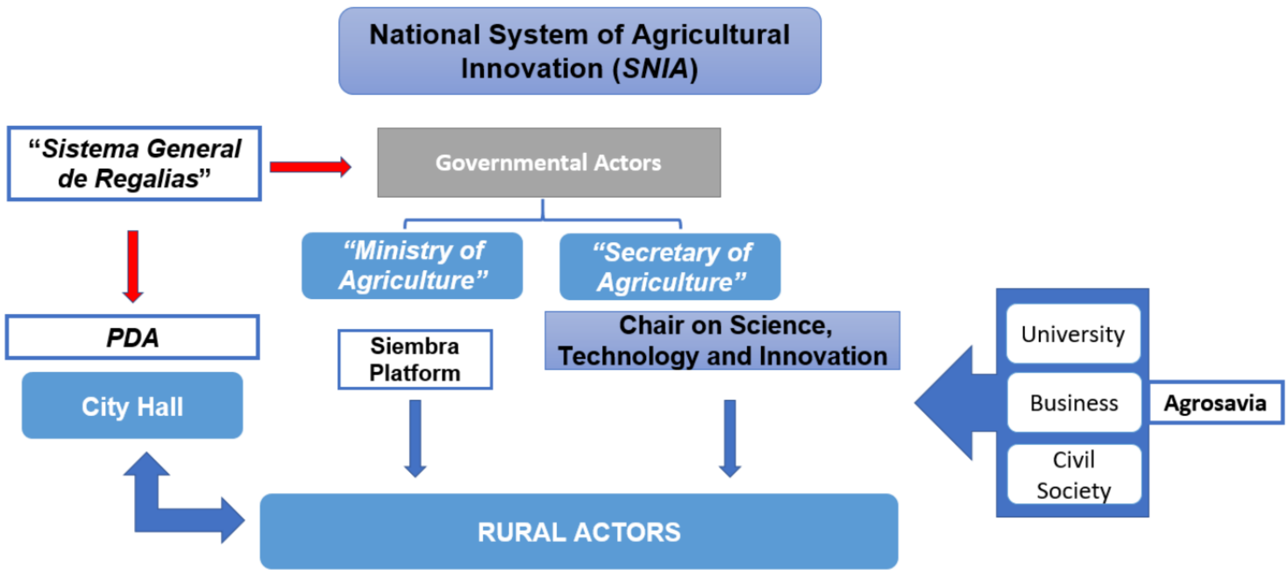
Source: Elaborated by the authors

According to Figure 3, there are no direct actions departing from Ruta N, considering that its acting focus is in the urban sector's high technology business. Rural producers decide to engage in Ruta N's activities on their own initiative and not on Ruta N's incentive. From this finding, the research is addressed for the governmental actors to understand the actions directed at the agricultural sector.

Government

Although the city halls act directly with the rural producers, in Medellin's ecosystem the "government" actor takes mainly a financier function. Figure 4 illustrates the interaction of the actors and projects for the sector by the government, the red arrows representing the financial flows and the blue arrows representing the knowledge flows.

Figure 4 - Knowledge flow for the rural producers by the government



Source: Elaborated by the authors

The innovation public policies directed at the agricultural sector in Colombia depart from the National System of Agricultural Innovation (SNIA), supported by Law § 1876 (2017), and coordinated by the Ministry of Agriculture and Rural Development. This ministry proposes the policies and it is left to the state governments to formulate the strategic plans on science, technology, and innovation, to be implemented in the cities after the definition of the demands (Gov1).

Gov1 interviewee considers an “institutional ecosystem”, where the universities, civil society, and the business (private and state) focus on the development of the small rural producers of the region. One example of a company that acts is Agrosavia - Colombia’s national company that has its own professional teams, and its own investigation, innovation, development, management, and commercialization projects for agriculture.

The relation among actors happens in the “Chair on Science, Technology and Innovation” of the Secretary of Agriculture, in which the strategic plans are updated, proposing demands that will be attended by the “*Sistema General de Regalias*”, which establishes mechanisms of equity in the resources distribution and finances the proposed actions. Besides, there is a platform that gathers information on rural producers and helps the decision-making by the Ministry of Agriculture and Rural Development, named “Siembra Platform”. Such a platform benefits the rural producers by providing financial resources adequate for their productive activities, in addition to investments in technological packages, infrastructure, machinery, research, and technology transference

In parallel to the Chair, the Antioquia State also has an agriculture development plan (PDA) with 3 big emphases: *i*) support to the productive infrastructure, *ii*) productive strengthening, and *iii*) formation and trading. The State has 24 productive chains, where some have their own dynamics - coffee, livestock, banana, sugar cane, and flowers - not the focus of this policy. The sectors such as aromatic, greenery, sustainable livestock, and cereal, in turn, have a low level of technological incorporation in their management, and, because of that, support actions are driven. Gov 1 interviewee approaches one example of the PDA interaction with the city halls.

> The city halls propose a project to the Secretary of Agriculture inside the PDA’s guidelines. From then the secretary develops an “umbrella” project. For instance: the university certifies 500 producers from 20 cities in good agriculture practices, with one contract. In the same way, another company, like Agrosavia qualifies cities with another chain. A way for the knowledge to circle and achieve the producer. It is also important that the city halls by developing projects with universities and specialized companies may acquire knowledge from diverse chains (Gov1).

In this study, it was identified that the government is characterized by encouraging interactions between other actors in the ecosystem, acting as an intermediary in knowledge flows. Based on public policies and financial incentives that increase the technological base of the rural context, government actions can be directed towards specific actors, for example: universities, companies in general and rural producers.

Considering that the University was cited by the government interviewees as an essential actor in the creation and dissemination of knowledge, the next section describes the results obtained with the university actors.

University

The university has an essential role in the production and dissemination of knowledge. In Medellin, the University of Antioquia - UDEA, from teaching, research, and extension activities, acts in different segments of society, where the agriculture sector is included. The UDEA is considered the most important institution of higher education in the department of Antioquia, consisting of 26 academic units, divided into 14 faculties, 4 schools, 4 institutes and 4 corporations (Bermúdez et al., 2022).

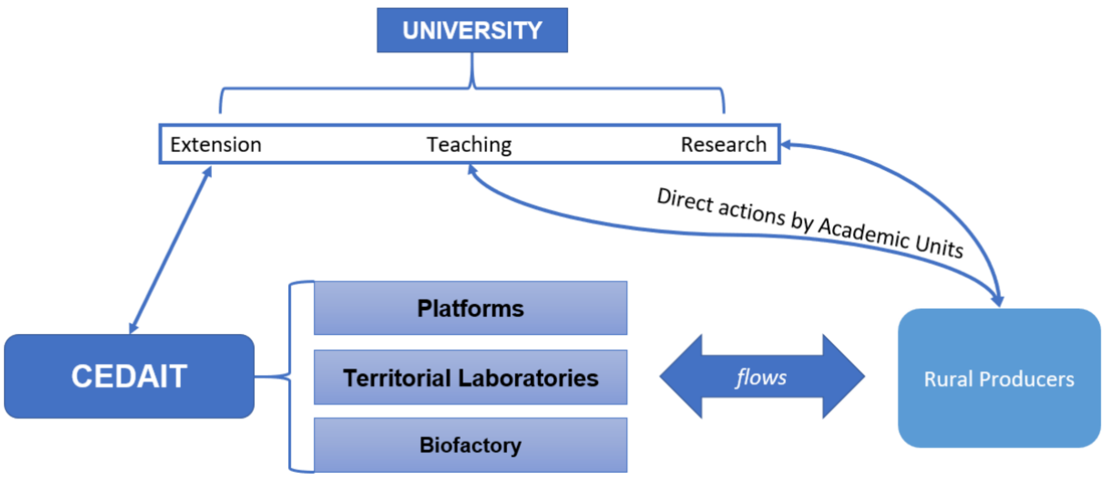
The UDEA's Innovation Management process makes part of the vice-presidency of extension, including four divisions: *i*) Culture and Patrimony; *ii*) Egress; *iii*) Social Interaction; and *iv*) Innovation. In the Innovation Division, specifically, there are 3 units: Government and Public Policy; Unity for the Peace, and the Center for Agri-Biotechnological Development (*CEDAIT*). The knowledge production and generation themes are addressed for the external actors (company, state, and society) and, due to the importance of the demands, there are actions on the part of the academic units. The Agrarian Sciences, Food Sciences, and Exact Sciences have developed research lines on agriculture themes, in addition to the existence of technological parks that aim at directing basic technologies for traditional cultivation. Uni10 highlights examples of such actions:

> The optimization of the irrigation systems and of the use of water is related to the Agricultural Sciences and Pharmaceutical Sciences College. Each one of them tries to bring high-accuracy technology for the greenhouses that allow the conditioning due to issues of climatic change and that is jeopardizing food security. But there are two components: one appropriation and another approximation with the rural communities (Uni10).

The university has different projects and actions directed to innovation, such as the E Park, Agrobiotech, Agcenter, among others, besides belonging to the CUEE (*Comité Universidade, Empresa, Estado*), composed of the ecosystem's strategic actors (universities, companies, state), and takes advantage of the space to articulate joint work routes. Dedicated to contributing to the productivity and competitiveness of the regional agricultural sector, CEDAIT stands out for being a model of transfer and social appropriation of knowledge, by approximating demands externally to the university labs, teaching staff, and research groups considered an articulation platform for technological and social innovations (Bermúdez et al., 2022).

CEDAIT is a structure inside UDEA maintained basically from the "*Sistema General de Regalias*" and has three products directed to the sector: Technological platforms, Biofactory and Territorial Labs. Figure 5 presents CEDAIT and its interactions inside UDEA.

Figure 5 - *CEDAIT*, its products, and interactions in the university



Source: Elaborated by the authors

Figure 5 shows that interactions occur in the Teaching, Research and Extension tripod, pointing out how the knowledge flow goes through *CEDAIT* until it reaches rural producers. The Biofactory aims to produce elite material to supply farmers in the country and abroad. Elite plants are raw materials with a high level of technology, material free of pests and diseases, and that guarantee to produce a greater quantity with fewer resources (Uni9).

The Platforms refer to an information and communication system in partnership with the Faculties of Agricultural Sciences and Economic Sciences. Such platforms are operated by the university and the Department of Agriculture. The platforms collect information from specific agricultural sectors, respecting their particularities, which makes it possible to provide technical assistance and, therefore, it allows better decision-making by rural producers. According to Gov3 "*When this tool was thought of, we wanted to solve a problem that is to put technology in agriculture*". The excerpt from Gov3's interview illustrates the work with local producers and the difficulties in the process of meeting demands.

> There are approximately 80,000 peasants who intended to be part of an association. There are no employees in this department to assist them, and there are peasants who have more than one productive unit, if you multiply that you will realize that it is a huge number and it is not possible to go from person to person. [...] Why don't we bring the technology closer to the producer virtually to see if we can solve the problem? Bring technology to make us efficient, because Antioquia buys 70% of the agricultural needs of other departments, which means that we are not food secure (Gov3)

The third product refers to the Territorial Laboratories, which constitute a space for the common construction of knowledge where the dialogue of knowledge is promoted from an interdisciplinary point of view, seeking to provide experimental spaces and appropriation of knowledge of rural communities (Aguilar-Marín et al., 2022). In the projects, there is information exchange about what is more important to the producers, in what aspects they believe they should provide follow-up, and what can be offered (Uni11). The actions proposed by Territorial Laboratories involve (Aguilar-Marín et al., 2022): *i*) workshops to learn "how to do"; *ii*) business follow-up in the region's municipalities; *iii*) creation of experimental agricultural production systems based on the producer-to-producer methodology; and *iv*) technical meetings on processing, commercialization and associations that allow the creation of associations of producers in the different chains.

In general, it is identified that *CEDAIT* has projects with rural producers of low technological incorporation, but there is still a lot to evolve in terms of technical assistance (Uni1; Uni4), mainly regarding innovation in the sector. Uni1's speech illustrates this perception, it highlights CEDAIT as a platform model and corroborates the importance of developing specific platforms for other sectors of the University.

> It is difficult for innovation to get into agriculture because it has many areas of knowledge. [...] We still don't have this whole trajectory. I also feel that we must start replicating CEDAIT's proposal for the entire university. [...] We need a platform for cultural and artistic enterprises, for example, that knows how negotiations are carried out in the countryside [...] There is the ecosystem of the city, but there are also technological platforms for sectors, for specific fields. I consider CEDAIT an innovation platform for the sector (Uni1)

Still, in relation to the interaction with rural producers, other initiatives and perceptions were highlighted. The interviewee Uni2 highlights the need for an ecosystem format specific to the agriculture sector. Corroborating this, Uni3 highlights the importance of respecting the specific characteristics of each production chain. Uni1 points out that the UDEA has initiatives, but it cannot be considered an ecosystem. Although it highlights the maturity of the Medellín Ecosystem and mentions it as a highlight for Latin America, it is noted that there are no consolidated actions for agribusiness, as shown in the following excerpt:

> I do not believe that the university acts like an ecosystem, that would be too pretentious. We offer all the instruments we have, but the university is part of a larger ecosystem. Medellín, for more than two decades, has been promoting these issues with many actors, including the university. If we don't have everything we need, we go to other actors so they can boost us.

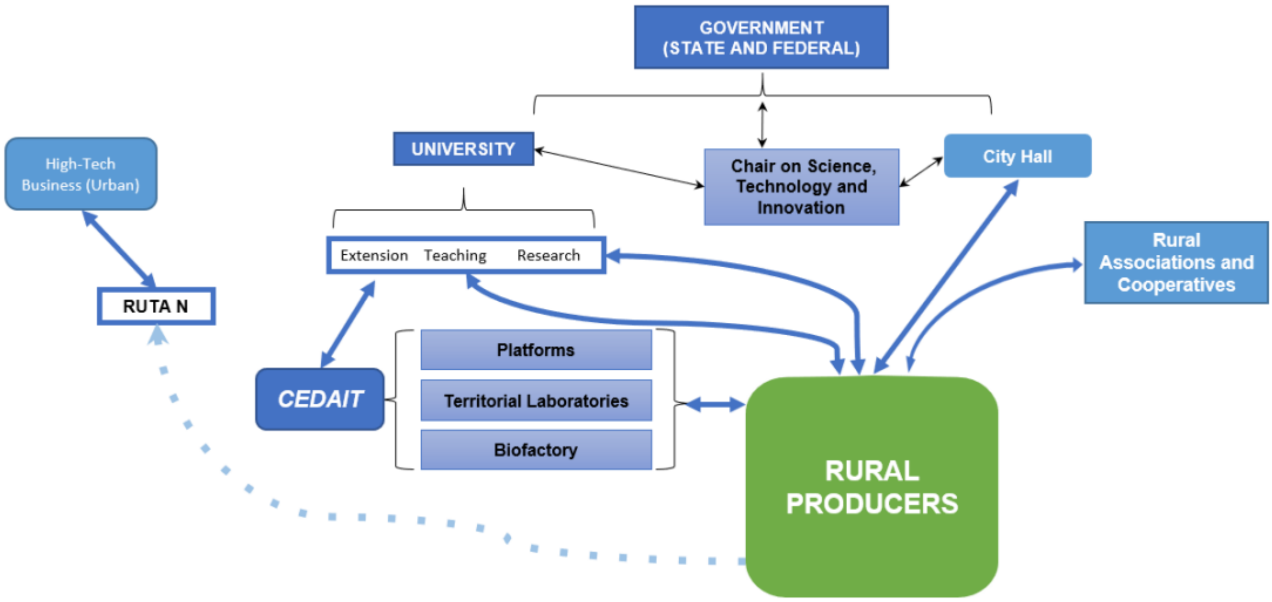
We have technology and knowledge assets that may be in other territories and, therefore, we do not have all that capacity (Uni1).

From the description of the perceptions of the different actors, it is possible to identify the relationships that occur in the regional ecosystem, with knowledge as a fundamental element. Specifically in the agricultural sector, there are knowledge flows, but still at an incipient level that requires greater investments by the ecosystem as a whole. Such evidence will be discussed based on the literature in the next section.

Discussion

Based on the results presented in the previous section, Figure 6 proposes a mapping of the knowledge flow between rural producers with low technological incorporation and actors in the regional ecosystem of Medellín. From the mapping, we can advance theoretically in relation to the flow of knowledge between the actors and variables such as technology and geographic distance.

Figure 6 – The mapping of knowledge flow between rural producers and the regional ecosystem of Medellín



Source: Elaborated by the authors based on the research data.

It is known that in the literature on regional ecosystems, actors assume multiple roles throughout the different stages of ecosystem construction (Rabelo & Bernus, 2015; Pique et al., 2019). At this stage where the ecosystem of Medellín is considered a reference in Latin America, the question is: What role do rural producers assume? At a time when producers do not have a direct role in defining the ecosystem, it is understood that rural producers have the role of "beneficiaries" being classified as civil society (Santos et al., 2021; Arena et al., 2022; Carayannis & Campbell, 2022). Conforme os autores supracitados, os atores pertencentes à Sociedade Civil podem ser "atuantes" ou "beneficiários". Com isso, entende-se que os produtores rurais, foco deste estudo, não possuem um posicionamento atuante nas políticas públicas e no planejamento do ecossistema, diferente de setores produtivos com maior desenvolvimento tecnológico, estes se encaixando como empresas. Portanto, os produtores rurais não se encaixam no papel de empresa, pois apesar de serem produtores de bens, eles não estão articulados ao ecossistema, tornando-se necessário um desenvolvimento mais assertivo e direcionado ao setor rural.

The knowledge flow mapped and demonstrated in Figure 6 occurs mainly through the transfer of knowledge from the university to rural producers. The results showed that the university is dedicated to developing digital platforms for the sector, investigations by research groups, technology parks, follow-up projects, and producer support, patents, among others. However, the intensity of the knowledge flows identified and mapped in the research are not yet measurable, requiring further detailed investigation in this regard.

Such evidence is in line with the United Nations (2023) objectives related to rural development which highlight the need to Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks, in order to increase the agricultural productive capacity in developing countries, in particular the least developed countries. The university in this context is the actor responsible for establishing the flow of knowledge, being that most of the time knowledge flows from the most concentrated environment (university) to the least concentrated environment (producers). As highlighted by Zawislak and Dalmarco (2011) and Dalmarco et al. (2015), when the university stimulates the flow, the transferred knowledge can be scientific or applied, with the interaction aimed at a new technology or market application.

The flow of knowledge is stimulated by financial investments by the federal and state governments, based on the set of laws, platforms, and benefit systems that establish policy guidelines for the sector. This point is in line with what is highlighted by Dalmarco et al. (2015) regarding the government stimulating the flow of scientific and applied knowledge, in order to increase the technological level of the actors and thus favoring the development of the productive sector. The regional and national geographic scope that the Medellín ecosystem encompasses is highlighted, and, according to the literature, it is at this level that government actors contribute to the institutional and regulatory framework essential for the emergence of innovations (Cobben et al., 2022), consolidating the flow of knowledge from public policies and funding (Carayannis & Campbell, 2022). Despite being considered by the interviewees as an "Institutional Ecosystem", it can be understood that it refers to the regional ecosystem of Medellín because it emphasizes all actors of the quadruple helix and their interactions (Rabelo & Bernus, 2015; Pique et al., 2019).

The understanding of the Institutional Ecosystem may be linked to some characteristics of the "Innovation System" existing in the government interactions of the Medellín ecosystem, which are perceived in a top-down logic (Edquist, 2005; Mercan & Göktas, 2011; Pidorycheva et al., 2020). However, the inclusion of other actors in the helix and the dynamism of interactions with rural producers demonstrates an ecosystem relationship where there is also a flow of knowledge on the part of producers (bottom-up). Examples of this interaction are the Territorial Laboratories, which carry out an exchange of knowledge to understand the demands of producers, as well as the case of CEDAIT platforms, which involve rural producers in the sector's development process, qualifying both its products and its technological capacity. In turn, by establishing interaction with producers, the university can receive market information that directs the development of its research and actions.

Despite the interactions shown between rural producers and ecosystem actors, the proposed actions are, in most cases, isolated. It is understood that the actions could be enhanced, as they disregard the presence of relevant actors in the region. It was identified that rural producers benefit from the ecosystem because they are in the region and access knowledge through externalities, an essential element of regional ecosystems (Scaringella & Radziwon, 2018). However, the development of an ecosystem does not occur only in the presence of actors and their individual actions, but in their joint interactions (Rabelo & Bernus, 2015; Pique et al., 2019).

In the regional ecosystem of Medellín, Ruta N is the main governance actor (Arenas et al, 2020), however, it does not present direct actions to rural producers. Considering the economic importance that the agricultural sector has for Medellín and the region, it is necessary for another actor to assume the coordination of actions that include rural producers, considering the peculiarities of each production chain. In addition, specific platforms for agribusiness, inserted in the ecosystem, can provide actions for the development of the segment, and support the innovations of rural producers. This point is in line with the literature that highlights regional ecosystems as aggregates of several smaller ecosystems (Visnjic, 2016), involving a complex conjunction of actors and a high degree of collaboration (Rabelo & Bernus, 2015).

Conclusions

The present study aimed to analyze how the knowledge flow occurs between rural producers and the regional ecosystem of Medellín. The results showed that rural producers assume a civil society role, being beneficiaries of ecosystem actions. The interaction between university and rural producers was highlighted, with the government being a promoter of actions directed to the sector, based on financial investments. Although there are knowledge flows for rural producers, the actions and projects developed by the regional ecosystem of Medellín are still incipient for this segment, although it is a reference ecosystem in Latin America.

The theoretical contributions of the research deal with expanding discussions on regional ecosystems in emerging countries and emphasizing the need to develop actions for the agricultural sector. In addition, it is understood as the identification of a knowledge flow model to be replicated, where a framework can be structured to be investigated in other regional ecosystems, as well as its interactions with the productive chains.

Considering the practical contributions, the study allowed a visualization of the interactions between the actors of the ecosystem with the rural producers, making it possible that future research expands the discussions on the role of the actors. The relevance of the university actor for the flow of knowledge was evidenced, with a unilateral interaction occurring mainly, where the main actions arise from the university and not from the demands of the producers, and the need to expand this process was identified during the research. It is still necessary to broaden the discussions in relation to other actors and their dynamics, since it is known that the helix does not consist of each actor individually, but in their interactions. Finally, public policies can be developed from the interactions and knowledge flows identified in the research.

Due to the objective of the research to indicate the mapping of the flows, the contributions obtained advance in the understanding of the knowledge flows between the investigated actors, however it is understood that advances are still necessary, such as: i) what is the intensity of the knowledge flows in the regional ecosystem?; ii) What capacity do rural producers have to absorb knowledge from the ecosystem based on the analysis of its absorptive capacity?; iii) How do the geographic limits of regional innovation ecosystems impact the flow of knowledge to the agricultural sector? and iv) What is the role of cooperatives and producer associations in intermediating knowledge flows between the regional ecosystem and rural producers?. These points show possibilities for future studies that contribute to the theoretical-empirical discussion addressed in the paper.

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ENTREPRENEURSHIP I

May 3rd: 3h10 pm – 5h pm

Chair

Ana Correia Simões (University of Porto, Portugal)

Papers

Cultural entrepreneurship - a study in the cinema sector in Paraná

Fernando Antonio Prado Gimenez, Misael Pantoja, Felipe Leal Alves Ferreira

Proposition of a conceptual framework on innovative entrepreneurship in the organizational context

Graziela Fontes Novaes, Cristina Dai Prá Martens

The social perception of women entrepreneurs in manufacturing - A literature review

Sandra Monteiro, Ana Correia Simões

Entrepreneurial orientation and business structuring in incubation process: a systematic literature review

Daiane Tretto Rocha, Cristina Dai Prá Martens

Cultural entrepreneurship - A study in the cinema sector in Paraná

Abstract ID#229

Fernando Antonio Padro Gimenez, Misael Pantoja, Felipe Alves Ferreira (Federal University of Paraná)

Purpose

The article describes the characterization of the performance of filmmakers/owners of film production companies in Paraná and the formation of the cultural entrepreneur's identity in this field. In the context of audiovisual as a business activity sector, we sought to answer the research question: what characterizes the performance of filmmakers and owners of film production companies in the state of Paraná? The film industry offers the audiovisual product with the greatest international reach and is responsible for the largest revenues of media conglomerates that dominate the sector internationally (Pangarker & Smit, 2013). In Brazil, it has economic relevance and presents a constant growth dynamic in recent years (Gimenez, Rocha, & Santos, 2015).

Literature Review

The theme of cultural entrepreneurship in Brazil is still little explored in the literature (Gimenez, 2017). In relation to cinema, filmmaking falls within cultural entrepreneurship, an action space in which the business logic is paired with the logic of cultural creation, to the extent that filmmaking is often not aligned with economic logic, or at least does not correspond to the market need (Almeida & Morelli-Mendes, 2014). Given this, cultural entrepreneurship has some obstacles because, as Davel and Corá (2016, p. 368), "for entrepreneurs in this sector, necessarily, the production of goods and services needs to be thought of from the cultural point of view, of its symbolic value and wealth of meanings." In other words, culture is the key and guiding element of a cultural entrepreneurship, and in relation to cinema, it is a direct result of the culturally understood process and practices of society. Cinema as one of the segments of cultural entrepreneurship is known to involve an extensive production chain, as the industry develops and expands to various segments. The film industry in Brazil has problems that still persist in the issue of exhibition, in which domestic films face some bottlenecks, preventing or hindering the production/distribution/exhibition process (Schröeder, 2012). Therefore, the opportunities in Brazil are gigantic, firstly for the size of the country being continental, and also for the diversity being one of the greatest riches of the country, which ends up having several contexts and regions that can be an extension source of insights for creation and ideas of stories and scripts to be worked on.

Methodological Procedures

The approach adopted was the Grounded Theory, which develops theory based on data that are systematically collected and analyzed, i.e., of an inductive nature. The Grounded Theory methodology implies a constant interaction of comparative analysis between collected data, theoretical reflection by the researcher, elaboration of explanations, new data collection, and re-analysis and re-elaborations, arriving at comparisons with previously formulated theories. The research procedures involved in-depth interviews with film production entrepreneurs in the state of Paraná, guided by an initial inquiry and taking the form of an unstructured interview. Thus, the goal was to develop a theory based on data that would characterize the formation of the cultural entrepreneur's identity in the field of cinema paranaense.

Findings

The main findings were: the existence of parallel careers in cinema; multifunctionality in the work routines; greater difficulty in acting in Paraná than in the RioSão Paulo axis; work roles mixed between the cultural side (creation, production, direction) and the management side; seeing themselves as cultural entrepreneurs to different degrees and for different reasons; the importance of some cultural institution to leverage the work of cultural entrepreneurship; culture, lack of continuity in the governments and the current president's policy as bottlenecks to the area; legitimacy brought to their work from participation in festivals and associations.

Implications

This research provides knowledge of the performance of professionals in the area of cultural entrepreneurship, specifically in Cinema, facilities, difficulties and public policies for the sector. It presents as a limitation the number of respondents, thus suggesting new research with the inclusion of more respondents.

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Proposition of a conceptual framework on innovative entrepreneurship in the organizational context

Abstract ID#244

Graziela Fontes Novaes, Cristina Dai Prá Matens (Uninove, BR)

Purpose

Innovative entrepreneurship and managerial innovation capacity have been related to the survival of companies and even nations (Jin & Lee, 2020). In addition, innovative entrepreneurship is one of the main sources of new technologies and knowledge, generating social and economic benefits for organizations (Beknazarov et al., 2020). According to Block, Fisch, & Van Praag (2017), innovative entrepreneurship has stimulated an intense discussion in academia and in practice. Still according to the authors, the academic literature is growing, but still dispersed and divided into several disciplines. Thus, this study objective is to propose a conceptual framework on innovative entrepreneurship in the organizational context, based on aspects identified in the existing literature analysis.

Literature Review

Innovative entrepreneurship focuses on creating new products, services, production methods or business models (Bradley, Kim, Klein, McMullen, & Wennberg, 2021). It is capable of stimulating business growth, generating value-added jobs and creating corporate and social wealth (Bradley et al., 2021). It consists in the process of commercializing new unique concepts, being one of the main channels for transferring scientific developments into viable products and technologies (Kravchenko, Kuznetsova, Yusupova, Jithendranathan, Lundsten, & Shemyakin, 2015). Thus, organizations that generate disruptive products or services for their customers are examples of innovative entrepreneurship (Ali, Kelley, & Levie, 2020). However, it is necessary to identify the factors that characterize innovative entrepreneurship in the organizational context.

Methodological Procedures

An exploratory study with a qualitative approach was done, through a systematic literature review. The search was carried out in the Web of Science and Scopus databases and after applying the protocol, 39 articles remained in the sample considered for conducting this research. For the data presentation, these were classified in relation to the methodological Approach and categories of analysis, which comprise, in addition to the definition, the factors that facilitate and inhibit innovative entrepreneurship, as well as its organizational and social consequences.

Findings

The study results present a conceptual framework that constitutes the factors that facilitate and inhibit innovative entrepreneurship, its definition and its organizational and social consequences. For the framework construction, the aspects that presented the highest frequency in each category of analysis of innovative entrepreneurship addressed were considered. In relation to the facilitating factors, were considered the existence of an adequate institutional environment, intellectual support from technology centers and universities, qualified human capital, provision of incentives by government agencies and knowledge management. On the other hand, the factors that inhibit innovative entrepreneurship are the difficulty in obtaining funding or incentives, inadequate government regulation, limited resources and lack of technical expertise. Regarding the organizational consequences, stand out economic growth, competitive environment formation, power to react to changes in the consumer market, increase in productivity and new markets conquest. Finally, the social consequences include the positive impact on job creation, the scientific and technological development stimulation and the increase in the local life quality and social well-being.

Implications

The conceptual framework resulting from this research contributes to a better understanding of the factors that permeate innovative entrepreneurship in the organizational context. From a practical point of view, having knowledge of these aspects can help companies to create a culture that encourages innovative entrepreneurship, benefiting from the consequences. As a suggestion for future research, empirical studies are recommended using the framework, aiming at verifying and validating, in a practical context, the factors found in this research.

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Challenges and Barriers that influence the social perceptions of women entrepreneurs - A literature review

Abstract ID#127 | Full Paper ID#431

Ana Correira Simões (Centre for Enterprise Systems Engineering, Portugal), Sandra Monteiro (School of Economics and Management of the University of Porto, Potugal)

Abstract: Throughout history, women have always overlooked in favour of men. Even thoughthere are increasing improvements in the area, there is a big gap to fill. More women are assuming empowering roles inside and outside of companies. Thus, research must keep up withthe evolution to document and permit the exploration of these new additions to society. Hence,there is a growing need to understand how these women succeed and whether common groundamong the different genders is reached. This paper aims to present a literature review on identifying the challenges and barriers that influence the social perceptions of women entrepreneurs, paying particular attention to the manufacturing sector. Among the most important findings, it is notable that the culture, gender equality, internet dependence, and institutions of each country impact not only the performance but also the social and professional perception of women entrepreneurs. The results of this study are relevant not onlyregarding the impact on society but, more importantly, to companies and their managers to understand the consequences of gender inequality. Likewise, this study's results are valuable to female-led firms that can benefit from new insights and improve their performance and productivity.
Keywords: Entrepreneurship; Women; Manufacturing; Image; Stereotype; Society

Introduction

For too long, patriarchy has restricted women's mobility, limited them financially and controlled their freedom (Nyarko, 2022). According to Cochran (2021), in 2018, women represented less than 22 per cent of start-ups' founders and are even more under-represented regarding high-growth entrepreneurship ventures. Nevertheless, female-led businesses and women entrepreneurship has become more apparent in the last 30 years (Moletta et al., 2021), and from an economic perspective, this role played by women in new firms is essential for the economic growth and social development of a country (Moletta et al., 2021).

Throughout history and in the existing literature – like studies from Moletta et al. (2021), Ekanem (2015), and Islam et al. (2020) – women have always generally been overlooked in favour of men. Furthermore, despite increasing improvements the regarding this, there is still a considerable gap to fill. More and more women are entering empowering roles inside and outside of companies. Therefore, research must keep up with the evolution and enable the exploration of these new additions to society. Hence, there is a growing need to understand how these women succeed and whether we have reached a common ground among the different genders.

Hence, this study aims to present literature findings on identifying the challenges and barriers that influence the social perceptions of women entrepreneurs, specifically in manufacturing.

This article is structured as follows, after this introduction, the second section presents the method used in this research. The study results are presented in section three, summarising the main findings collected and analysed from the literature. Finally, the main conclusions of this study are presented.

Methodological Procedures

For this study, a literature review was applied as a widely known research method in the management literature (Newbert, 2007; Abatecola et al., 2013; Poggesi et al., 2016). This method was considered adequate for the article's primary purpose since it explains the research process, which can better analyse the literature gaps and identify future research avenues.

To this end, the Scopus and Web of Science databases were used to identify the articles related to the research topic. Only English literature was considered. Afterwards, the snowballing method was applied to develop the theme further. The snowballing method consists of starting with a sample of a few selected papers and, from their references going further inside the theme of the study, being hence very appropriate for systematic literature reviews (Wohlin, 2014).

Table 1 shows the search expression used, organised by keywords applied in the databases.

Table 1: Search expression

Keyword	Search string
Woman	"Women" or "Female" or "Wom*" or "Gender" or "Girl"
	AND
Entrepreneur	"Entrepreneur*" or "Produc*" or "Fabrica*" or "Firm" or "Enterprise" or "Company" or "Start-up" or "Venture" or "Business"
	AND
Manufacturing	"Manufacturing" or "Manufactur*" or "STEM" or ("Science" and "Technology" and "Engineering" and "Math*") or "SET" or ("Science" and "Technology" and "Engineering")

Source: Authors' own elaboration

Table 2 presents the screening steps to achieve the final set of articles selected for further analysis. First, the irrelevant studies regarding their title were discharged. Secondly, the same was done based on the abstract. Finally, based on full reading, a set of 47 articles was considered for further analysis.

These selected articles were fully analysed by coding the relevant data based on the key concepts and definitions. Later, each study's results were systematised to facilitate comparing and connecting concepts and data from each article. Each conclusion was also examined and compared among others to verify its relevance.

Table 2: Screening steps

Screening steps	Scopus	Web of Science	Total
# Articles with selected keywords	119 061	26 352	145 413
# Articles after eliminating irrelevant ones (based on the title)	1 141	249	1390
# Articles after eliminating irrelevant ones (based on abstract)	109		109
# Articles after eliminating irrelevant ones (based on the entire article)	47		47
Articles for further analysis	47		47

Source: Authors' own elaboration

Challenges and Barriers to women entrepreneurs' Image

Women in Manufacturing

The manufacturing sector is mainly male-dominated, which has started to cause some concerns (Goel & Tiwari, 2020). According to Islam et al. (2020), there are fewer women-led firms in the manufacturing sector than men-led ones, with percentages such as 22% versus 31% respectively. Also, Kuschel et al. (2020) add to the statistics with a recent study that states that 52% of women in STEM areas of work abandon their jobs in their mid to late thirties.

From what concerns specific statistics of women in the manufacturing sector, despite the recent improvements, only around 30% of the sector are female employees (Oyón, 2022). Despite the apparent increase from 2016 (33.3%) to 2022, the share of women at a junior staff level is only 36.9%. This number decreases in mid-level staff (24%), at senior level (15%) and at top-level CEO (9%) across most industries (World Economic Forum, 2022).

Moreover, the gender gap in leadership in manufacturing stands at 19% (World Economic Forum, 2022). This gap also demonstrates that there is a strong influence of social expectations regarding gender roles and what men and women are supposed to participate in (Oyón, 2022), which goes accordingly to the literature (ex. Moletta et al. (2021); Ekanem (2015); Islam et al. (2020)).

Regarding current policies that affect women in manufacturing, they are still a "work in progress" instead of a finished product (Henry et al., 2022). Some countries present public policies and programs to support and enhance specifically women's entrepreneurship and help them achieve their goals with little resistance (Henry et al., 2022). Unfortunately, this is the case for some countries where women entrepreneurs' policies and programs are inconsistent with the country's reality (Henry et al., 2022).

Dimensions of influence on women entrepreneurs' image

According to the literature, there are four main types of factors that have a heavy influence on themselves, but mainly on the barriers that women face to become an entrepreneur: cultural environment, gender equality status, institutional context and business, and personal networks (Fang et al., 2022).

Cultural context

The cultural environment is crucial when considering and defining what is expected from society and perceived in terms of male and female roles (Appelbaum et al., 2019). It is critical in the understanding of gender inequalities. It should always be considered during research and when proposing policy and strategy changes and operational decisions (Appelbaum et al., 2019).

From a cultural perspective, the literature shows that some cultural contexts are more represented than others in entrepreneurial activities, depending on the country of origin, which is often related to the culture of said country (Daulerio Jr., 2018). Furthermore, societies have quite a heavy influence on the roles played by their citizens in terms of gender-related stances and behaviours (Demirbağ et al., 2021).

In literature, it is suggested that the Status Construction Theory (Ferguson et al., 2020) explain the different inequalities of gender based on cultural influence. It describes how beliefs spread and are created, as well as how these shift the normal social dissimilarities and morph them into trends of inequalities, which later become social norms integrated into society and culture (Ferguson et al., 2020). Therefore, according to Ferguson et al. (2020), in society, status can bring prestige and respect to different individuals, despite the economic and power sources. Furthermore, culture has influenced gender roles in such a way that they are often believed to be fixed. It is associated with more significant gender system reasoning and traditional roles based on biological attributions and gender inequalities (Skewes et al., 2018). Thus, society's perception of women's occupations and jobs affects their career choices (Schnittker & Ettl, 2021), which can lead to limits professionally.

These gender perceptions and clichés frequently show influence through social and environmental messages that impact young girls and boys and their career development expectations (Brush & Gatewood, 2008). Women are regularly forced to abandon and sacrifice their careers to answer to others' required needs – the socially imposed gender roles they must fill (Goel & Tiwari, 2020). When the environment and cultural context is not progressed enough or conducive for professional women, the term "social navigation" was invented to describe the situation where women challenge gender roles imposed by culture – which induce violence, insecurity, and discrimination (Lahiri-Dutt, 2022).

Consequently, the role of cultural context and environment, which has thus been recognised as essential and influential in women's career choices and external perception (Ekanem, 2015), is also identified as decisive in their entrepreneurial ventures.

Gender Equality

As Daulerio Jr. (2018) stated, since women entrepreneurs' impact on a country's activity is so relevant, there is a need to have a higher understanding of the gender differences that might influence them.

Most women live their whole lives unaware of having been targets of gender discrimination, despite the existence of objective evidence (Ibarra et al., 2013). In society, social norms exist based on preconceived and stereotyped gender roles, which differentiate women and men (Ibarra et al., 2013;

Giménez & Calabrò, 2017; Alqahtani, 2020). Furthermore, helping with the increase in gender bias, women are assumed to be less competitive, less pro-risk, and have a less authoritative presence, which leads to less acceptance in top positions – including in management, politics, and sports (Ferguson et al., 2020). Nevertheless, the simple fact of the persistent wage gap, even nowadays, is worrying for society and the financial world.

According to Rendall (2017), there has been an increasing rise in the brain and an increased fall in brawn, leading to a closing of the gender gaps. However, women are still prevented from reaching the limited and overcrowded men's top positions.

The first prejudice against women leaders is regarding their gender, which unfortunately goes against the traditional role of leaders, which is filled with very masculine embodied stereotypical traits (Alqahtani, 2019). Thus, their biggest challenge lies in the root of gender inequalities in the professional world (Elgin & Elveren, 2021; Cochran, 2021).

As traditional managerial efficiency is believed to be a male trait, more and more women are starting to employ these masculine traits to pass on a 'more competent' image of themselves and try to get more creditability (Martin et al., 2015; Fernandes & Mota-Ribeiro, 2017; Appelbaum et al., 2019). Women continue to adopt "masculine" leadership styles, which can have disadvantages (Appelbaum et al., 2019).

When considering the entrepreneurial field, this has also been stereotyped as a male arena, despite recent studies indicating that females who have mothers who were entrepreneurs are more likely to be entrepreneurs as well (Gimênez & Calabrò, 2017). Unfortunately, women are also viewed as "intruders" in this sector, despite considerable evidence that gender characteristics cannot be defined only by their biological sex (Appelbaum et al., 2019).

Fighting for gender equality has been said to bring multiple benefits to society and the economy of each country (Nguyen, 2021). However, a complete corporate restructuring, the most obvious way to close this gap, is challenging to achieve (Appelbaum et al., 2019). Still, this gender inequality and the gap continue to influence and endanger women's path to becoming entrepreneurs and leaders, thus preventing also more economic prosperity in the world in egalitarian and economic outcomes (Giménez & Calabrò, 2017; Abegaz & Nene, 2018).

One point to look forward to is that most societies commit to gender equality, considering it an important goal (Wolfram et al., 2020). Furthermore, women and men entrepreneurs share similar academic backgrounds, which shows the gap closing on the educational side (Poggesi et al., 2020). However, discrimination continues subtly, especially regarding performance evaluations and hiring criteria (Wolfram et al., 2020).

Hence, just like the cultural environment dimension, gender inequalities also seem to hinder the professional path of women, as seen, also in the entrepreneurial context.

Institutional environment

According to Giménez and Calabrò (2017), institutions are divided into two main categories: informal and formal. Regarding informal institutions, it is found dimensions such as gender roles, social norms, family, religions and ideologies, and codes of conduct (Giménez & Calabrò, 2017). Inside the formal ones, there are the economic rules and regulations, political rules, and education (Giménez & Calabrò, 2017).

North (1990) considers societal logic as "informal social norms" that control social interactions and economic contexts. Thus, considering that institutions guide economic behaviours, literature focused on whether they also facilitate or inhibit women's and men's entrepreneurship ventures (Giménez & Calabrò, 2017).

It was found that social norms are deeply rooted in society and influence women's and men's entrepreneurial traits, attitudes, perceptions, and opportunities (Giménez & Calabrò, 2017). Furthermore, like gender roles influence the institutional context, it is also considered that gender beliefs influence the building of institutions (Giménez & Calabrò, 2017). Nevertheless, it is essential to note that the literature agrees, saying that discriminatory behaviours from the institutional context towards the different genders do not exist due to legal restrictions or the awareness of the importance of female firms for formal institutions, such as banks (Poggesi et al., 2016; Gui-Diby et al., 2017; Ghosh, 2018). Likewise, according to Pogessi et al. (2016), this relationship between women-led firms and credit institutions should not be caused by the gender of the borrower but is more likely due to specific organisational characteristics. Nevertheless, literature considers the gender of the loan officers as a trait that could influence the traditional processes of loan applications for either male or female entrepreneurs, hence also influencing the entire course of negotiation (Pogessi et al., 2016).

Considerable differences in start-up capital, size, and growth of the firms between female-led and male-led companies have always been typical (Martin et al., 2015). Furthermore, education seems to be part of the institutional context that matters most in increasing entrepreneurship performance (Demirbağ et al., 2021). Hence, it is also noticeable how the institutional context influences female entrepreneurial ventures and their performance.

Business and personal networks

Business and personal networks can be defined as a set of companies or people that preserve stable relationships with each other (Moletta et al., 2021). These networks have been identified as decisive for entrepreneurship performance (Bourdil & Géraudel, 2016).

Regarding female-specific owned businesses and vis-à-vis entrepreneurship, in literature are branded as weaker and more informal than men's (Poggesi et al., 2016; Poggesi et al., 2020; Cho et al., 2020; Kuschel et al., 2020; Said & Enslin, 2020; Kang, 2022; Fang et al., 2022). This phenomenon has been justified by the intensive gender homophily of men being more likely chosen to operate in a network wholly composed of men than women (Burt, 2019). Once again, the conservative idea of gender is shown.

Specifically, in women's cases, cooperation with business networks can boost performance and the company's progression and success (Martin et al., 2015; Said & Enslin, 2020; Moletta et al., 2021; Fang et al., 2022). This collaboration environment amplifies and evolves with trust, competency, and good personal relationships, strengthening exchanges of information and knowledge sharing and improving the chances of business success (Moletta et al., 2021).

Hence, just like all the other dimensions, even if on a smaller scale, the impact of networks on women entrepreneurs' barriers and challenges is proven to be relevant as well.

Women entrepreneurs' barriers and challenges

In the literature, the challenges of women entrepreneurs, in general, are usually more significant when compared to men (Anggadwita & Dhewanto, 2016). To start and run a business, women must face various barriers during education and in their professional life (Anggadwite & Dhewanto, 2016; Goel & Tiwari, 2020). Among the main challenges/barriers, the literature identifies multiple categories – non-conductive cultural environment, gender inequalities, and informal and formal institutions (Anggawita & Dhewanto, 2016; Giménez & Calabrò, 2017; Li et al., 2020). Midst them, specific challenges arise, such as briefly described in Table 3.

Table 3: Barriers and challenges faced by women entrepreneurs

Barrier/challenge	Brief description	Reference
Gender bias	Implicit and often unconscious form of attributing stereotypical traits to genders.	Poggesi et al., 2016; Giménez & Calabrò, 2017; Gui-Diby et al., 2017; Hardy & Kagy, 2018; Alqahtani, 2019; Appelbaum et al., 2019; Alqahtani, 2020; Said & Enslin, 2020; Cho et al., 2020; Elgin & Elveren, 2021; Moletta et al., 2021; Fang et al., 2022; Gashi et al., 2022
Role of children	The role that women are often attributed as the caretaker of the children in the couple.	Poggesi et al., 2016; Giménez & Calabrò, 2017; Gui-Diby et al., 2017; Hardy & Kagy, 2018; Alqahtani, 2019; Appelbaum et al., 2019; Alqahtani, 2020; Said & Enslin, 2020; Cho et al., 2020; Moletta et al., 2021; Gashi et al., 2022
Reduced income	Income for women is often less than men's, even when employed in the same position.	Poggesi et al., 2016; Hardy & Kagy, 2018; Said & Enslin, 2020; Elgin & Elveren, 2021; Moletta et al., 2021
Perception of low efficiency	The perception is that women perform less efficiently than men in entrepreneurial ventures or individual job roles.	Alqahtani, 2019; Appelbaum et al., 2020; Moletta et al., 2021; Fang et al., 2022
Leadership gaps	The perception is that women have fewer leader-like traits and are given fewer leadership position opportunities.	Appelbaum et al.; 2019; Alqahtani, 2020; Cho et al., 2020; Kulkarni & Mishra, 2022; Fang et al., 2022
Difficulty in accessing funding	Difficulty that women entrepreneurs have when trying to access funding due to gender bias or gender stereotypes in formal institutions.	Poggesi et al., 2016; Appelbaum et al., 2019; Said & Enslin, 2020; Kulkarni & Mishra, 2022; Fang et al., 2022; Gashi et al., 2022
Sectoral segregation	Women-owned businesses are often in the service sector, leading to increased barriers and limitations when trying to enter more male lead industries.	Poggesi et al., 2016; Giménez & Calabrò, 2017; Alqahtani, 2020; Elgin & Elveren, 2021; Fang et al., 2022; Gashi et al., 2022

Source: Authors' own elaboration

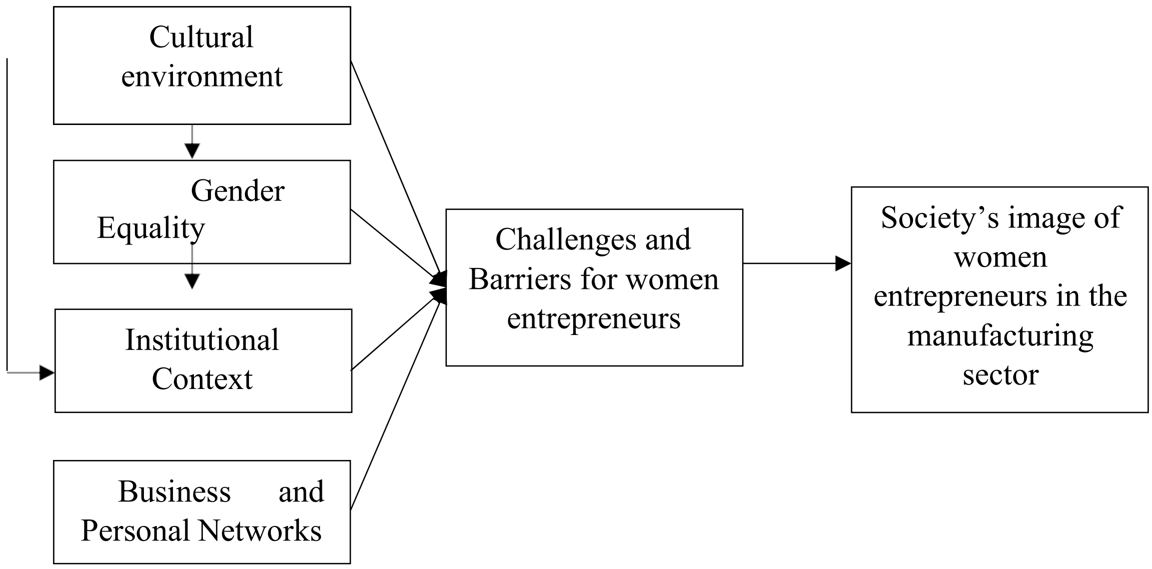
Even being felt by men, most of these barriers and challenges affect women differently and, often, more deeply (Brush & Gatewood, 2008; Hardy & Kaggy, 2018).

Despite some scholars stating the existence of self-discriminatory behaviour and the hypothesis of preconceived mental barriers (Poggesi et al., 2016; Feijó-Cuenca et al., 2019), most studies confirm the reality and dimension of these challenges. The existence of a glass ceiling felt by women, stated by Ruiz et al. (2022) and Kulkarni & Mishra (2022), can prevent the business development and the optimisation of their full talent and potential. Women leaders often face a very implicit type of discrimination that induces restricted top positions and openings in decision-making (Kulkarni & Mishra, 2022).

Conceptual framework

Based on the literature results, a conceptual framework was designed to understand the multiple factors that affect not only the challenges and barriers of women entrepreneurs in general (directly) but also the women's image created by society, specifically in the manufacturing sector (indirectly). As illustrated in Figure 1, four main dimensions influence the development of barriers and challenges in society that hinder women entrepreneurs' professional ventures: cultural environment, gender equality, institutional context and business and personal networks.

Figure 1: Conceptual framework



Source: Authors' own elaboration

Conclusions

This paper aims to present a literature review on identifying the challenges and barriers that influence the social perceptions of women entrepreneurs, paying particular attention to the manufacturing sector. According to the literature, four main dimensions influence the development and implementation of societal barriers and challenges that hinder women entrepreneurs' professional ventures: cultural environment, gender equality, institutional context and business and personal networks. Three of these dimensions - cultural environment, gender equality and institutional context - are based on stereotypes and gender role norms developed through the years, which often leads to delays in reaching a common ground professionally among men and women.

Moreover, society's perception of women entrepreneurs, according to the literature, continues with much progress since not only the traditional and stereotypical role of women keep getting imposed on them, but also, when in the field, women are often victims of discrimination and prejudice, obstructing their business and personal development.

Nevertheless, there is a further need to acquire more information and increase the research spread regarding the dimensions that influence the barriers and challenges of women entrepreneurs and to what extent they continue to influence society's perception of these female entrepreneurs.

Future work will consider studying these challenges and barriers in real contexts using a research design with a qualitative approach with a multiple case study.

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Entrepreneurial orientation and business structuring in incubation process: a systematic literature review

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Abstract: The objective of this study is to examine the relationship between Entrepreneurial Orientation (EO) and business structuring in the incubation process. A theoretical-conceptual approach was adopted, based on a systematic literature review (SLR) in the Web of Science and SCOPUS databases, using the string "Entrepreneurial Orientation" AND Incubat*. A total of 31 articles were selected after applying the research protocol for the full reading phase. The findings point to seven relationships between EO and business structuring in the incubation process: performance, network formation, innovation, ambidexterity, absorptive capacity, speed to the market, and buffering mechanisms. These results have implications for the management of incubators and their strategies. This systematic review provides insights for researchers from universities and public incubators, as well as private incubators promoting business development. Additionally, indications for future research are made to encourage advancements for EO and incubation practice and theories.
Keywords: Entrepreneurial orientation, incubators, incubation, structuring of new businesses, systematic literature review

Introduction

Entrepreneurial orientation (EO) constitutes a variable that contributes to strategic positioning and organizational performance (Lumpkin & Dess 1996). EO refers to the decisionmaking processes, practices, and activities that lead to new entry (Lumpkin & Dess 1996). This phenomenon is related to the way entrepreneurs implement entrepreneurship, with intentional behavior and decision-making (Martens et al., 2010). This construct is represented by five dimensions, innovativeness, risk-taking, proactiveness, autonomy and competitive aggressiveness (Miller, 1983; Lumpkin & Dess, 1996), and can be addressed in its inaugural form (Miller, 1983), through the first three dimensions.

Vincent & K.A. (2021, p. 102) point out that "entrepreneurial orientation could be a significant antecedent of start-up performance among incubator firms". Young and emerging companies find support for the new business development process in business incubators (Ayyash et al., 2022; Gerdsri et al., 2021; Hughes et al., 2007a; Vincent & K.A., 2021). One of the roles of incubators is to guide entrepreneurs in structuring their businesses (Lita et al., 2020), through a systematic method (Bøllingtoft, 2012; Hackett & Dilts, 2004). Incubators can provide physical infrastructure services, business support, and networks (Breivik-Meyer et al., 2020; Gerdsri et al., 2021; Son et al., 2022; Vanderstraeten & Matthyssens, 2012). Thus, they constitute a strong instrument to support the challenges and limitations in the initial phase of the company (Wu et al., 2021).

Although enterprises in a business incubator (incubatees) receive similar services and use incubators for competitive advantage (Hughes et al., 2007b; Vincent & K.A., 2021), they differ in their performance due to their EO (Wang, 2008; Wu et al., 2020b), since incubatees may perform poorly due to the lack and/or inadequate configuration of EO (Hughes & Morgan, 2007). Thus, the degree of EO of incubatees impacts the entrepreneurs' ability to recognize opportunities, mobilize resources, and act in networks (Millette et al., 2020).

Therefore, EO plays a key and characteristic role in distinguishing the entrepreneurial process, understood as the journey of a new venture from the beginning to the completion of its creation (McMullen & Dimov, 2013; Shane & Venkataraman, 2000), defined as the stage at which an entity is sustained in the market (Davidsson & Gruenhagen, 2021). This phase of a business is achieved through structures and processes that lead the development of products and/or services that promote the organization's sustainability in the market.

The behavioral patterns that allow entrepreneurship to be defining for a business (Covin & Lumpkin, 2011) are present in the actions of the enterprise from the creation phase (Na-Allah & Ahmad, 2022). Thus, EO is significantly important for the performance of emerging businesses (Rauch et al., 2009; Lumpkin and Dess, 1996). This support for new businesses, which considers EO in the process, is pointed out as a conditioning factor for their survival and performance (Huynh et al., 2017a; Wu et al., 2020a).

The concerns that motivated this study were the relevance of examining whether and to what extent incubators are capable of influencing the EO of incubatees (Clausen & Korneliussen, 2012), the recommendation for further qualitative studies evaluating the scientific production on EO in emerging business contexts (Martens et al., 2016), as well as the realization that there was no literature review systematizing the relationships between EO and Business Incubation in the searched databases. In this context, a systematic literature review (SLR) is conducted with the aim of examining the relationship between EO and business structuring in the incubation process.

Vincent e K.A. (2021, p.10) point out that "incubator firms constitute a specific, noteworthy sampling for the study of the relationship between EO and firm performance". Despite significant advances in the study of EO in the last 30 years (Martens et al., 2016), the application of the concept in other organizational contexts, such as incubation processes and in the management practices of business incubators, remains an underexplored area (Blok et al., 2017). Therefore, in addition to mapping the literature that relates EO and the structuring of new businesses in the incubation process, the degree of evolution and approaches of research in this field are presented, as well as recommendations for future research.

The results of this study indicated seven relationships between EO and incubation, as well as contradictory findings regarding the effectiveness of incubation on new venture performance (Brown & Mawson, 2016; Soetanto & van Geenhuizen, 2019). A variety of theories were also identified in conjunction with EO, which aligns with Miller's (2011) recommendation to draw on theories from other disciplines to advance the field. This study contributes to the advancement of the EO theory by indicating that the development and strengthening of the entrepreneurial culture in nascent firms occur through the articulation of EO applied to the incubation strategy, which favors internal (among incubatees) and external relations, which includes the network of relationships in the entrepreneurial ecosystem.

Methods

This study adopted the systematic literature review (SLR) as its method. The premise of an SLR is to perform a reproducible survey of evidence on a research question (Tranfield et al., 2003). The stages recommended by Tranfield et al. (2003) are: planning the review; conducting the review; disseminating the results. In the first phase, the planning was carried out with the evaluation of the importance of the study and the elaboration of the research objective. In the second phase, the execution was carried out, which started with the identification of the literature in the Web of Science and SCOPUS databases in October 2022. Table 1 presents the research protocol.

Table 1

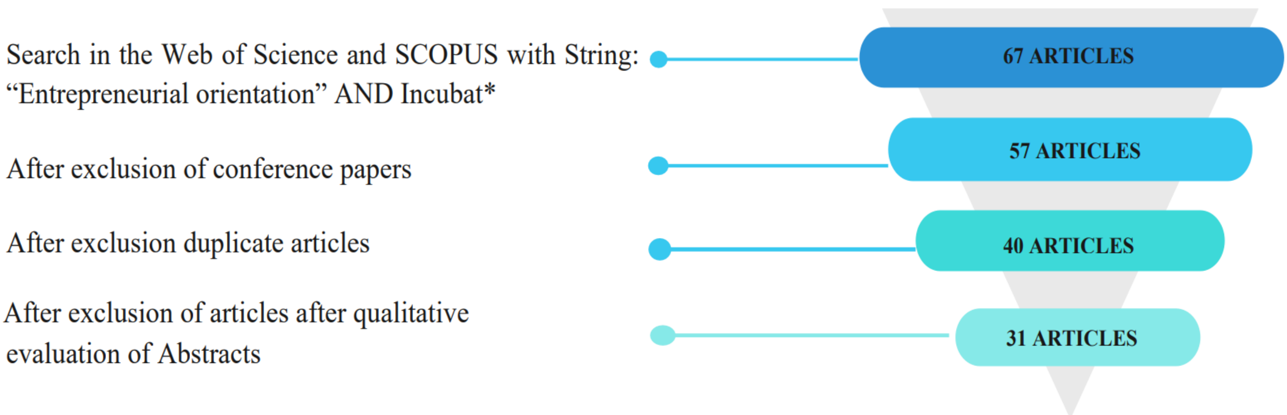
Research Protocol

Protocol	Description
Database	Web of Science and Scopus.
Post Type	Articles, except conference articles.
Languages	Common any language
Term	No start date restriction. October 18, 2022
Area	No area restriction.
Search box	Title, abstract and keywords.
Search terms	("Entrepreneurial orientation" AND incubat*)
Inclusion Criteria	Articles that discuss the relationship between entrepreneurial orientation, incubation of companies and that the incubation process is associated with the creation of new enterprises.
Exclusion criteria	Articles unavailable for full reading, forms of incubation that are not related to the creation of new ventures. Conference articles.

The results found in the databases were exported to the StArt software, where filtering was carried out through reading titles, abstracts, and keywords. There was no time restriction, and it was identified that the available works in the databases that combine EO and Incubation represent a recent field of study (Campbell & Allen, 1987; Covin & Lumpkin, 2011; Hackett & Dilts, 2004; Martens et al., 2016; S. Mian et al., 2016; S. A. Mian, 1997). After executing the research protocol, a funneling and filtering of publications were obtained, represented in Figure 1.

Figure 1

Narrowing down publications by criteria



We proceeded with the stage of full reading of the 31 articles, carried out in the Zotero software, and the development of a results matrix using an Excel spreadsheet. In this Search in the Web of Science and SCOPUS with String: "Entrepreneurial orientation" AND Incubat* After exclusion of conference papers After exclusion duplicate articles After exclusion of articles after qualitative evaluation of Abstracts 67 ARTICLES 57 ARTICLES 40 ARTICLES 31 ARTICLES spreadsheet, we entered identification data of the studies, concept and field of application of the research, methodological approach, theoretical perspective adopted, results, and conclusions of the sample studies.

Results

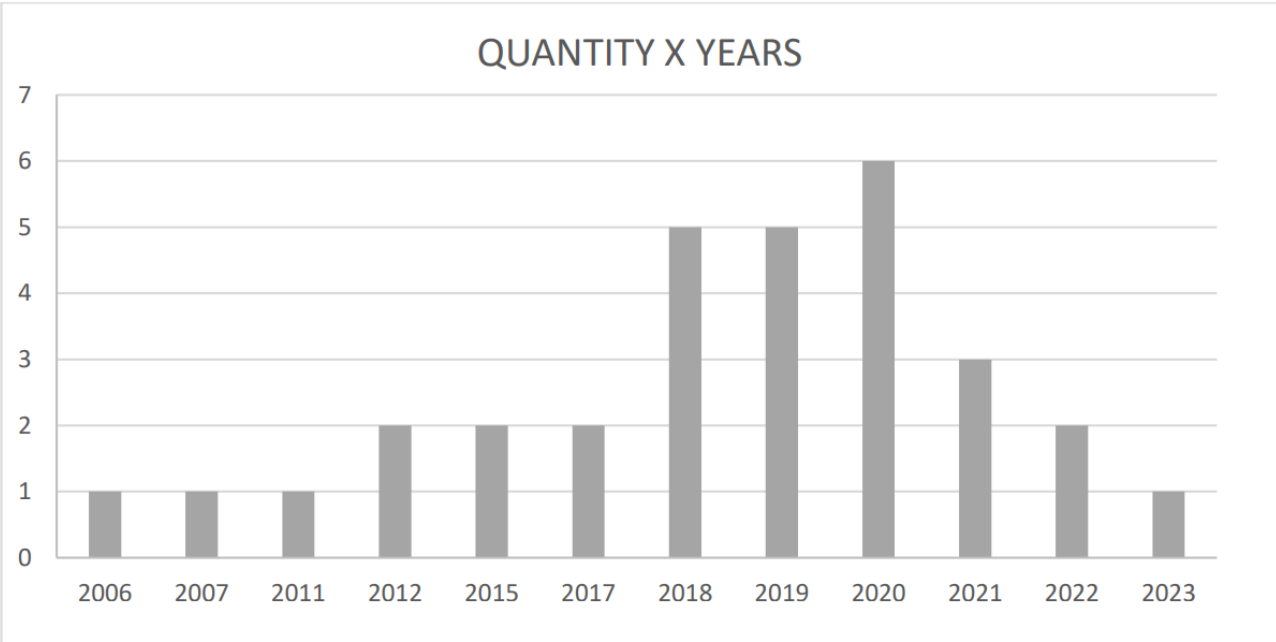
In this section, a characterization of the sample of 31 articles that composed the SLR is first presented. Then, the results of the analysis between EO and the incubation of new ventures are explored.

Characterization of sample studies

The publications correlating the themes of EO and incubator/incubation, selected to be part of this study, start in 2006 (Figure 2). The majority of the sample studies are from the years 2018, 2019 and 2020. It was possible to retrieve an article from February 2023, made available by the International Journal of Information Management.

Figure 2

Number of publications per year



The international relevance of a journal is attributed according to its impact factor by the Scientific Journal Rankings (SJR) indicator. In this SLR, the distribution of the study quartiles corresponds to 17 articles in quartile 1 - Q1, 9 in Q2, 3 in Q3 and 1 in Q4. One journal 0 1 2 3 4 5 6 7 2006 2007 2011 2012 2015 2017 2018 2019 2020 2021 2022 2023 QUANTITY X YEARS did not present an impact factor indicator and was represented by the acronym "N.A." indicating that it does not apply. Table 2 presents the distribution of journal quartiles.

Table 2

Identification of publications with indication of Quartile

Periodic	No. of Posts	Quartile
Asia Pacific Journal of Innovation and Entrepreneurship	1	Q2
British Journal of Management	1	Q1
Competitiveness Review	1	Q2
Environment and Planning C-Government and Policy	1	Q2
Expert Systems with Applications	1	Q1
Innovation-Organization & Management	1	Q4
International Journal of Entrepreneurship and Innovation Management	1	Q2
International Journal of Information Management	1	Q1
International Journal of Innovation and Learning	1	Q3
International Journal of Innovation and Technology Management	1	Q3
International Small Business Journal	1	Q1
Journal of Accounting & Organizational Change	1	Q2
Journal of Business Research	1	Q1
Journal of Cleaner Production.	1	Q1
Journal of Computer Information Systems	1	Q1
Journal of Entrepreneurship in Emerging Economies	1	Q2
Journal of Hospitality and Tourism Technology	1	Q1
Journal of Open Innovation: Technology, Market, and Complexity	1	Q1
Journal of Research in Marketing and Entrepreneurship	1	Q2
Journal of Small Business and Enterprise Development	1	Q1
Journal of Business Strategy	1	Q2
Journal Of Technology Transfer	3	Q1
New England Journal of Entrepreneurship	1	NA
Revista Brasileira de Gestão de Negócios (Brazilian Journal of Business Management)	1	Q3
Sustainability	1	Q2
Technological Forecasting & Social Change	2	Q1
Technovation	2	Q1

Regarding the methodological approach adopted in the studies, it was identified that 20 of the 31 studies used a quantitative method, 8 were qualitative studies, and 3 adopted a mixed method. A total of 29 studies are empirical in nature. Therefore, the predominance of empirical and quantitative studies is noteworthy. The predominant methods in quantitative studies were multivariate statistical analysis, especially regression analysis (Almeida et al., 2021; BreivikMeyer et al., 2020; Chang et al., 2006; Chen et al., 2022; Clausen & Korneliussen, 2012; Fernández-Alles et al., 2015; Frare et al., 2022; Hughes et al., 2007b; Huynh et al., 2017a; Montiel-Campos, 2018; Na-Allah & Ahmad, 2022a; Rakthai et al., 2019; Salvador, 2011; Soetanto & van Geenhuizen, 2019; Son et al., 2022; Vincent & K.A., 2021; Wu et al., 2020b) and structural equation modeling (Carvalho et al., 2021; Frare et al., 2022; Hughes et al., 2007b; Huynh et al., 2017a; Lita et al., 2020; Rakthai et al., 2019; Verbano et al., 2020).

There is no predominance of demographic regions in which the studies were developed, with Asian, African, European and American countries in the sample. As for the objects of study, there are early-stage companies that are in the process of incubation or have already gone through it (graduates), named in several ways – startups, spin-off, ventures, and high-tech companies. The studies are also divided between public incubators, university-related, and private incubators. This information is presented in full in table 3.

Table 3
Conceptual, methodological and geographical perspectives adopted in the sample publications.

Article Central Theme	Search Country	Object of Study	Methodological approach	Authors
Performance of Incubators	USA	Incubators	Quantitative	Chen et al. (2022)
Performance, *Business Intelligence* and Competitiveness	European countries.	Graduated startups	Quantitative	Caseiro & Coelho (2018)
Performance of Creative Industry ventures	Indonesia	Enterprises in the craft sector	Quantitative	Lita et al. (2020)
Performance and absorptive capacity of startups	India	Incubators and startups	Quantitative	Vincent & K.A. (2021)
Individual EO performance and self-efficacy	Nigeria	Startups of graduates	Quantitative	Na-Allah & Ahmad (2022a)
Performance, learning, networking, ambidexterity	United Kingdom	Emerging companies	Quantitative	Hughes et al. (2007b)
Performance, effects of incubation on the crossing of Death Valley (VoD)	Korea	Spin-offs	Quantitative	Son et al. (2022)
Incubator networks and performance of new ventures	China	Incubatees	Quantitative	Wu et al. (2020b)
Innovative Capacity and Performance of Incubatees in University Incubators	Thailand	Graduated incubatees of university incubators	Quantitative	Rakthai et al. (2019)
Absorptive capacity, dynamism and innovation	Brazil	Startups	Quantitative	Carvalho et al. (2021)
Resources and skills for spin-off development	Spain	Spin-offs	Quantitative	Fernández-Alles et al. (2015)
Performance after incubation	Europe	Spin-offs	Quantitative	Soetanto & van Geenhuizen (2019)
Innovation and technology transfer through incubators	Taiwan	Universities	Quantitative	Chang et al. (2006)
Multi-method of EO evaluation	The Netherlands	Startups	Quantitative	Rezaei et al. (2012)
Performance and management control systems	Brazil	Startups	Quantitative	Frare et al. (2022)
Ambidexterity of exploratory and exploitative innovation	United Kingdom	Startups	Quantitative	Hughes et al. (2021)
Performance of incubatees and non-incubatees	Portugal	Incubatees and non-incubatees	Quantitative	Almeida et al. (2021)
Buffering mechanisms and speed to the market	Norway	Incubators	Quantitative	Clausen & Korneliussen (2012)
Interactions between universities, incubators and spin-offs	Latin America	Universities	Quantitative	Montiel-Campos (2018)
Spin-off networks and performance	Spain	Spin-offs	Quantitative	Huynh et al. (2017)
Spin-offs Performance	Italy	Startups	Qualitative	Verbano et al. (2020)
Framework for New Circular Economy Incubator Structures	USA	Circular economy incubators	Qualitative	Millette et al. (2020)

Knowledge transfer and innovative practices	China	Startups	Qualitative	Du & Wang (2019)
Performance and dynamic capacity	Canada	Incubator and incubatees	Qualitative	Sadreddin & Chan (2023)
Mechanisms to accelerate and increase EO in startups	USA	Startups	Qualitative	Stayton & Mangematin (2019)
Incubation policies and dynamic capabilities	United Kingdom	Companies and Public policy makers	Qualitative	Brown & Mawson (2016)
Skunk Works, innovation in collective ventures	-	Literature	Qualitative	Larsson (2019)
Incubation process and performance	The Netherlands	Incubatees	Qualitative	Blok et al. (2017)
Influence of incubators and science parks as brands	Turim	Spin-offs	Mixed	Salvador (2011)
Development of EO scale in social entrepreneurs	India	Social Entrepreneurs	Mixed	Satar & Natasha (2019)
Performance, influence of incubator; buffering mechanisms and networking	Norway	Incubators and incubatees	Mixed	Breivik-Meyer et al. (2020)

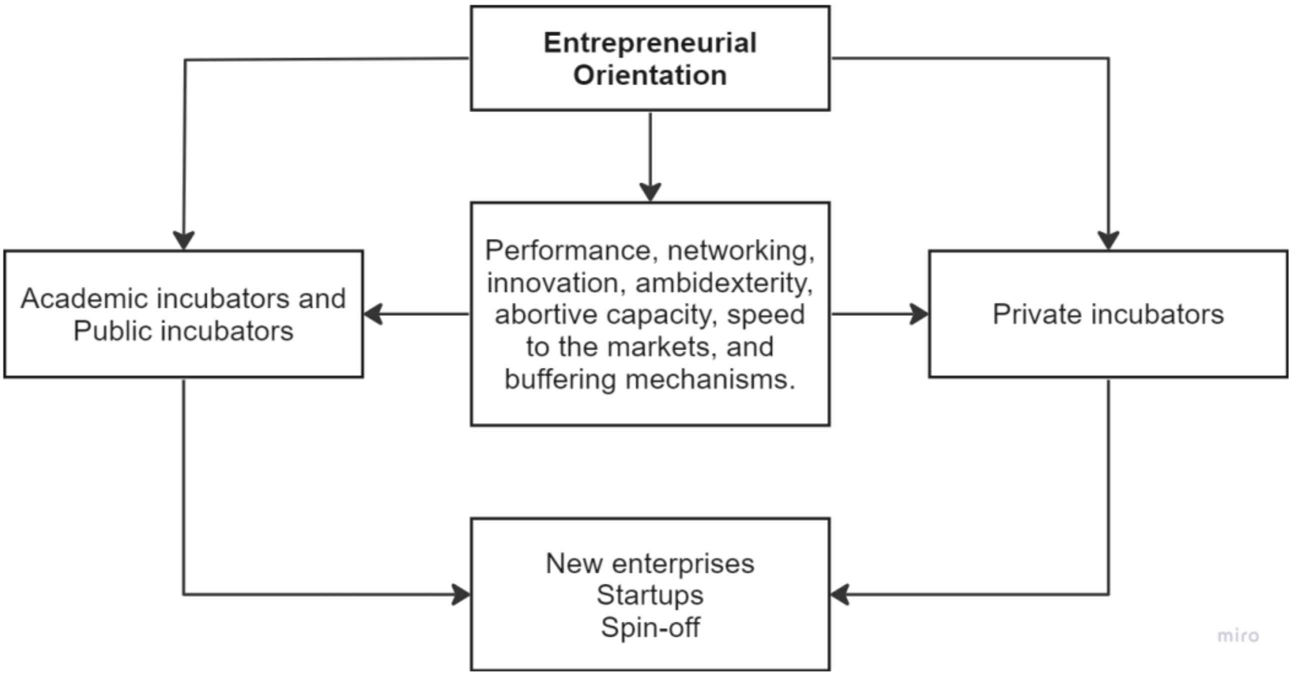
Regarding the theories adopted to support the studies, it is possible to verify the prevalence of Entrepreneurial Orientation in 18 studies, followed by Resource-Based View (RBV) in 4 studies and Learning Theory in 3. The other theories are identified in only one study: Social Cognitive Career Theory (SCCT), Role Theory and Institutional Theory, Affordance Theory, Skunk Works, Imprinting Theory, Dynamic Capabilities, and Absorptive Capacity (ACAP).

Analysis of the relationship between EO and incubation of new enterprises

The analysis of the sample studies indicates how EO relates to the incubation process. These relationships occur through the EO of universities and their influence on spin-offs and the impact of EO on incubators, incubatees and/or graduated incubatees. The way EO relates to incubators, the incubation process, and the creation of new ventures is represented in Figure 3.

Figure 3

Conceptual model of EO relationships with new venture creation in incubation.



Based on the analysis of the articles, it is possible to identify that the EO impacts performance, networking, innovation, ambidexterity, abortive capacity, speed to the market, and buffering mechanisms. This influence is identified both in the strategies of the incubator, in the incubation process, and in the results of new ventures, which are analyzed in the context of incubation or after it. Next, each of these factors is analyzed individually.

Performance is one of the most prominent aspects in the studies. EO is presented as a driver of performance (Verbano et al., 2020) that improves various aspects of new ventures: commercial results (Vincent & K.A., 2021), environmental dynamism (Wu et al., 2020b), leadership orientation (Rakthai et al., 2019), system management performance (Frare et al., 2022), hard and soft skills performance of incubatees (Vincent & K.A., 2021) and students entrepreneurs performance (Chen et al., 2022).

This relationship with the performance of student entrepreneurs is investigated through the moderating role of EO, from the perspective of internal locus of control, which impacts the relationships between academic incubator and business success of student entrepreneurs (Chen et al., 2022). It has been found that students with a strong EO perform better in business decision-making in both good and bad times, i.e., they have skills to deal with market seasonality.

Research comparing the outcomes of incubatees and non-incubatees (Blok et al., 2017), have found higher performance in the early years of life compared to non-incubatees. In fact, it is suggested that the return on assets (ROA) is higher for incubatees (Almeida et al., 2021).

However, there are arguments that point to the possibility of suffocation of the dynamic capabilities of incubatees or making them dependent on the support offered by the incubator (Brown & Mawson, 2016). The findings of Soetanto e van Geenhuizen (2019) suggest that commercial performance may decrease if the link between new ventures in incubation and incubators is not minimized after the completion of the process.

Another relationship between EO and new venture incubation concerns the formation of **Network**. These connections formed and facilitated by incubators expose emerging businesses to a wealth of collaborative opportunities (Hughes et al., 2007b). Research examines the benchmark achieved by incubatees through the learning obtained via incubator networks (Hughes et al., 2007b). The results of this network learning can be secure and immediate; however, they can also blind firms to the value of exploration and long-term learning building, which is more uncertain in its outcomes, but promotes substantial gains (Hughes et al., 2007b).

These strong relationships with networks are particularly important for the business success of ventures with novelty liabilities and, in some cases, the inexperience of entrepreneurs (Chen et al., 2022). Networks form links that favor the construction of knowledge and the promotion of a strong EO in new ventures (Vincent & K.A., 2021). This critical role in aiding entrepreneurs (Chen et al., 2022), especially in expanding connections with networks (Blok et al., 2017; Breivik-Meyer et al., 2020; Hughes et al., 2007b; Huynh et al., 2017b; Rakthai et al., 2019; Wu et al., 2020b), is pointed out as a survival imperative, with more experienced firms motivating EO behavior (Stayton & Mangematin, 2019).

The lens of EO has been used to assess the **Innovation** capability of universities and incubators through the generation and exploration of intellectual property (Chang et al., 2006). The EO of universities is mainly influenced by university policies that either reinforce or suppress academic entrepreneurship (Chang et al., 2006). The empirical results of the Chang et al.'s (2006) research show that university entrepreneurship policies are the most determining factors in the university's innovative performance, not only in patenting and licensing, but also in the incubation of companies. Accordingly, Lita et al. (2020) they connect the EO and the organizational culture of institutions as factors that positively impact organizational innovation.

However, there is a counterpoint to the unanimity of the EO as the driver of innovation (Larsson, 2019). The argument is based on the validity of "Skunk Works" as a more conducive strategy in fostering innovation. This practice starts from the premise that by creating an innovative culture "habitat", innovators' autonomy is stimulated through the seven dimensions (Isolation, Customer Needs, Focus, Planning, Reliable Project Manager, Multifunctional Teams and Taking advantage of overlaps) that "co-vary, and are all required to facilitate a Skunk Words environment" (Larsson, 2019, p. 42). In this sense, the author asserts that the dimensions of Skunk Words are more suitable for promoting innovation, to the detriment of the dimensions of EO.

In terms of **Ambidexterity**, it is considered an essential factor in managing the knowledge acquired by incubatees (Hughes et al., 2007b). Ambidexterity emerges as a reconciler of exploration and exploitation learning and relies on the mediation of EO to balance both (Hughes et al., 2007b). An exploitative approach provided by the incubator and networks can generate short-term knowledge gains. However, it can become a long-term trap by limiting exploratory learning, which is fundamental to the competitiveness and innovativeness of emerging businesses (Hughes et al., 2007b, 2021).

The studies by Hughes et al. (2007b, 2021) emphasize the importance of working on EO in incubation processes. As a result of a research that examined exploratory learning and EO in 211 high-tech emerging companies located in incubators in 2007, and a research that examined the strategic behavior of 1,000 technology-based incubatees in 2011, the authors point out that EO positively affects exploratory and exploitative innovation. EO was considered a means to manage the interfaces between both and serves as a unifying mechanism for innovation activities and supports its ambidexterity (Hughes et al., 2007b, 2021).

Absorptive capacity is pointed out in studies as a potential enhancer of the EO effect (Vincent & K.A., 2021). This capacity enables the association between EO and the performance of new ventures in the incubation context (Vincent & K.A., 2021), increases the speed of innovation, and stimulates innovativeness (Carvalho et al., 2021). This favors especially emerging businesses that need to use knowledge absorption as a strategic mechanism to turn environmental changes into opportunities for the company (Carvalho et al., 2021; Vincent & K.A., 2021). However, incubators need to be cautious not to suffocate the dynamic capabilities of their incubatees, and their experiences abroad with their successes and failures, which can contribute exponentially to the absorptive capacity (Brown & Mawson, 2016).

Speed to the market is another aspect pointed out in the studies as a result of EO (Clausen & Korneliussen, 2012). EO is related to the speed at which a new entry is made and has a statistically significant and positive effect on the speed of offering new products to consumers (Clausen & Korneliussen, 2012). These results indicate that the way a new entry is pursued during the incubation process will influence the pace of economic growth of companies at the beginning of commercialization.

Stayton e Mangematin (2019) indicate that new ventures have a sense of urgency to get to the market and generate revenue, which forces them to take risks and increase proactivity. Thus, the urgency mechanism develops the EO of incubatees and helps with speed to the market. Another way to contribute to speed to the market is pointed out by Salvador (2011), in this case, incubators and science parks can provide greater speed with their brand effect for emerging businesses, which would come through an endorsement in which incubators would have a role as guarantors of the potential of the incubatees in investor investments.

Regarding **Buffering**, it is a mechanism that examines the support relationship between incubators and incubators (Breivik-Meyer et al., 2020). This relationship is known as buffering mechanisms, which involves the transfer of knowledge, capital and external connections to promote the development of new companies. The results of the study indicate that buffering mechanisms contributes to the development of the internal capacity and the acquisition of external resources of new ventures. The suggestion is that the EO of the incubator managers influences the development of the incubatees, and they should plan strategies in accordance with the companies' resource needs (Breivik-Meyer et al., 2020).

In this wake, Clausen e Korneliussen (2012) adopt the idea of hosting and building as two types of buffering mechanisms in the incubation business context. The research findings indicate that hosting is more important in the incubator context. The provided services can differ, and their influence on development will depend on the extent to which companies use the available services. Therefore, the effectiveness of buffering also depends on the incubatees' absorption.

Based on the results of the systematic literature review, the following propositions were formulated:

P1: Entrepreneurial orientation is a precursor for sustaining companies that have gone through business incubation;

P2: All dimensions of EO are valuable to be developed and/or strengthened in ventures during the incubation process in order to achieve better performance.

Discussion

The sample of studies in this systematic review indicated seven relationships promoted by EO in the process of incubating new ventures (Figure 2). The largest percentage of studies focused on the impact of EO on performance, which is also reflected in innovation, the importance of connection networks developed during incubation, absorptive capacity, speed to the market, ambidexterity, and buffering mechanisms. However, the studies are still fragmented, lacking a mass of research to provide robustness for both researchers and the practice of incubators.

These relationships corroborate Martens et al. (2016) who point to a higher degree of research linking EO and performance. Additionally, it is possible to connect the results and contributions of the sample research with the clusters developed in bibliometric study on EO scientific production (Martens et al., 2016): Cluster 1 - performance, enterprise, resources, growth, and knowledge; Cluster 2 - innovation, business performance, marketing, market, market orientation, and strategic direction; Cluster 3 - small and medium enterprises, business performance, innovation, proactivity, and risk; and, Cluster 4 - entrepreneurship and management.

We identified the association of EO with other theories, with the Resource-Based View (RBV) as dominant. The least frequent theoretical approaches are the Learning Theory, Social Cognitive Career Theory (SCCT), Role Theory, Institutional Theory, Affordance Theory, Skunk Works, Imprinting Theory, Dynamic Capabilities Theory, and Absorptive Capacity (ACAP). This association is recommended by Miller (2011), who suggests adopting theories from sister disciplines in the study of EO to contribute to understanding how organizations function.

Furthermore, Miller's (1983) contributions through the dimensions of innovativeness, risk-taking, and proactiveness are more present in the structure of research scales. There is a predominance of scales based on Covin e Slevin (1989) that, in some cases, received adaptations from researchers (Clausen & Korneliussen, 2012; Hughes et al., 2021; Huynh et al., 2017b; Rezaei et al., 2012; Soetanto & van Geenhuizen, 2019). Rauch et al. (2009) point to the predominance of studies that approach EO as a unidimensional construct. However, few of the analyzed works make it clear whether the adopted approach is unidimensional or multidimensional.

EO refers to the methods, practices, and styles of decision-making (Lumpkin & Dess, 1996). Thus, business management is directed towards an entrepreneurial way of acting that results in performance, and the results obtained by including the dimensions of EO in incubation strategies facilitate the ability to manage knowledge (Hughes et al., 2007b, 2021; Vincent & K.A., 2021), stimulate innovations (Carvalho et al., 2021; Casemiro & Coelho, 2018; Lita et al., 2020; Na-Allah & Ahmad, 2022b; Satar & Natasha, 2019), reduce time, and increase the chances of success for new entries (Clausen & Korneliussen, 2012). However, research has not determined whether all dimensions (Lumpkin & Dess, 1996) of EO are valuable for embryonic companies.

Some critical points about EO and incubation need to be considered. Firstly, there is an inherent risk of overprotection (Soetanto & van Geenhuizen, 2019) of incubators and technology parks. The lack of experiences abroad, taking risks, building networks, and experiencing failures and successes can hamper the absorptive capacity of the incubatees. Secondly, the value of incubators for the survival, growth, and innovation of new entrants has been questioned (Brown & Mawson, 2016; Soetanto & van Geenhuizen, 2019). Research indicates a slowdown in ventures after the incubation process is completed (Almeida et al., 2021; Blok et al., 2017; Stayton & Mangematin, 2019).

These contradictory results on the positive impact of the incubation process on the performance of new ventures may be a consequence of the heterogeneity of incubation practices and the contexts in which they occur (Soetanto & van Geenhuizen, 2019). Focusing on the EO of incubatees during the incubation process is a way to promote the performance and the capability of being sustained of the companies after incubation (Stayton & Mangematin, 2019). In this line, Blok et al. (2017) call for research that investigates incubation processes through an understanding of incubator management practices.

Finally, to generate high-performance returns, EO needs to be strongly configured (Hughes et al., 2007b), and each dimension of the EO can vary independently (Lumpkin & Dess, 1996). The incubator can assess the configuration of the EO of the new venture through admission criteria (Sadreddin & Chan, 2023) or during the incubation phases (Gerdsri et al., 2021). In this context, the potential contribution of incubators in promoting EO is central, as they can reinforce strong dimensions and develop weak dimensions that will be necessary for maintaining business performance after incubation.

Final considerations

The purpose of this SLR was to examine the relationship between EO and business structuring in the incubation process. The results indicate that the studies are focused on seven factors (performance, networks, innovation, ambidexterity, absorptive capacity, speed to the market and buffering mechanisms) that influence the relationships promoted by EO in university spin-offs, incubator management, and the performance of incubatees or graduated incubatees.

Based on the evaluated literature, EO is considered an antecedent of new ventures when driven by higher education institutions through innovation policies and technology sharing in created spin-offs. EO can also be observed as a consequence of the actions of incubators on their incubatees. This is identified in studies that compare the performance between incubatees and non-incubatees at the start of activities, which show that emerging companies that went through incubation perform better. However, this high performance is questioned for not being sustained, and further studies can be developed to identify the causes of this decline in performance after incubation.

As an academic contribution, this study collaborates as an examination of the EO in issues that are still little discussed and relevant to entrepreneurship and social development, by looking at the process of creating businesses in incubators. Additionally, understanding the role of EO for the performance of companies in a context where they have no initial sales contributes to filling a gap pointed out in research (Clausen & Korneliussen, 2012)

This SLR lso suggests insights for the practice of incubators. The identified factors contribute to analysis and decision-making related to the direction of incubation practices. Furthermore, it contributes to the action of institutional policy makers. As many studies analyze the EO of universities, it is useful to consider the factors that involve institutional policies aimed at developing new ventures, in addition to guiding them to adjust their EO strategy (Wu et al., 2020b).

This study has some limitations. The research was conducted on only two databases (Scopus and Web of Science) which reduces its scope. This limitation can be addressed with further research that includes grey literature and other databases, which can complement this study. Future research could explore the influence and incorporation of each dimension of EO in the stages of the incubation process, and how these dimensions can be combined and configured in incubator strategies.

Gaps were identified regarding difficulties faced after incubation, in some cases with low performance and volatility in the face of challenges due to the lack of support from the incubator. Research could address these gaps: are incubators failing in their incubation methodology? Are incubees not mature enough to be graduated? Thus, research that relates the stages of the incubation process and how EO is related or recommended in each step could be addressed in new studies. The results of these studies would contribute to the development of artifacts that would support the performance and the capability of being sustained after incubation.

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TECHNOLOGICAL INNOVATION I

May 3rd: 3h10 pm – 5h pm

Chair

Leon Pretorius (University of Pretoria, South Africa)

Papers

Seeded technology roadmaps: Leveraging on the niches
Petrus Letaba, Ntombi Ditlopo

An Approach to Optimize Multi-family Residence HVAC Systems using Digitalization
Bilal Faye, Osman Ahmed, Andrew Rodgers

A strategic perspective of CNEN's portfolio of nanotechnologies: Technical insights at a glance
Daniela Lima Cerqueira Archila, Tereza Raquel Taulois Campos

Systems thinking and strategy in highly complex and dynamic environments: An initial system dynamics model
Martin Schleith, Leon Pretorius, Herman Steyn

Designing a Systematic Technology Application Selection Process to Unlock the Potential of Technologies
Sarah Manthey, Orestis Terzidis, Arianne Haaf, David König

Seeded technology roadmaps: leveraging on the niches
Abstract ID#162 | Full Paper ID#436

Petrus Letaba (University of Petroia, South Africa), Ntombi Ditlopo (Departament of Science and Innovation)

Abstract: The challenge associated with technology roadmaps is their subsequent implementation and keeping them alive for long-term. In order to overcome such challenges, this study proposes a technology roadmapping framework that makes use of the existing niches as a template for the future. The South African Research Infrastructure Roadmap's portfolio of selected three national research infrastructures (RIs) is used to demonstrate this framework. An advantage on the choice of the RIs is that they were conceptualised around the same time as part of the roadmap portfolio. Document analysis and the interviews are used for data collection. Data analysis focuses on progress in implementing each RI and the status quo during its conceptualisation. There is a significant progress in implementing the roadmap in cases where there were already niche initiatives during the conceptualisation of the RI. However, it is found that for the RIs that are started afresh, there is a slow progress in their implementation. It is argued through this study that technology roadmaps should not necessarily be used to implement novel ideas, products and technologies. Where possible, some existing successes can be used as the seed of innovation and the technology roadmap in a quest to achieve a vision at a large scale.
Keywords: Seeding, Technology Roadmap, Upscaling, Niche Innovation, Implementation

Introduction

The historical application of technology roadmaps is with regard to planning for complex technology delivery projects in which the future market needs determines the products that should be developed, which in term provides a clear scope on which technologies to acquire or develop over time. However, some of the niche innovations already have a pathway which is very clear and has been demonstrated to be successful at a small scale. By successful demonstration we mean there is already an existing market/ beneficiaries for the niche innovation at a small scale. The product or service features have also been piloted and implemented at a small scale through the acquired/developed technology. If an upscaling of these proven niche innovations is too complex and can take a long period to implement, then this will necessitate a new form of roadmapping, namely: niche innovations upscaling roadmap. We call this the seeded roadmaps, with an assumption that the niche innovations are the seeds for large scale innovations that can be realised in future.

The usage of the niche innovations as seeds of future innovations can increase the likelihood of implementation success, hence this is an important area for the technology roadmapping area as implementation is often a major issue (Daim & Oliver, 2008). The objective of this paper is to provide a conceptual basis for the development of technology roadmaps for upscaling of the niche innovations. Such seeded roadmaps can be used in different scenarios such as the first, second and third generation technology roadmapping. According to Letaba et al. (2015). First generation technology roadmaps are used for the incremental innovations on stable product-technology platforms. Niche innovations are ideal in seeding such stable product-technology platforms that can be implemented at a scale in the future. Second generation technology roadmaps entail the insertion of a single root emerging technology into a stable product-technology platform. For seeded technology roadmaps, such emerging technology can be introduced to the existing value chain at a small scale to understand its impact and later be introduced at a large scale. Lastly, the third-generation technology roadmaps involve the multiple emerging technologies without the existing product-technology platforms. An absence of the existing innovation value chains for the third-generation technology roadmaps could also benefit from the initial seeding through the niche innovations. Such seeding can even allow for the government to figure out their role in incentivising and regulating the emerging technologies.

This study investigates the use of niche innovations to speed-up the implementation of a technology roadmap. We introduce a phrase "seeded technology roadmaps" to denote such roadmaps. We make use of the three South African Research Infrastructure Roadmap (SARIR)'s research infrastructures (RIs) as the unit of analysis. This 15 -year roadmap (2016 – 2030) was initiated as a collaboration between the South African government and the European Commission to establish the large-scale research infrastructures in domains of Humans & Society, Health Biological & Food Security, Earth & Environment, Materials and Manufacturing, Energy as well as Physical Sciences & Engineering (Wood et al., 2013). These RIs are placed mainly at the public institutions such as the universities, science councils, national facilities and other government agencies. Although this infrastructure roadmap prioritised 17 RIs, following the first order evaluation, only 13 RIs were approved for the first edition of the SARIR. This study was inspired by the five-year evaluation of the SARIR, a period which is sufficient to determine whether the roadmap implementation is on track. From the 13 RIs, 11 have been implemented. The review was done only on the RIs that have been running for five years.

In addition to the introduction section, the rest of this paper is structured as follows: the theoretical background section reviews the relevant literature in order to ground this research on existing theoretical base. This is followed by a section describing the methodology used for data collection, summary of the results and discussion of results sections, and lastly the conclusion.

Theoretical Background

Given the objectives of this study, the literature review was conducted on the relevant topics such as the strategic niche management, innovation upscaling modes, barriers and strategies as well as the technology roadmaps. Due to a limited literature on the national RIs/ national research facilities, there is no direct review of roadmapping and roadmap implementation for these initiatives.

Strategic Niche Innovations Management

The approach of niche management suggests that sustainable innovation journeys can be facilitated by creating technological niches i.e., protected spaces that allow the experimentation with the co-evolution of technology, user practices, and regulatory structures. The assumption was that if such niches were constructed appropriately, they would act as building blocks for broader societal changes towards sustainable development (Schot & Geels, 2008).

Strategic niche management (SNM) is a recently developed approach that could help to induce a broad socio-technical transition towards more sustainable development. It is designed to facilitate the introduction and diffusion of new sustainable technologies through protected societal experiments in fields such as wind energy, circular economy, just transitions, net-zero emissions manufacturing, biogas, public transport systems, electric vehicle transport and eco-friendly food production. A major challenge in SNM concerns the processes by which such experiments can evolve into viable market niches and ultimately contribute to a broader shift towards sustainable development (Caniëls & Romijn, 2008).

Through the use of multilevel perspective, the niche innovations can be managed strategically by understanding how they interact with the existing regime, within the evolving innovation landscape. As it is illustrated in Table 1, the niches in a form of emerging technologies can be radical in a way that they are evolutionary and substitutive (model 1) or incremental through a generative and interactive process (model 2). The rules and actors do differ for these two models. According to Le Masson et al. (2012), the regime unlocks in model 2 to help identify an alternative to the evolutionary model. A result is a collaboration between the niche(s) and the regime. In the evolutionary, substitutive model, the strategic niche innovations are driven by the determined individual entrepreneurs who are creating their own path that is weakening the existing regime. This is the most difficult pathway which requires an assistance from the government in shielding and stabilising the winning niche innovation.

Table 1: Two models for the impact of the niches with the regime

	Model 1: evolutionary, substitutive	**Model 2: generative, interactive**
Interaction between the niches and the regime	The weakened regime is replaced by a winning niche	The regime contributes to the emergence of niches and is transformed into a new regime through synergies and hybridisations
Rules	Locking: stabilises one path, reduces uncertainty	Unlocking: inhibits lock-in, generates multiple paths
Actors	Individual entrepreneurs with their own strategy	Collaboration in the unknown
System	A weakened system is replaced by one stemming from a niche	Actors work on the incumbent system and on the alternatives in niches

Source: Le Masson *et al*. (2012)

Generally, policymakers should exert pressure on the existing regime, while simultaneously stimulating alternative technologies. Raven (2005) suggests that generic instruments such as tradable emission rights, emission norms and competition policy are most likely to be effective to achieve the first aim, whereas more specific stimulation measures are envisaged to nurture new technologies. Policies should further:

- aim to bring about synergies across niches;
- try to stimulate hybrid technologies that can act as bridges in a transition from the incumbent to a new regime;
- take advantage of opportunities for niche development afforded by the emergence of new markets with new requirements; and
- stimulate different technologies with complementary characteristics. To achieve this, the government must adopt a plural role: it should act as initiator of societal debate, stimulate experiments, ensure that learning takes place on the basis of these experiments and safeguard the continuity of the process

Innovation Upscaling

Most of the niche innovations remain as the niches for way too long, without a tangible return on investment. This do happen even if such niches have proven to possess a significant potential for success if implemented at a large scale. The upscaling of the niche innovations is necessary as there are many solutions to our current challenges such as sustainability transitions that are already known, adopted, and tested by some of the pioneer actors or are in advanced stages of development (Lambin et al., 2020). Various modes of upscaling compiled by van den Heiligenberg (2020) from different sources in the literature are as follows:

- Quantitative: upscaling in terms of the number of beneficiaries
- Organisational: upscaling in terms of expanding the capacity of existing business, i.e., developing resources, building a knowledge base, employingmore people, or developing management systems
- Geographical: upscaling in terms of regional expansion, i.e., serving morepeople in new regions and extending into new markets
- Deep: upscaling in the sense of achieving greater impact in an existinglocation, e.g., through reaching increasingly poorer segments of the population
- Functional: upscaling in terms of developing new products and services
- Replication: upscaling in terms of the replication of a particular businessmodel, by supporting and incubating new entrepreneurs
- Institutional: upscaling in terms of transforming existing institutions and creating new ones

1) Several barriers to upscaling of the niche innovations have been documented by various scholars as shown in Table 2. These can be grouped into

2) Innovation upscaling supporting policies;

3) Funding for high upfront costs

4) Supporting infrastructure for upscaling;

5) Lack of awareness of the niche innovation by relevant stakeholders;

6) Resistance from the incumbents/ regime;

7) Intellectual property issues;

8) Short-term, quick win strategies; and

9) Unresolved technical/ technology issues (e.g. battery technology for electric vehicles).

Table 2: Barriers to upscaling of the promising niche innovations

Niche Innovation	Upscaling Barriers	Reference(s)
Vehicle to grid in UK	Battery technology; high up-front costs; lack of infrastructure; inadequate information provision	(Meelen et al., 2021)
Circular economy initiatives	Tensions with established interests; ingrained routines or dominant business models	(Janssen & van Diepen, 2021)
Welfare technology innovation	Lack of awareness among potential users; general concerns towards technology and fear of loosing human contact; poor technicalusability; lack of digital literacy among users; the cost of acquisition, implementation and operation	(Aaen, 2019)
Agricultural innovations	Lack of enabling policies; slow dissemination of technologies; intellectual property rightissues; inadequate infrastructure for capacity development; lack of financial resources	(Paroda, 2018)
Sustainability	Short-term, profit seeking imperatives from market competition and financial markets; powerful vested interests defend the status quo and reinforce the intrinsic inertia of social and technological systems	(Lambin et al., 2020)

According to Lambin et al. (2020), promoting adoption at scale of existing solutions requires the following three elements:

- Improving understanding and raising awareness of critical mass of stakeholders
- Creating motivations and incentives for new practices by embedding the practices into the institutional and policy standards or by modifying taxes and subsidies
- Developing capabilities to implement new practices at a socially acceptable cost

Science, Technology and Innovation Roadmaps

Science and technology (S&T) roadmaps are used in industry, government and academia to portray the structural relationships among science, technology, and applications. Roadmaps are employed as decision aids to improve coordination of activities and resources in increasingly complex and uncertain environments. Specific uses of roadmaps include: S&T management (including strategy, planning, executing, reviewing, and transitioning); S&T marketing; enhancing communications among researchers, technologists, product managers, suppliers, users, and other stakeholders; identifying gaps and opportunities in S&T programs; and identifying obstacles to rapid and low-cost product development. S&T managers also use roadmaps to help identify those S&T areas that have high potential promise, and to accelerate the transfer of the S&T to eventual products. However, there has been little attention paid to the practice of roadmapping in the published literature (Kostoff & Schaller, 2001).

The main benefit of technology roadmapping is that it provides information to make better technology investment decisions by identifying critical technologies and technology gaps and identifying ways to leverage R&D investments. It can also be used as a marketing tool. Technology roadmapping is critical when the technology investment decision is not straight forward. This occurs when it is not clear which alternatives to pursue, how quickly the technology is needed, or when there is a need to coordinate the development of multiple technologies. The technology roadmapping process consists of three phases - preliminary activity, development of the technology roadmap, and follow-up activity (Carvalho et al., 2013).

In recent years, technological advances have motivated industries, companies and even governments to look for an improved alignment between strategic objectives and technology management, preferably through the application of structured and flexible approaches that use techniques such as technology roadmapping (Garcia & Bray, 1997). It is proposed that the roadmapping technique can help companies to survive in turbulent environments by providing a focus for scanning the environment and a means of tracking the performance of individual technology, including potentially disruptive technologies. Technology roadmaps are deceptively simple in terms of format, but their development poses significant challenges. In particular, the scope is generally broad, covering several complex conceptual and human interactions (Phaal et al., 2004). This study reported that technology roadmapping framework makes use of the existing niches as a template for the future. However, an overall challenge that need to be addressed is a lack of implementation or slowness in implementing the technology roadmaps. Mostly what slows down the implementation of technology roadmaps is the lack of appropriate skills for the new technologies, the unpredictable nature of technologies and the change that people or system that won't fully embrace it. This paper explores how the promising niches can be used to accelerate the technology roadmap implementation.

Methodological Procedures

In order to determine the impact of the niche innovations on implementation success of technology roadmaps, the three RIs that are part of the SARIR were used. These are the Expanded Freshwater and Terrestrial Environmental Observation Network (EFTEON), Natural Sciences Collection Facility (NSCF) and Swallow Marine Coastal Research Infrastructure (SMCRI). All the three RIs are part of the Earth & Environment domain and they were conceptualised around the same time, hence it is reasonable to compare their implementation pace.

Document analysis is a dominant research methodology used to collect and analyse data. The interviews conducted with the stakeholders of the RIs (programme managers, senior researchers, executives, students, etc.) also helped with the understanding of the objectives of the RIs, implementation progress and the challenges, as well as the future plans. The documents used are the proposals of the three RIs as well as the SARIR document developed by Wood et al. (2013). The proposals contained the two set of information, namely: different components of the infrastructure roadmap and some seed elements that demonstrate the existing niche innovation prior to the implementation of the roadmap. Table 3 shows the components of the RI's roadmap that are selected for the purpose of this study such that they include various components of a generic technology roadmap. The knowledge management role of technology roadmap proposed by Phaal et al. (2001) is used to rationalise the alignment of the components of SARIR with the layers of generic technology roadmap.

Table 3: SARIR and Generic Technology Roadmap Components

Generic Technology Roadmap	Research Infrastructure Roadmap
Market/ Strategy (know-why)	Value Proposition; Management; Governance
Products/ Services (know-what)	Value Chain; Impact
Technology (know-how)	Infrastructure
Research	Scientific Excellence
Resources	Funding

The value proposition, management and governance provide a context for the research infrastructure development (know-why). According to Wood et al. (2013), the national research infrastructure includes major facilities, equipment or sets of instruments, collaborative networks and knowledge-containing resources such as collections, archives and data- and biobanks. This definition is synonymous to that of technology which is a delivery platform (know-how). As part of the ultimate impact of the RI, the knowledge products/services or data are delivered within the new or existing local and global value chains (know-what).

An implementation progress of the three RIs is deduced from a 5-year review of SARIR. Due to the confidential nature of this review, this study does not cover details about the review. The implementation progress of the RIs selected is not necessarily based on the review report but the authors' assessment as part of this study. Lastly, in order to deduce the upscaling purpose of the RI roadmap, the different types of upscaling provided by van den Heiligenberg (2020) are used.

Results

The extracted roadmapping components of the three selected Earth & Environment domain RIs (from the interviews and documents analysis) are shown in Table 4. They all had a good contextual background which included a good value proposition and appropriate management and governance plan. All the three RIs provides a value proposition on access to excellent infrastructure and also provision of data to different stakeholders as a public good.

At the operational level, such data could be disseminated in a form of policy or technical advice to the various stakeholders to provide intelligence on different ecosystems. Some of the RIs such as SMCRI and NSCF already had some existing local or international value chains for dissemination of their knowledge products or services. The unique RI such as EFTEON would be expected to establish new implementation pathways.

Various advisory structures would oversight successful steering of the roadmap implementation. The boards of the hosting institutions were also anticipated to play a critical part in ensuring proper governance of the RI, an example being a board of the South African National Biodiversity Institute (SANBI) for the NSCF. Governance is important given magnitude of the expenditure each RI would incur over a 15-year period (approximately R500 to R600 million).

Table 4: Research Infrastructure Roadmap Objectives

	Swallow Marine Coastal Research Infrastructure	**Natural Sciences Collection Facility**	**Expanded Freshwater and Terrestrial Environmental Observation Network**
Value proposition	To tap into South Africa's geographical advantage by providing access to cutting edge research platforms and data in all the coastal biogeographic regions from the three oceans	Natural science collections and the data associated with these are a crucial resource for a wide range of stakeholders	Datasets to understand ecological trends and their causes; a set of locations for conducting ecological, biodiversity, hydrological and social research
Infrastructure	A platform of at least 3 research vessels and various instrument arrays for "bay-scale" research aimed at studying physical, biological, geological and geophysical features of coastal marine environments to a depth of ~100 meters	Consolidated and resourced natural science collection institutions with the mandate to manage and curate in accordance with international best practice and to ensure optimal availability and accessibility of the material for scientific research	Each EFTEON site would have a standard set of automated, state-of-the-art instruments, covering the carbon and water cycles, meteorology and air quality; and a package of standard
Scientific excellence	The array of sensors and research platforms proposed in the SMCRI would place South Africa and its scientists at the forefront of climate and global change research in the coastal zone	While taxonomic research is unlikely to ever be considered cutting edge, it should be thorough, careful and accurate, and provide comprehensive, user-friendly rather than fragmented and inaccessible outputs	The proposed ETFEON system is globally unique in the degree to which it integrates social, biological and physical environmental observations
Value chain	There is a concerted international effort to establish more long-term ecological research sites around the world	16 institutions were to participate in the NSCF, including national and provincial museums, one municipal museum, three science councils and three universities	It would provide a platform for several research institutions, including universities and public research institutes
Impact	Provision of data to grow the "blue economy" especially in the key sectors of fishing, aquaculture, oil and gas, shipping, mining and coastal development	Data sets integrated across institutions and analysed can provide an understanding of past and present patterns in the distribution of biodiversity, and allow future predictions that can inform decision-making	Understanding of the regional ecological processes (including climate change and environmental pressures) and an ability to measure them
Governance	To be guided by several advisory structures (e.g. SMCRI Technical Advisory Forum and Sentinel Site Technical Liaison Committees)	SANBI Board would be responsible for the Internal Audit, Risk Management, approval of the Strategic Plan and the Quarterly Reports of the NSCF and final approval of budget; advisory structures	EFTEON Advisory Panel would advise on the general scientific and strategic direction; Thematic Technical Committees (TTC) would provide stakeholder guidance on technical aspects of the EFTEON
Management	Managing a distributed RI with staff and instruments deployed over 3 000 km of coastline (including sub-Antarctic islands) will require substantial managerial and administrative support from the host entity	The NSCF Director would lead the overall implementation. The individual Directors or managers of participating institutions would be responsible for implementation in their own institution, with support from the Co-ordinating Hub staff	ETFEON Coordinator and a cohort of early-career Node Scientists (also using existing prototypes and an existing SAEON management framework)
Funding	The proposed budget and financial plan for the SMCRI over the 14-year Life Cycle would be reliant on a National Government Capital (R200 million) and National Government Baseline (R436 million) Funding Grant from the DSI	The total cost of the NSCF infrastructure over a 15-year period is estimated at R617.8 million (R64.0 million capital expenditure)	The total cost of the ETFEON infrastructure over a 15-year period is estimated at R509.5 million, of which nearly 80% are the staff and bursary costs

Table 5 shows that SARIR was not necessarily started afresh, as several niche research infrastructures already existed. These niche infrastructures that were not necessarily national in scale had various seed elements that could be used for the implementation of the nation research infrastructure roadmap. Out of the three RIs that are part of this study, EFTEON is the less seeded, with seed managerial framework, value chain and Skukuza Flux Tower at the Kruger National Park. The South African Environmental Observation Network (SAEON), an entity of the National Research Foundation (NRF), was in a position to provide this managerial framework for the EFTEON. This RI was poised to use the existing value chain with collaboration with the organisations such as the International Long Term Ecological Research (ILTER), FLUXNET (international earth systems scientists' network) and The Group on Environmental Observations (GEO).

Table 5: Seed Elements of the Research Infrastructure Roadmap

	Swallow Marine Coastal Research Infrastructure	**Natural Sciences Collection Facility**	**Expanded Freshwater and Terrestrial Environmental Observation Network**
Seed infrastructure	Algoa Bay Sentinel Site	Large number of widely dispersed and under resourced natural science collections	Skukuza Flux Tower
Seed scientific excellence	The Algoa Bay Sentinel Site is the best monitored coastal area in Africa	The field of taxonomy is relatively well established in South Africa	None
Seed governance	Existing advisory structures, such as the NRF Board (Fiduciary control), SAEON and SAIAB Advisory Councils and the SAEON Elwandle Node Liaison Committee	SANBI Board	None
Seed funding	In-kind contributions of capital equipment (R35.5 million) would be made in Year 1 by SAIAB and SAEON	None	None
Seed management	Elwandle Node management	The NSCF would be governed within the SANBI	All the EFTEON operations would occur within the SAEON Operational framework
Seed value chain	South Africa has in recent years become one of the international leaders of coastal long-term ecological research through the efforts of SAEON in the Algoa Bay Sentinel Site	There are several major global initiatives that are key to the research to be carried out by collections-based researchers, and to the use of collections by researchers outside of the collections	Available international networks such as ILTER and FLUXNET, and bilateral agreements with specific research infrastructure programs, etc. (e.g. GEO)
Seed impact	None	The natural science collections were already providing materials for research and foundational biodiversity data and that is required for the several different global initiatives, national strategies, as well as a wide range of research initiatives	None

For SMCRI, most of the seeding components for its upscaling roadmap were already there, making use of the Algoa Bay Sentinel Site. This long-term ecological research site was established by SAEON in 2007 (Dorrington et al., 2018) and was managed under the Elwandle Node prior to the establishment of SMCRI. SMCRI is managed by both SAEON and the South African Institute for Aquatic Biodiversity (SAIAB), which are both well established units of the NRF. A critical seed component that was missing for SMCRI, building from the Algoa Bay Sentinel Site niche innovation is the impact. As Table 6 shows, the upgrading goal for SMCRI is exactly to address this issue, by expanding geographically and upgrading of the existing infrastructure (functional and deep upscaling) in order to achieve its intended impact.

In contrary, for the NSCF, various collections already had some impact. As part of the SARIR, these collections would benefit from modernisation of their facilities, standard operating procedures, etc. By definition, this is a typical organisational and deep upscaling.

In terms of the roadmap implementation, both SMCRI and NSCF are firmly at a combination of national research infrastructure setting-up and operational stages (Table 6). Both are not yet at the stage in which the ideal impact can be realised. The seeded components of the roadmap seem to have accelerated the operational phase and are serving as a template for upscaling success. As EFTEON was the least seeded, more time went into conceptualiation and setting-up stages.

Table 6: Research Infrastructure Implementation Pathway and Status

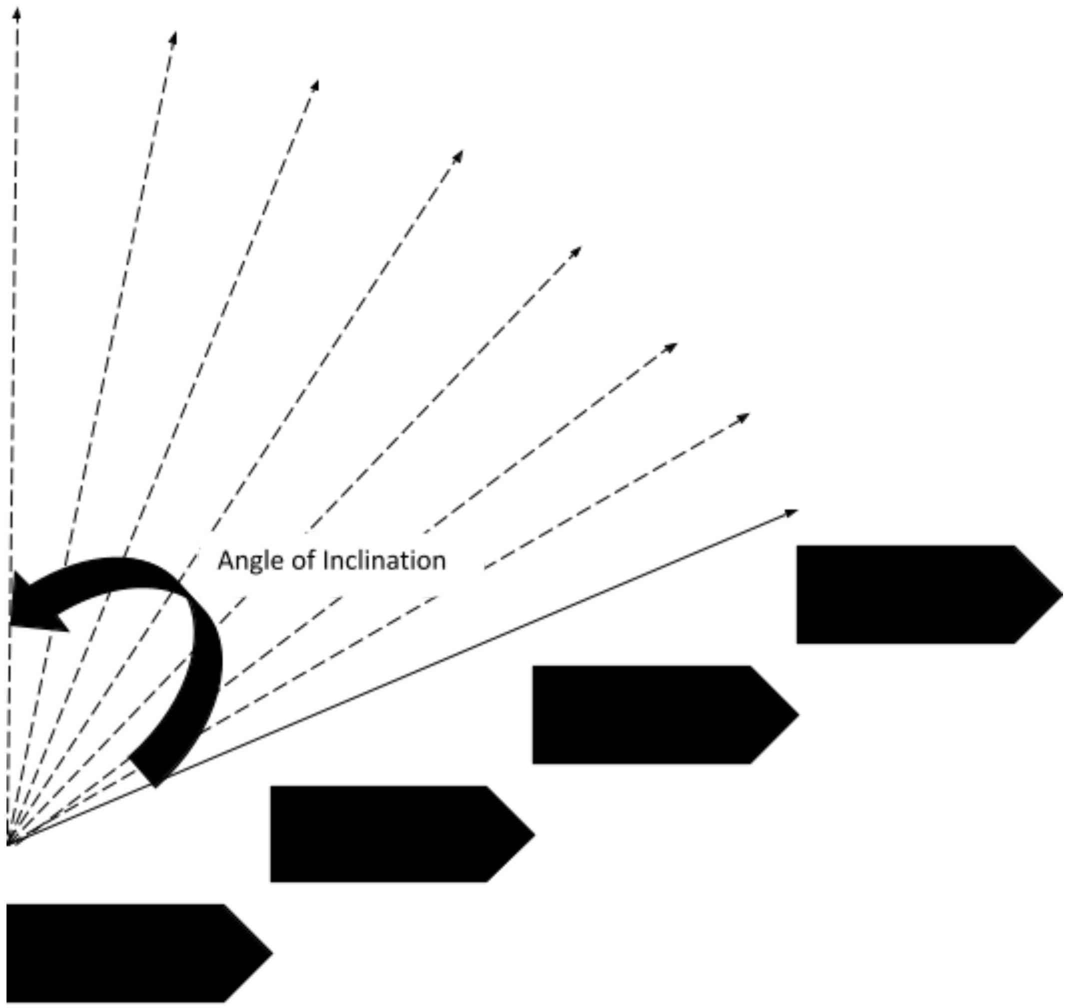
	Swallow Marine Coastal Research Infrastructure	Natural Sciences Collection Facility	Expanded Freshwater and Terrestrial Environmental Observation Network
Upscaling goal	Significant geographic expansion and upscaling of existing infrastructure	Organisational and deep upscaling	Functional upscaling
Roadmap stage	Operational/ Setting-up	Operational/ Setting-up	Setting-up

Discussion

The progress on the implementation of the three RIs selected for this study showed that the existing niche innovations do have some impact on success of the roadmap. A 'Generic Seed Technology Roadmap' is introduced in Figure 1. This roadmap still makes use of the usual four layers, namely: market, products/ services, technology and research and development. However, a pathway for seeded technology roadmaps can be different in a way that all or some of these roadmap components might already exist, albeit at a niche scale, during the inception of the roadmap implementation. An inclination angle shown in Figure 1 shows an extent of how a technology roadmap is seeded. The larger the inclination angle, the more seeded is the roadmap, vice versa.

Through an additional focus on upscaling, the seeded technology roadmaps truly incorporates the sociotechnical aspect of innovation. As shown by Heiligenberg (2020), upscaling brings in addition issues such as organisational innovation to expand the capacity of existing niches, deepening of the niche impact, replication of successful niche models, etc. Functional upscaling, which entails development of new products and services, resonates more with the traditional roadmapping objective, of which products/service development is driven by changing market needs or a newly created technology/ capability that is at a disposal of the organisation.

Figure 1: Generic Seeded Technology Roadmap



Conclusions

This paper has introduced the Seeded Technology Roadmaps as a means to promote the implementation of technology roadmaps. These roadmaps are catalysed through the already successful niche innovations. However, the seeded roadmaps are not necessarily used exclusively for the incremental innovations. Both incremental and radical innovations can be piloted at a small scale followed by upscaling that is suitable for a specific roadmap. The three RIs that are part of the SARIR successfully demonstrated the use of niche innovations in accelerating the implementation of the roadmap.

The Seeded Technology Roadmaps are important in this era of the fourth industrial revolution in which there are multiple emerging technologies with a potential for a wide range of impact. Due to high uncertainty in managing, regulating and enabling these technologies, the seeding can eliminate such uncertainties prior to a full—blown implementation of a roadmap through upscaling. This study is a very important contribution in building understanding of a new generation of sociotechnical transition technology roadmaps. It has laid a ground work for more in-depth studies in this knowledge area.

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An Approach to Optimize Multi-family Residence HVAC Systems using Digitalization

Abstract ID#343

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Background

Global urban centers can play a big role in decarbonization efforts as cities account for more than 70% of the man-made fossil fuel CO_2 emission [1]. In fact, buildings in cities generate 30% of the world's Greenhous Gas Emission. Majority of city- dwellers live in multi-family residences or apartment buildings. Therefore, focusing on the often-ignored market of multi-family residences in major urban centers will be a good start in achieving the decarbonization goals.

Scope

In a U.S Department of Energy (DOE) funded project, the Pacific Northwest National Laboratory (PNNL) has partnered with FCP LLC, a national real estate investment company. This partnership focuses on applying and demonstrating low-cost optimization applications for HVAC systems in multi-family housing by using a seamless-IoT infrastructure that acquires building's operating data to find the optimal setpoints of the different energy consuming devices such as chillers, boilers, pumps, and fans. This data-driven optimization [2][3][4] approach is pragmatic and easily transferrable to other buildings. In this paper, we shall focus on the technical approach and provide some preliminary results.

Technical Approach

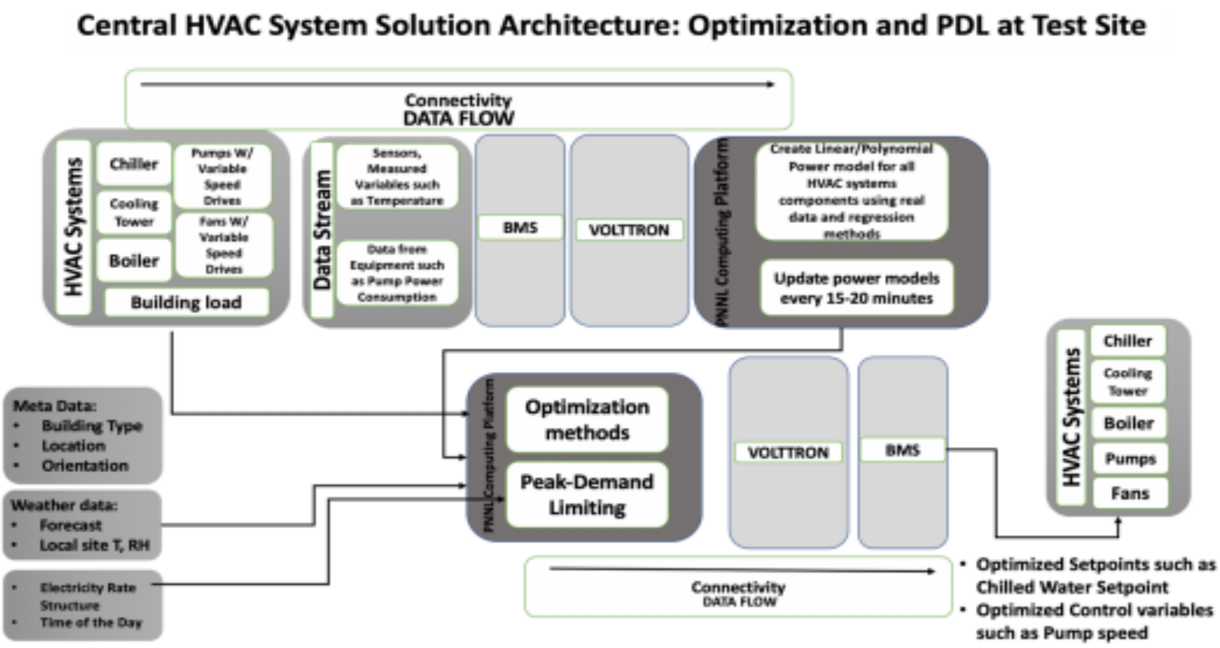

Figure 1: Solution Architecture for Central HVAC System

Figure 1 shows the proposed solution's overall architecture. The idea here is to do simple and pragmatic real-time optimization by collecting data from the IoT Platform-Integrated VOLTTRON, BMS (Building Automation System) and Mechanical System's local controller. VOLTTRON, developed at PNNL, is a control software platform that links operating data to cloud platform where optimization algorithm is executed [5]. The optimization algorithms do piecewise linear regression of the power models of all consuming equipment such as chillers, boilers, pumps, and fans.

VOLTTRON is also used to obtain data from the sub-meters that measure the energy consumption of the HVAC system devices and other sensors [5]. The data is retrieved on a cloud platform for further processing to update the power models. After processing, the total system power is calculated mathematically as a sum of the power consumption of cooling tower fans, chillers, distribution pumps, and heating plant. The mathematical models are re-evaluated every 15-20 minutes as load varies [2]. Once the optimal setpoints are determined, the results are dispatched to VOLTTRON and ultimately, fed to the HVAC system via BMS.

Figure 2 below shows an overall network using Digitalization, where data flows using Ethernet5 and BACnet6 communications networks. This hybrid network essentially enables data communication between VOLTTRON, Building Automation System (BAS), Energy Meter (EMON), and BMS front end. The BACnet network shows how the data flows across all the physical devices.

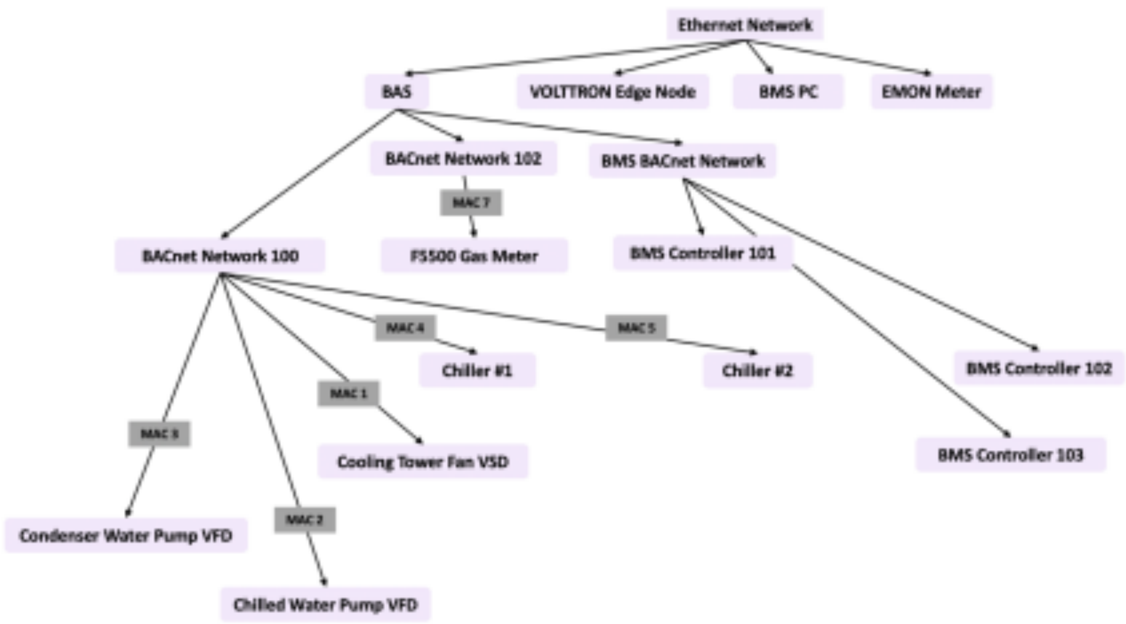

Figure 2: Data-Flow Architecture

Test site

The current project's test site is a multi-family housing in Tempe Arizona. The property is split into four quadrants and each quadrant has roughly 130 apartments. The total floor area of each quadrant is about 94,000 sq. ft. The mechanical system consists of a 2-pipe system that runs chilled or hot water through individual Fan Coil Units depending upon the season. The fully configured and operational HVAC system has two 77 tons water cooled scroll chillers that provide chilled water to the apartments. The condenser is cooled using a cooling tower where the fan pushes high velocity air and cools the condenser water that is supplied from the chiller. The gas fired boiler will supply hot water when the seasonal change-over takes place.

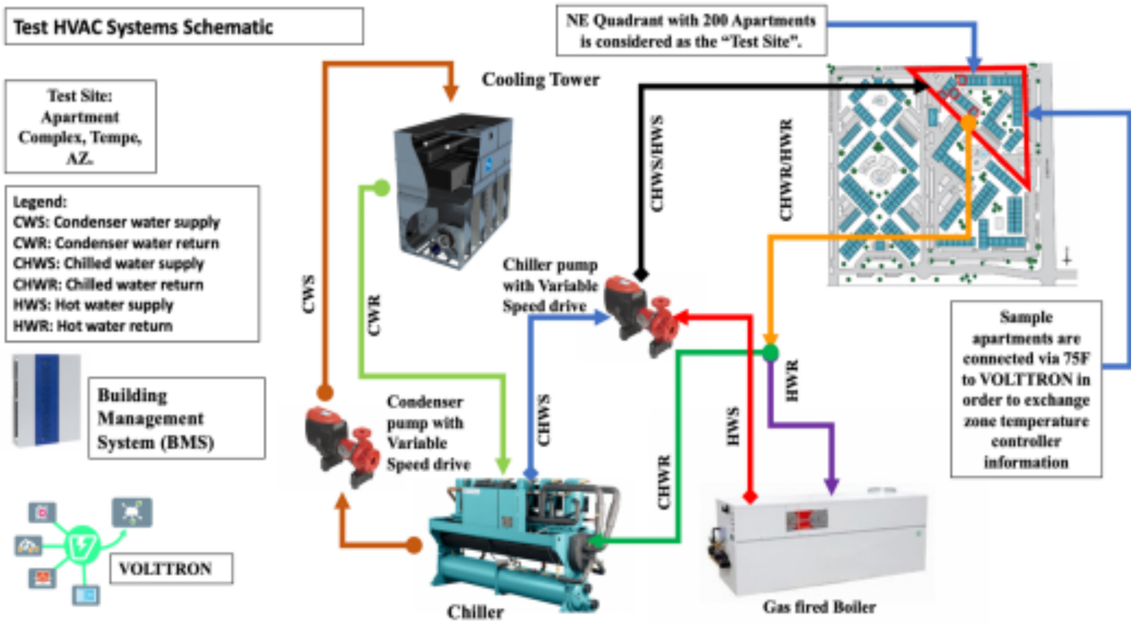

Figure 4: Test plant in Tempe Arizona

Results

So far, we have been able to calculate total energy savings by simulating the operation using linear power models of all energy consuming equipment. We were able to calculate the optimal setpoints of chilled water leaving temperature and cooling water leaving temperature by using simple calculus of variation methods. Table 1 shows that we realized 12.6 % of energy savings on the chiller side and 48.7% on the tower loop when simulated power is compared to real power consumptions over a limited period from September 29th until October 31st. It is important to note that the month of October is a warm month in Arizona.

Table 1: Energy Savings Percentage Results (September 29th – October 31st, 2021)

Mean (% Energy Savings Cooling Tower Side with Linear Model)	48.6098818
Mean (% Energy Savings Chiller Side with Linear Model)	12.5450208

As sample results, figures 5 and 6 show that simulated power consumption is lower than the measured power for the data received on October 13th, 2021, from 12 PM until 8PM.

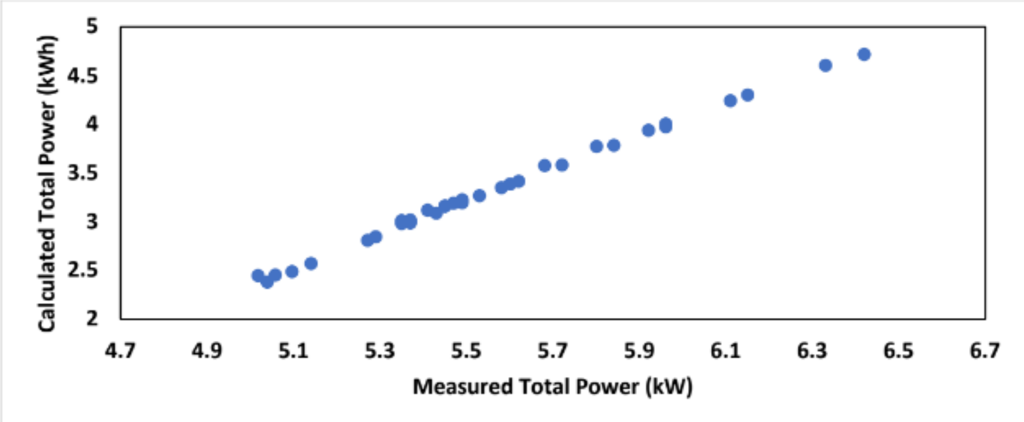

Figure 5: Comparison Between Model-Calculated and Measured Cooling Plant Total Power on the Chiller-Side.

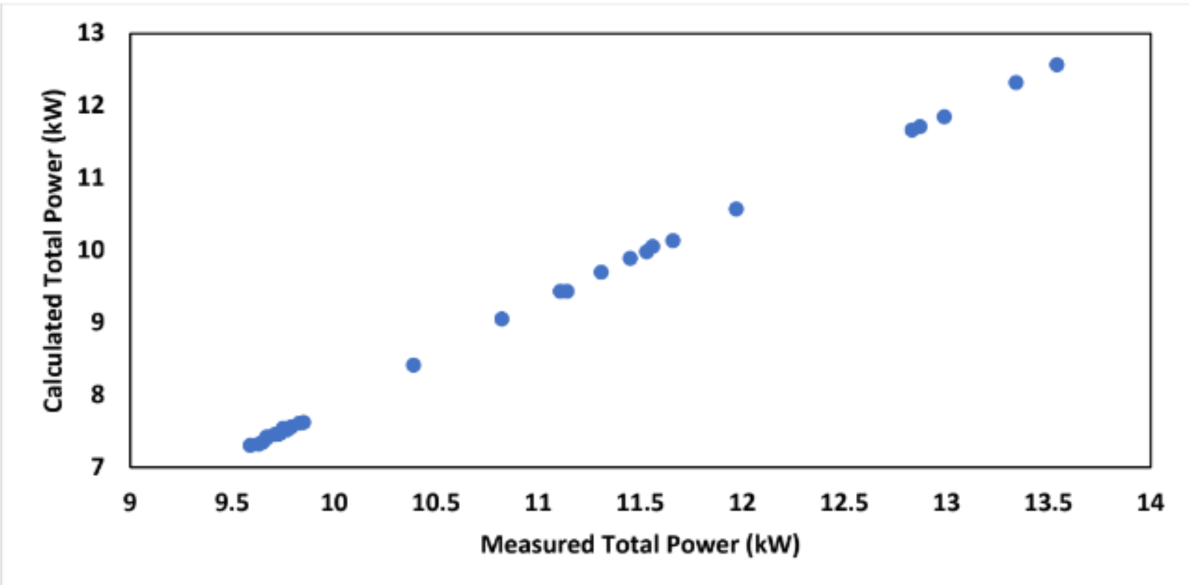

Figure 6: Comparison Between Model-Calculated and Measured Cooling Plant Total Power on the Cooling Tower-Side

Table 2 shows that both the percent error and root mean squared error are low for the data in Figures 5 and 6, indicating a good agreement between the calculated and measured results. Tables 3 depict the results for a day in October.

Table 2: Error Between Calculated Power vs. Measured Power for Data in Figures

Figures	Model	% Error	RMSE	R-squared	Equation
#5	Chiller Linear Model	0.1832129	1.94279075	0.9993	y = 1.355x - 5.6936
#6	Cooling tower Linear Model	0.40538974	2.24660928	0.9977	y = 1.6844x - 6.0443

Table 3: Energy Savings Percentage Results (October 13th, 2021, 12 PM - 8PM)

Mean (% Energy Savings Cooling Tower Side with Linear Model)	40.5489743
Mean (% Energy Savings Chiller Side with Linear Model)	18.3212896

We shall continue to calculate savings using simulated data and continue to monitor the implementation of our optimization approach at the test site.

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A strategic perspective of CNEN's portfolio of nanotechnologies: technical insights at a glance

Abstract ID#226 | Full Paper ID#441

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Abstract: The National Nuclear Energy Commission (CNEN) of Brazil has a broad spectrumof R&D activities – nuclear technologies and application of ionizing radiation in agriculture, environment and industry, as well as alternative energies, biotechnology, nanotechnology andadvanced materials. This article refers to the assessment of CNEN's portfolio of patented nanotechnologies filed at the Brazil Patent Office, using a quantitative and qualitative research method that combines the following criteria: technological clusters for mapping R&D activities in nanotechnology; applications in alignment with green and environmentally sustainable technologies; technology maturity level; and market potential. The results signalize six main technological clusters under development in the fields of environment, pharmaceutical industry and energy, specifically for the chemical industry (polymers, fertilizers and minerals) and electronics (materials and equipment). More than half of the portfolio have moderate or moderate-to-strong market potential. Nevertheless, low maturity level of most nanotechnologies represents a weakness to be overcome to further advance the proof-of-concept stage. The main contribution of this article is to highlight nanotechnology asa key enabling technology through a strategic portfolio view that can foster collaborative innovation aligned with environmentally sustainable solutions.

Keywords: nanotechnology; innovation; nuclear technology; sustainable technologies

Introduction

In the recent decades R&D activities in nanotechnology have driven technological advancement globally (LEYDESDORFF, 2008; ISLAM; MIYAZAKI, 2009, 2010; DOLSFSMA; LEYDESDORF, 2011; CANCINO et al.; BOTELHO et al., 2021).

Nanotechnology domains are diverse, from electronic materials to the biomedical field, which permeates gene therapy, drug management and new drug discovery techniques (ISLAM; MIYAZAKI, 2009, 2010; CANCINO et al. 2014). Nanotechnology has been the basis for achieving wide-ranging benefits for society, including improved health, agriculture, smarter electronics and cleaner sources of energy. In addition, sustainable R&D is considered a strategic activity to generate disruptive alternative solutions (PIALOT E MILLET, 2018) and to adopt, develop and improve clean technologies aiming at reducing environmental impacts (BRASIL, 2010).

It is worth mentioning the importance of recent regulation issued by the Ministry of Science, Technology and Innovation (MCTI)1 (BRASIL, 2021), which points out the priorities within the scope of R&D and innovation projects between 2021 and 2023. In effect, this regulation establishes six technology areas as priorities: I – Strategic; II – Enabling; III – Production; IV – Sustainable Development; V – Quality of Life; and VI – Promotion, Popularization and Dissemination of Science, Technology and Innovation (STI). Further, its article 3 regards the nuclear sector as one of the four Strategic Technologies. Nanotechnology

[1] Ordinance No. 5109, of August 16th, 2021.

is included as an enabling technology, and renewable energy, treatment and recycling of solid waste and treatment of pollution are embraced as sustainable development. In this sense, there is a great opportunity for CNEN's nanotechnologies in connection with nuclear applications and sustainable energies.

This article aims at assessing CNEN's portfolio of nanotechnologies through a quantitative and qualitative research method that combines technological clusters based on the International Patent Classification (IPC); potential applications of nanotechnology aligned with green and environmentally sustainable technologies; maturity level based on the Technology Readiness Level (TRL) scale; and market potential. The main contribution of this article is to highlight nanotechnology as "emerging and enabling". Through a strategic portfolio view, it may support CNEN in creating a collaborative innovation ecosystem with industry in Brazil, aiming at leveraging companies' productivity, competitiveness and technical capabilities aligned with environmentally sustainable solutions.

Theoretical Background

The use of patent data has a long history on decisions related to innovation management (CANDELIN-PALMQVIST et al., 2012; WEILING et al., 2018; GUDERIAN et al, 2021).

Organizations rely on patent data for decision-making on whether to protect their inventions, including start-ups, universities and research institutions. Patent data is global and when objectively collected and prepared for analysis, it is made available in a timely, systematic and documented manner. Thus, it is considered advantageous and can complement other forms of data collection, such as surveys that are subject to limited generalization and require waiting time to be obtained (ERNST & OMLAND, 2011; BUEHLER et al., 2017; GUDERIAN, 2019; GUDERIAN et al, 2021).

Intellectual property (IP) and sustainable development

The IP system drives innovation as well as the transfer and dissemination of technology, including environmental technologies. If, on the one hand, IP rights provide economic incentives to develop new solutions, on the other, they can help in the diffusion of innovation to regions of greatest need, through licensing agreements, joint ventures, among others mechanisms of technology transfer (DIETTERICH, 2020).

According to the United Nations Sustainable Development Goals (SDGs), more than a half of them require the achievement of green technological solutions. Undoubtedly, this is stimulating and emphasizes the urgency of developing and using the potential of environmentally sustainable solutions (DIETTERICH, 2020).

The Decree No. 9073, of June 5th, 2017, which promulgates the Paris Agreement under the United Nations Framework on Climate Change, mentions in its article 10 that "it is essential to accelerate, encourage and enable innovation to contribute to an effective and long-term global response to climate change and to promote economic growth and sustainable development" (BRASIL, 2017).

Given the direct relationship between industrial property and technological development, in 2010, a virtual tool linked to the IPC system, known as the WIPO Green Inventory, was put into operation. The referred tool basically has two clear objectives: to facilitate the search and identification of so-called green technologies; and to help researcher and investors concentrate efforts on R&D resources to develop green technologies (WIPO, 2010). WIPO Green Inventory comprises seven major areas as green technologies, and each one is subdivided into subareas, which are linked to IPC codes.

In 2013, the WIPO GREEN database was launched aiming at accelerating green technology innovation and its transfer towards expanding the acceptance and use of green technologies in support of the transition to a low-carbon future. The WIPO GREEN online marketplace contains thousands of possibilities in construction, chemicals and advanced materials, energy, agriculture and forestry, green products, pollution and waste, transport and water. Green technologies on the database cover both adaptation to climate change and mitigation technologies (WIPO, 2019).

In Brazil, the patent system has also sought to act as a driver for economic and sustainable development, behaving as an inducer for innovation in environmental matters. This can be observed in the relationship between green technologies and the patent system through the pilot program "Green Patents" of the National Institute of Industrial Property (INPI). The program was launched in 2012, under INPI Resolution 283-2012 (BRASIL, 2012), aligned with public policies related to the engagement against climate change in the form of Law 12187-2009, which establishes the National Policy on Climate Change (PNMC) (BRASIL, 2009).

Relevance of technology and commercial applicability

It is difficult to measure the impact of R&D or innovation activities (BICAN AND BREM, 2020). Often, innovation managers call on patent analysis and for this, various patent indicators are applied, from patent portfolio sizes and patent citations to data extracted from patents (BUEHLER et al., 2017; FANKHAUSER et al. 2018; GUDERIAN, 2019). This

variety of patent indicators stems from the variation in patent values and commercial applicability (JENSEN AND WEBSTER, 2011; ADRIANO AND ANTUNES, 2017).

Razgaitis (2007), in turn, points out four factors to be used in the qualitative analysis of technologies: (1) the scope of IP asset protection, (2) the technology development stage or maturity, (3) the size and the market value and (4) the sustainability of the innovation in question compared to present and foreseen competitive alternatives.

Nanotechnology, due to the peculiar properties of materials at the nanometer scale, clearly supports a wide range of technologies. An OECD study (OECD, 2007) examined the breadth of nanotechnology patent applications by categorizing them into six fields of application, based on IPC, according to keyword analysis: electronics, optoelectronics, medicine and biotechnology, measurements and manufacturing, environment and energy, nanomaterials.

In a more recent study, Jürgens and |Herrero-Solana (2017) also presented the most important classifications for searching nanotechnology patents. The main conclusions of their study were: a) patents are a very important source of information used to observe, track and analyze nanotechnology, but due to their multidisciplinary character, it is often difficult to detect all the relevant documents in a database; b) keyword-based search is unreliable, as some documents use nanotechnology only as a buzzword and other documents avoid its use so as not to be detected by patent monitoring activities; using patent classifications for a patent search is therefore recommended to retrieve relevant documents; c) the B82Y subclass is the most widely used nanotechnology classification, incorporated in both the Cooperative Patent Classification and the International Patent Classification; d) using the code B82Y in the Cooperative Patent Classification retrieves many more patent documents than using the International Patent Classification.

Technology Readiness Level (TRL) is a methodology to determine the maturity of a technology by offering a measurement system. It facilitates decision-making and comparison between technologies in the management of innovation projects (LAURINDO, 2014). Originally developed and implemented by NASA, the TRL was disseminated by industry and evolved into a metric applicable to several areas of research over the years (TOMASCHECK et al, 2016). Its use has also proven helpful in the design of complex technical systems that incorporate emerging technologies (GAO et al, 2013), which is the case of nanotechnology.

TRL has also a direct relation to market potential: if a technology can be demonstrated, especially through a prototype, market becomes more attractive, as well as the interest of investors, companies and competitors (HSIEH, 2013). It is worth mentioning that the analysis of the external environment complements the study of an organization's portfolio and its maturity level, through which the possibilities for expansion and the resulting challenges are identified. This is especially relevant in the case of different applications of the same technology (RAZGAITIS, 2007; LAURINDO, 2014).

Methodological Procedures

This section presents the research steps to evaluate and characterize CNEN's patent portfolio of nanotechnologies, based on the IPC grouping, and to select those with potential applications in the form of products, processes or technological services and that are aligned with the concept of sustainable green technologies. Figure 1 illustrates the method used through the concept map.

The data elaboration, the selection of CNEN's portfolio of patented nanotechnologies and its division into sub-areas was conducted on APOL, Questel Orbit and PatSeer softwares and on Espacenet database. Based on the literature review, two references were selected (OECD, 2005; JÜRGENS & HERRERO-SOLANA, 2017) to serve as the basis for the comparative analysis, especially between IPC and technological domains. In addition, the authors' technical knowledge of the 21 patent applications contributed to their selection. The rationale is explained below.

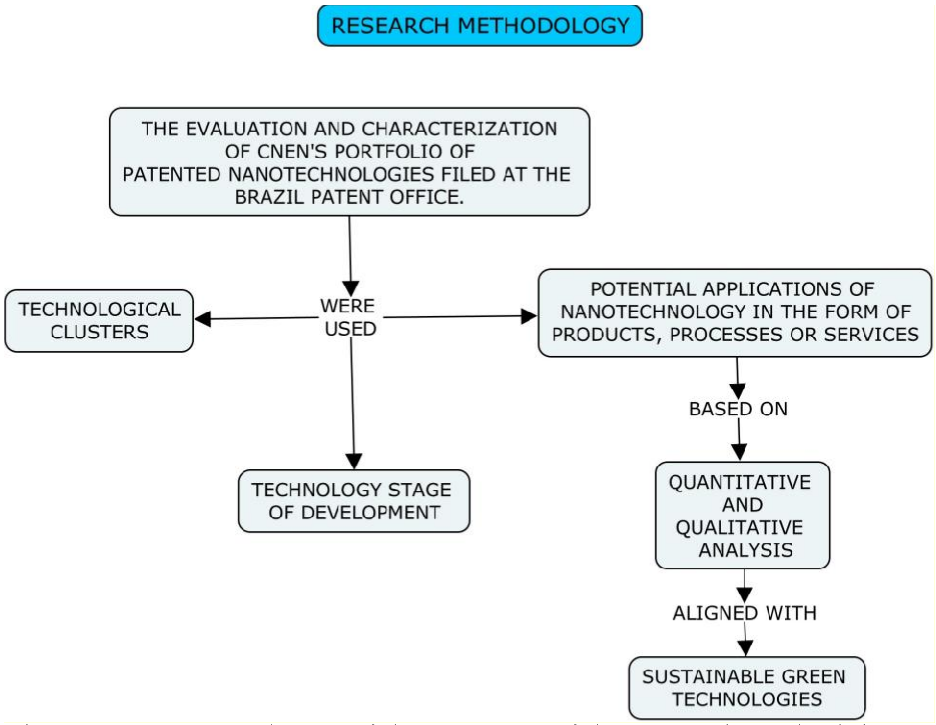

Figure 1: Conceptual map of the structure of the research methodology. Source: Prepared by the authors.

International Patent Classification

The extraction of CNEN's patent portfolio was based on the APOL system (LDSOFT, 2021), an IP process control software signed by CNEN to monitor its patent applications. The portfolio extraction includes only national applications.

The data management took place in August 2021, accounting for 43 active patent processes from 2016 to 2020. This time frame was selected due to three reasons: a) based on Foster (1986), technologies may likely become obsolete if lifetime is greater than five years;

b) CNEN's patented nanotechnologies from 2016 to 2020 are advancements from patent applications filed until 2015 in the same technological domains (predominantly in IPC subclasses B01J and H01M3); and c) only one nanotechnology was patented in 2014 (BR1020140047182) within the pharmaceutical domain (IPC subclass A61K) as an improvement of patent application no. 17 (BR1020200029312)4, according to Table 2. In this manner, either obsolescence or improvement of previous technologies may have an impact on the five-year period.

Among the 43 processes, 21 addressed nanotechnologies, simultaneously using Jürgens and Herrero-Solana (2017) and the OECD (2007) criteria. In addition, a search was carried out on Espacenet to retrieve all the IPC classes and subclasses referring to nanotechnology and compare them with the two references in the literature previously mentioned. Table 1 summarizes the comparative relationship between the three studies.

TABLE 1: IPC classes and subclasses in the field of nanotechnology according to the OECD criteria (2007), Jürgens e Herrero-Solana (2017) and Espacenet.

IPC	DESCRIPTION	Espacenet	OECD (2007)	JÜRGENS & HERRERO-SOLANA (2017)
A61	Medical or veterinary science; hygiene	X	X	X
B01	Physical or chemical processes or apparatus in general	X	X	
B05D	Processes for applying fluent materials to surfaces, in general	X		X
B21	Mechanical metalworking without essentially removing material; punching metal		X	
B23	Machine tools: metalworking not otherwise provided for		X	
B32B	Layered products, *i.e.,* products built-up of strata of flat or non-flat		X	
B81B	Microstructural devices or systems		X	
B82B	Nanostructures formed by manipulation of individual atoms, molecules, or limited collection of them as discrete units; manufacture or treatment thereof	X	X	
B82Y	Specific uses or applications of nanostructures; measurement or analysis of nanostructures; manufactures or treatment of nanostructures (nanobiotechnology or nanomedicine/ nanotechnology for information processing, storage or transmission/ nanotechnology for interacting, sensing or actuating / nanooptics / nanomagnetism / nanotechnology for materials or surface science / methods or apparatus for measurement or analysis of nanostructures / manufacture or treatment of nanostructures)	X		X
C01B	Non-metallic elements; compounds thereof	X	X	X
C01G	Compounds containing metals not covered by subclasses C01D or C01F		X	
C02F	Treatment of water, wastewater, sewage, or sludge	X	X	
C03B	Manufacture, shaping, or supplementary processes		X	
C03C	Chemical composition of glasses, glazes, or vitreous enamels; surface treatment of glass; surface treatment of fibres or filaments from glass, minerals or slags; joining glass to glass or other materials		X	
C04	Cements; concrete; artificial stone; ceramics; refractories		X	
C07	Organic chemistry		X	
C08	Organic macromolecular compounds; their preparation or chemical working-up; compositions based thereon	X	X	
C09	Dyes; paints; polishes; natural resins; adhesives; compositions not otherwise provided for; applications of materials not otherwise provided for		X	
C12	Biochemistry; beer; spirits; wine; vinegar; microbiology; enzymology; mutation or genetic engineering	X	X	
C22	Metallurgy; ferrous or non-ferrous alloys; treatment of alloys or non-ferrous metals		X	
C23C	Coating metallic material; coating material with metallic material; surface treatment of metallic material by diffusion into the surface, by chemical conversion or substitution; coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapour deposition, in general	X	X	
C30	Crystal growth		X	
G01	Measuring; testing	X	X	X
G02	Optics		X	X

*Cooperative Patent Classification (CPC)[5] subclass for new technological developments for mitigation and adaptation against climate change focusing on the reduction of GHG emissions. Source: Prepared by the authorsbased on OECD (2007), Jürgens and Horrara-Solano (2017) and Espacenet.

Questel Orbit Intelligence and PatSeer softwares were also used to help map and systematize the 21 patent applications in nanotechnology.

The selection of the nanotechnology sample, using, firstly, the IPC criterion, was based on the unification of the methodologies adopted by the studies of OECD (2007) and Jürgens and Horrara-Solano (2017), complemented with the search conducted on Espacenet.

Assessment of technological sustainability of nanotechnologies

This research step was based on selecting, manually, according to the IPC Green Inventory, the patent applications referring to the development of green technologies (processes and/or products). Complementarily, patent applications were aligned with the areas and sub-areas categorized in the WIPO GREEN database. A limitation is that WIPO GREEN does not include medical technology classification. In this sense, all technologies related to pharmaceuticals, nanomedicine or potential application in medical diagnostics were enclosed in "improved materials" belonging to "products, materials and processes".

Once CNEN's patented nanotechnologies were selected, an association with green technologies was considered for each patent application. For this purpose, two precepts were used, the WIPO GREEN database and the WIPO Green Inventory. Thus, if a patent application contemplates one of the two criteria or both, simultaneously, it can be regarded as an environmentally sustainable solution. Questel Orbit software was used to select each patent application by technological domain.

Prioritization analysis of nanotechnologies

The prioritization analysis comprises a qualitative approach to represent the 21 patent applications in nanotechnology in accordance with Razgaitis (2007). Commercialization of technologies require the definition of a specific strategy for each technology, given its characteristics. In this study, TRL and market potential were selected as the main characteristics of the prioritization analysis.

Results

A survey of the 21 patent applications in nanotechnology was characterized by technological domain to support the analysis of technology maturity level, market potential and environmentally sustainable applications. It can be summarized according to Figure 2.

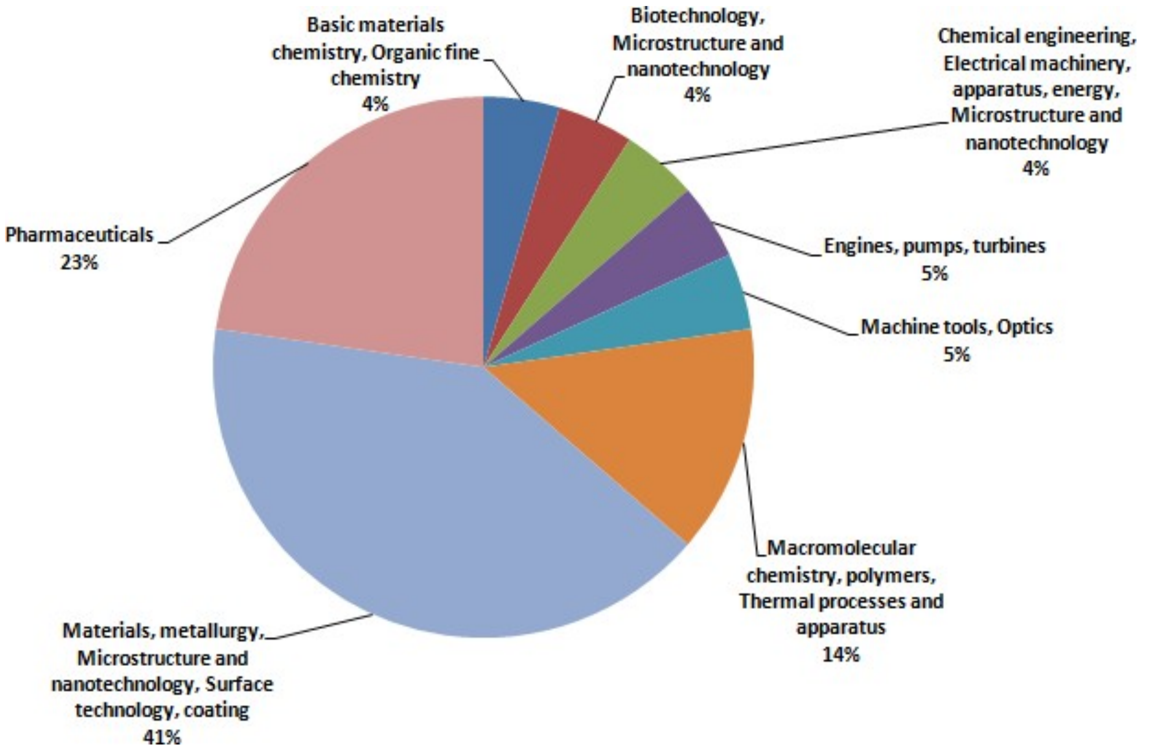

Figure 2: CNEN's nanotechnology portfolio by technological domain. Source: Questel Orbit.

Following that, the association with green technologies was considered for each patent application according to WIPO GREEN database and the WIPO Green Inventory. This relationship is summarized in Table 2.

TABLE 2: CNEN's portfolio of nanotechnologies aligned with green technologies according to WIPO GREEN database and WIPO Green Inventory.

	Publication Number	Title	Technology Domain	WIPO Green Inventory	Green Technology/ WIPO GREEN database
1	BR102016010306	Adsorbent nanomaterial from residue from the semi-dry flue gas desulphurization system, preparation process and its application	Materials, metallurgy, microstructure and nanotechnology, surface technology, Coating	C01B* C01F B82Y	Water treatment; wastewater treatment; products that avoid toxic or other emissions

2	BR102016016445	Incorporation of transition metal nanoparticles in graphene-based compounds for the formation of a nanocomposite in powder form	Materials, metallurgy, microstructure and nanotechnology, surface technology, coating	C30B C01B* B82Y	Bio-based product: products that avoic toxic or other emissions; chemica and industrial processes
3	BR102016017022	Use of green surfactant formulation to obtain graphene	Basic materials chemistry, organic fine chemistry	C07H C07J C11D	Chemical and industrial processe: products that avoic toxic or other emissions
4	BR102016025975	Thermal reduction of graphene oxide at low temperature and hydrogen pressure	Macromolecular chemistry, polymers, materials, metallurgy, thermal processes and apparatus	C01B* C08K F27B F27B	Chemical and industrial processe: improved materials
5	BR102016027586	Preparation process of metallic carbon-supported nanoparticles for application as electrocatalysts in proton exchange membrane fuel cells	Chemical engineering, electrical machinery, apparatus, energy, microstructure and nanotechnology	B01J B82B H01M*	Fuel cells
6	BR102016028723	Process of bacterial transformation and cell transfection using hybrid nanoparticle	Biotechnology, microstructure and nanotechnology	C12N B82Y	Bio-based product: chemical and industrial processe
7	BR102017020020	Nanosilica production process from sugarcane residue ash	Materials, metallurgy, microstructure and nanotechnology, surface technology, coating	C01B* B82Y	Recycling and reus solid waste treatment; chemica and industrial processes
8	BR102017023706	Thermal reduction process of graphene oxide in medium vacuum aiming raw material for supercapacitors	Materials, metallurgy, microstructure and nanotechnology, surface technology, coating	C01B*	Improved material:
9	BR102018010397	High purity zeolite synthesis process using different types of coal ash	Materials, metallurgy, microstructure and nanotechnology, surface technology, coating	C01B*	Solid waste treatment; chemica and industrial processes
10	BR102018068897	Process for obtaining hybrids of boron nitride and magnetic ferrite nanotubes	Materials, metallurgy, microstructure and nanotechnology, surface technology, coating	C04B A61N G01N B82Y	Chemical and industrial processe: improved materials
11	BR102018069286	Process for obtaining polymeric material with chitosan	Basic materials chemistry, macromolecular chemistry, polymers, pharmaceuticals	A61K A01N* C08B C08L	Improved farm inputs; bio-based products

12	BR102018076860	Efficient random laser by differential control of gain and light scattering	Machine tools, optics	H01S* B23K	Improved materials (potential applicati in the detection of chemical substance or in medical diagnosis)
13	BR102019009121	Sol-gel method of manufacturing metallic microspheres with customized porosity	Materials, metallurgy, microstructure and nanotechnology, surface technology, coating	B22F C01B*	Chemical and industrial processes improved materials
14	BR102019009124[6]	Sol-gel method of manufacturing a coherently bonded metal coating on the surface of ceramic bodies forming cermets	Engines, pumps, turbines	G21C*	Chemical and industrial processes improved materials waste avoidance
15	BR102019011218	Sulfur doping process of titanium dioxide films	Materials, metallurgy, surface technology, coating	C23C C01G	Water treatment; chemical and industrial processe
16	BR102019017415	Process for obtaining cross-linked polymeric hydrogels by using ionizing radiation for cleaning surfaces of works of art	Macromolecular chemistry, polymers	C08G C08B C08K	Biodegradable/ biocompatible products; chemical and industrial processes
17	BR102020002931	Simultaneous synthesis process and sterilization of hybrid nanoparticles	Materials, metallurgy, microstructure and nanotechnology, surface technology, coating, pharmaceuticals	A61K B82Y A61P	Improved materials nanotechnology; b based products; waste avoidance
18	BR102020007225	Synthesis of radioactive and non-radioactive gold nanoparticles for therapeutic use	Pharmaceuticals	A61K B82Y G01N A61P	Improved materials nanotechnology
19	BR102020009121	Graphene synthesis process using ultraviolet radiation assisted photo-oxidation method	Materials, metallurgy, microstructure and nanotechnology, surface technology, coating	C01B* B82B	Products that avoid toxic or other emissions; improve materials
20	BR102020016119	Drug delivery polymer-based nanoparticles, mechanisms of final nanodrug admission and its use for prophylactic and therapeutic treatment of viral and bacterial respiratory diseases	Pharmaceuticals	A61K A61P	Improved materials
21	BR102020019797	Nanoplatform production process for encapsulation and drug delivery and nanoplatform obtained thereof	Pharmaceuticals	A61K	Improved materials bio-based products

*IPC subclasses related to green technologies according to WIPO Green Inventory. Source: Prepared by theauthors based on Questel Orbit, WIPO GREEN database and WIPO Green Inventory.

Figure 3 details Figure 2 per year, considering the relationship between the number of patent applications and technological domains.

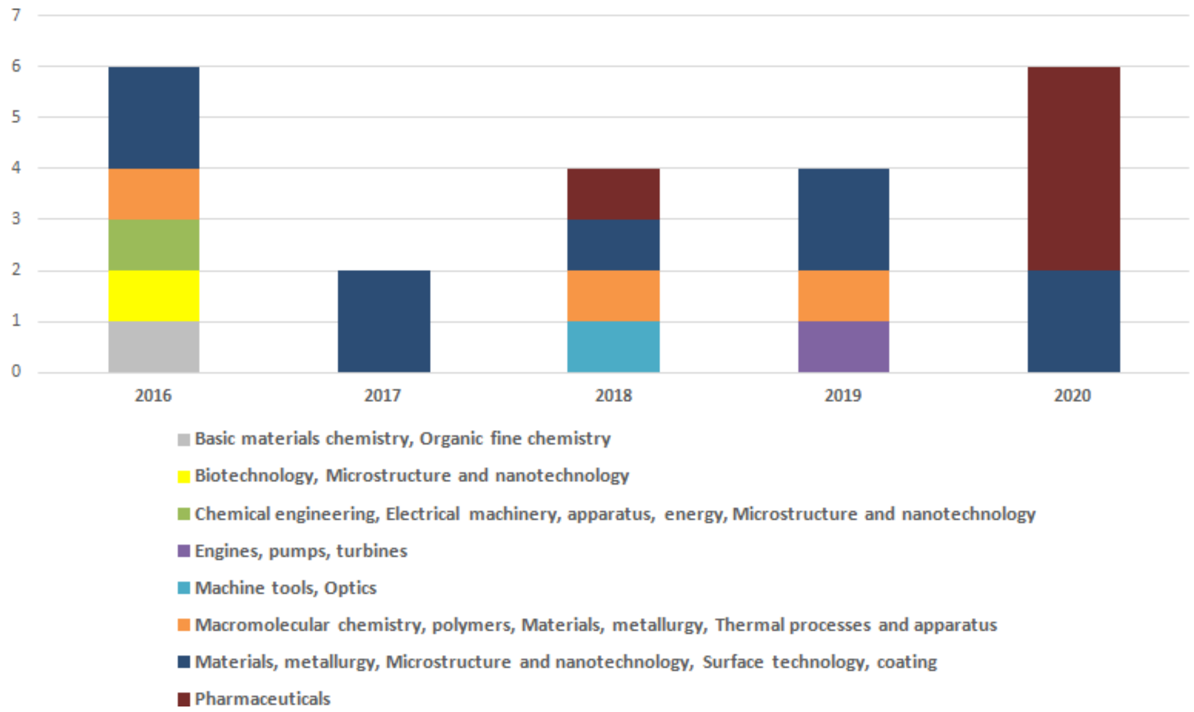

Figure 3: Trends in nanotechnology patent applications by technological domain. Source: Prepared by theauthors.

As Table 2 refers to the alignment of CNEN's portfolio of nanotechnologies with green technologies, from 2016 to 2020, Figure 4 points out that most technologies can be considered as environmentally sustainable solutions, whether in relation to the final product and/or the process. The predominant field of sustainable nanotechnologies is "improved materials", which includes "pharmaceuticals", and "chemical and industrial processes".

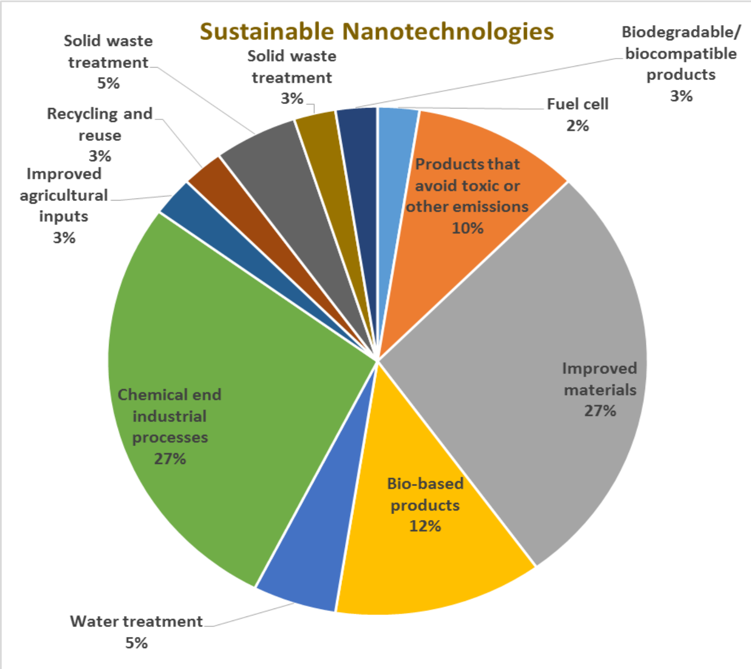

Figure 4: CNEN's nanotechnologies according to WIPO GREEN database and WIPO Green Inventory. Source:Prepared by the authors.

Figure 5 is an excerpt from Figure 4 and details the sustainable bias of the 21 patent applications in nanotechnology. Finally, the main industrial sectors in which such technologies could turn into practical applications are shown in Figure 6. This, in turn, helped in ranking market potential of nanotechnologies.

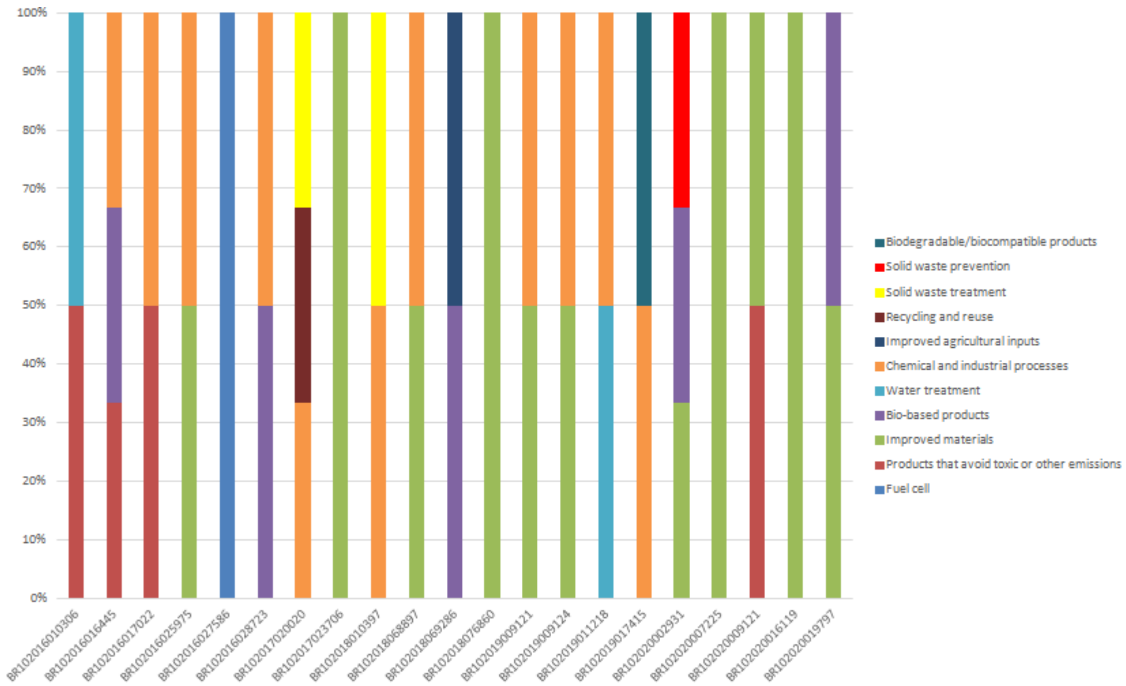

Figure 5: Alignment of each one of the 21 patent applications in nanotechnology with sustainable technologies. Source: prepared by the authors.

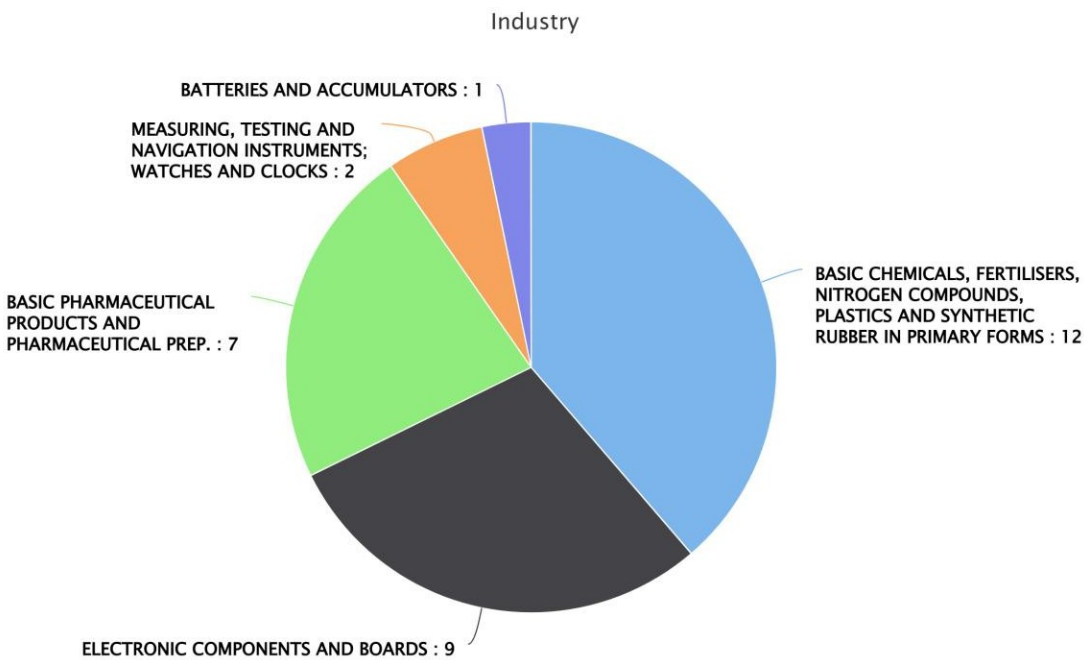

Figure 6: Main industrial sectors for the application of CNEN's nanotechnologies. Source: PatSeer.

TRL and market potential were attributed to each patent application based on the literature (RAZGAITIS, 2007; GAO et al, 2013; HSIEH, 2013), a brief interview with the main researchers involved in the technology development processes and analysis of industrial sectors according to Figure 6.

Four characteristics were considered in the interview: a) demonstration of the technology in terms of proof of concept, data from tests and/or prototype; b) types of products and/or services that can incorporate the technology; c) similar products and/or services in the market; and d) industrial sectors, companies and countries that might be interested.

Invention evaluator reports were prepared by TekCapital7 for five of the total patent applications (nos. 13, 17, 18, 19 and 21), indicating the following market factors: size, growth, profitability, and competitive landscape. Based on these market factors, the interview survey and industrial sectors, brief analyzes of the remaining 16 patent applications were prepared. Figures 7 and 8 present the final results of TRL and market potential.

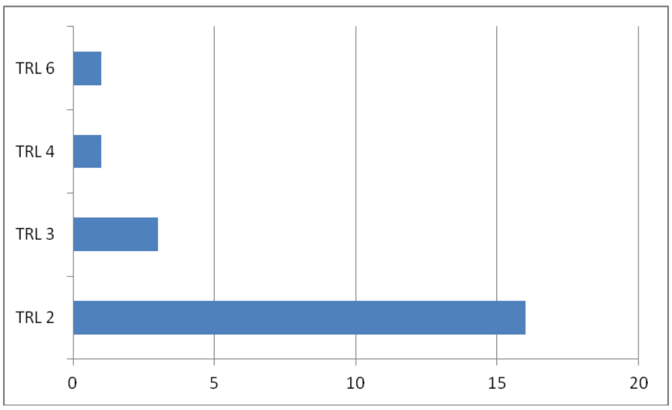

Figure 7: Technology maturity level.
Source: Prepared by the authors.

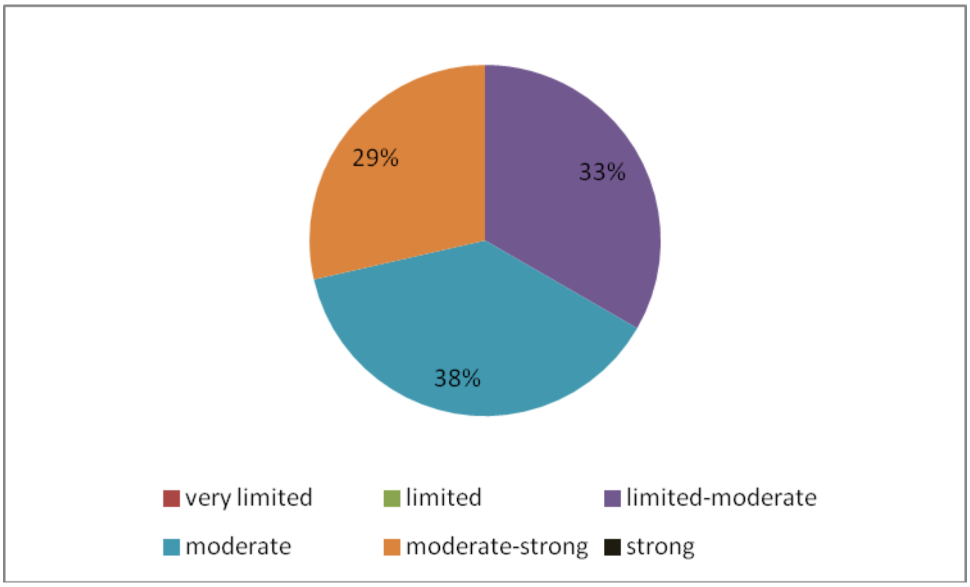

Figure 8: Market potential.
Source: Prepared by the authors.

Discussion

In a general and qualitative approach, the results reveal that the sample of patented nanotechnologies in the last five years is quite varied, encompassing several fields of application, from fuel cells, chemical engineering, macromolecular chemistry, basic materials and equipment to biotechnology, microstructure, optics and pharmaceuticals (Figure 2). The technological domain with the higher number of patent applications is “materials, metallurgy, microstructure, nanotechnology, surface technology, coating” (41%), followed by “pharmaceuticals” (23%) and then by “macromolecular chemistry, polymers, processes and thermal devices” (14%).

Evaluating the trends in patent applications in nanotechnology by technological domain over the selected years (Figure 3), it can be noted that "materials, metallurgy, microstructure and nanotechnology, surface and coating technology" is the only technological domain presenting patent applications every year. "Macromolecular chemistry, polymers, processes and thermal devices" is the next predominant domain per year followed by "pharmaceuticals". The increase in patent applications is especially notable in "pharmaceuticals", which is most prominent in 2020, when it achieves the highest share among the eight technological domains.

In attention to green technologies, a dialog between CNEN’s portfolio of nanotechnologies and the SDGs can be perceived (Figure 4). Technologies addressing biotechnology for environmental treatment, zero-waste or zero-emission industrial processes and solid waste treatment can be highlighted. All of them are recognized as global trends both in the SDGs and in national STI strategy. The portfolio also features other technologies: biodegradable/biocompatible products; fuel cells for promoting clean energy; chemical engineering; nuclear technologies applied in industrial processes and waste treatment; materials processing encompassing advanced technologies with applications in medicine.

Another interesting finding is that most technologies present a sustainable bias in more than one field, as shown in Figure 5. For example, patent application no. 2 (BR102016016445) refers to a bio-based product that avoids toxic emissions and does not generate waste. Patent application no. 14

(BR102019009124), in turn, refers to the development of an improved material and deals with a non-waste industrial chemical process at the same time.

Figure 6 presents the five main industrial sectors (1- basic chemicals, fertilizers, plastics and synthetic rubbers; 2- pharmaceuticals; 3- electronic components and boards; 4- measuring, testing and navigation instruments; and 5- batteries) in which such technologies could turn into practical applications. Other industrial sectors can be regarded as secondary: medical and dental instruments and supplies; cement, lime and gypsum; metallurgy; irradiation, electromedical and electrotherapeutic equipment; and communication equipment.

Given these industrial sectors as relevant for the global economy and considering Figure 8, it is reasonable to understand that the total sum of “moderate - moderate to high” market potential accounts for 67%, although most nanotechnologies are ranked at TRL level 2, as shown in Figure 7.

In this connection, the last finding remarks that CNEN’s R&D in nanotechnology may have practical applications to the real world with market potential. On the other hand, concerning the stage of development, the low technology maturity level indicates missing strategic mechanisms to advance relevant environmentally sustainable nanotechnologies that could be profiting from innovation. Implications for institutional policies should be discussed and explored in future studies for creating incentives to researchers and high-performance teams aiming at fostering collaborative innovation with industry to advance the maturity level of these nanotechnologies.

Considered as an enabling technology, the data indicate perspectives and opportunities to sustain R&D and innovation in the field of nanotechnology in a public research organization.

Conclusions

It is possible to observe in this study that CNEN’s portfolio of patented nanotechnologies aligned with green and environmentally sustainable solutions proved to be “strong” in its diversity, “moderate” in market potential, but “weak” in its technological maturity. Maturity level is an important element for assessing the stage of technology development, in other words, positioning a technology at a given stage of the innovation process. Advancing to more advanced stages is a key issue for attracting industry interest and partnership. For this reason, most technologies need to be at least validated in lab scale.

CNEN's commitment to developing R&D activities in nanotechnology in connection with the SDGs can be recognized due to the introduction of innovative technologies seeking to replace conventional ones in waste treatment and development and improvement of clean technologies with the intention of minimizing environmental impacts. However, these technologies are still isolated cases and do not comprise a cohesive set of institutional strategic actions aiming at structuring robust systems of solutions that meet the dictates of the SDGs in the pursuit of sustainability. In this sense, it is also clear that CNEN has a long way towards the development of green technologies and environmentally sustainable solutions due to their importance for the global and national economies, as well as to the SDGs, WIPO Green Inventory and WIPO Green database.

CNEN's patent portfolio of nanotechnologies has the potential to promote environmental benefits, social and economic returns for society and opportunities to create markets in the nuclear field. Appropriate public policies aiming at achieving sustainable paths of socioeconomic development should be previously regarded as an important step to expand and encourage environmentally sustainable R&D. It is also relevant that senior managers change their mindset to expand and encourage R&D initiatives for cleaner technologies, combined with the country's economic, environmental and technological strategy. A tactical method integrated into processes, products and services could be a path for turning the SDGs into practice to increase efficiency in the use of raw materials, water and energy and to develop improved materials in various industry sectors.

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Systems thinking and strategy in highly complex and dynamic environments: an initial system dynamics model

Abstract ID#133 | Full paper ID#409

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Abstract: In an ever rapidly changing environment, it is becoming more and more challenging for companies to defend their market shares. Disruptive technologies and legal provisions have the potential to threaten the business of entire industries. The ability to continuously create competitive advantages in even shorter cycles will be decisive for sustainable success in the future. This paper aims on initial testing and designing a System Dynamics (SD) model based on the findings of an Initial Conceptual Model

Keywords: strategy definition, strategy execution, systems thinking, system dynamics

Introduction

Due to disruptive technologies and changing legal requirements business risk increased significantly. Companies struggle with shorter product life cycles and a high dynamic and complex environment [1]. Currently, for example, the automotive industry faces one of its greatest disruptive threats: the digitalization and electrification of the powertrain [2] [3]. Thus, it will become more and more challenging being successful in markets and creating sustainable growth. Therefore, companies are forced to revise their strategy building and execution processes to be able to adapt to a rapidly changing market environment. Many scholars focused on identifying instruments which can deal with such challenges best. Gary, Kunc, Morecroft & Rockart [4] emphasized the high potential of SD modeling in decision making and strategy definition in dynamic contexts. Maani and Maharaj [5] and Thomson and Bank [6] illustrated that systems thinking, and SD modeling can improve complex decision making significantly. Schaveling and Bryan [7] explained that SD modeling can lead to better and robust decisions. Cosenz and Noto [8] concluded that SD modeling can consider complex and dynamic environments to enhance strategy processes. Furthermore, Gary and Wood [9] showed why some managers decisions are more successful than others using SD modeling leading to strategies with competitive success.

The next section highlights some underlying literature. This will be followed by introducing the research method. In addition, the paper focuses on the conceptual model and it's discussion. The objective in this paper is therefore designing and initial testing of a System Dynamics model aimed at strategy in a rapidly changing environment.

Theoretical Background

Strategy Definition

Companies can create competitive advantage as part of strategy definition from different sources, such as attractive positions in the market or from core competencies [10]. However, competitive advantages are not lasting forever and therefore it is important to continuously create competitive advantages in a highly dynamic market environment. Thus, it is of great importance to make robust decisions in a shorter period than the competitors. A powerful instrument in strategy definition that can fulfill these requirements is the OODA Loop [11]. It consists of the 4 steps:

- (O)bserve,
- (O)rientate,
- (D)ecide and
- (A)ct

To cope with highly dynamic environments, Bremer enhanced the OODA loop with dynamics and received the Dynamic OODA loop, the DOODA loop [12]. As a major enhancement, it links sense-making during the orientation phase to the strategic targets [13]. Weissenberger-Eibl, Almeida and Seus [14] pointed out, that it is important to use a system thinking approach that enables companies to adapt to dynamic environment, market, and business changes. They emphasized in this context the importance of differentiation in relation to the market efficiency. Therefore, they referred to the core competency model from Wildemann [10].

Strategy Implementation

Once having defined or crafted a strategy, the implementation is at least just as important as the definition [15]. To further optimize the implementation process, Srivastava and Sushil referred to a framework [16] [17] [18], existing of the four pillars align, automate, act, and adapt, to develop a model for factor alignment [19] based on a broad literature review. As a result, they identified seven major factors:

- AL1 Business Units
- AL2 Resource commitment
- AL3 Policies
- AL4 Operations
- AL5 Structure
- AL6 Best practices
- AL7 Community orientation

To identify the interdependencies and the importance of these factors, they conducted three surveys within the Indian infrastructure industry aiming at significantly enhancing the strategy implementation process in highly dynamic markets.

Table 1 Reachability matrix and level partitioning of the factors [19]

	AL1	AL2	AL3	AL4	AL5	AL6	AL7	Reachability	Antecedence	Intersection	Level
AL1	1	0	0	1	0	1	1*	1, 4, 6, 7	1, 2, 3, 5	1	3
AL2	1	1	1	1	0	1	1	1, 2, 3, 4, 6, 7	2, 3, 5	2, 3	4
AL3	1	1	1	1	0	1	1	1, 2, 3, 4, 6, 7	2, 3, 5	2, 3	4
AL4	0	0	0	1	0	0	0	4	1, 2, 3, 4, 5, 6, 7	4	1
AL5	1	1	1	1	1	1*	1	1, 2, 3, 4, 5, 6, 7	5	5	5
AL6	0	0	0	1	0	1	1	4, 6, 7	1, 2, 3, 5, 6, 7	6, 7	2
AL7	0	0	0	1	0	1	1	4, 6, 7	1, 2, 3, 5, 6, 7	6, 7	2

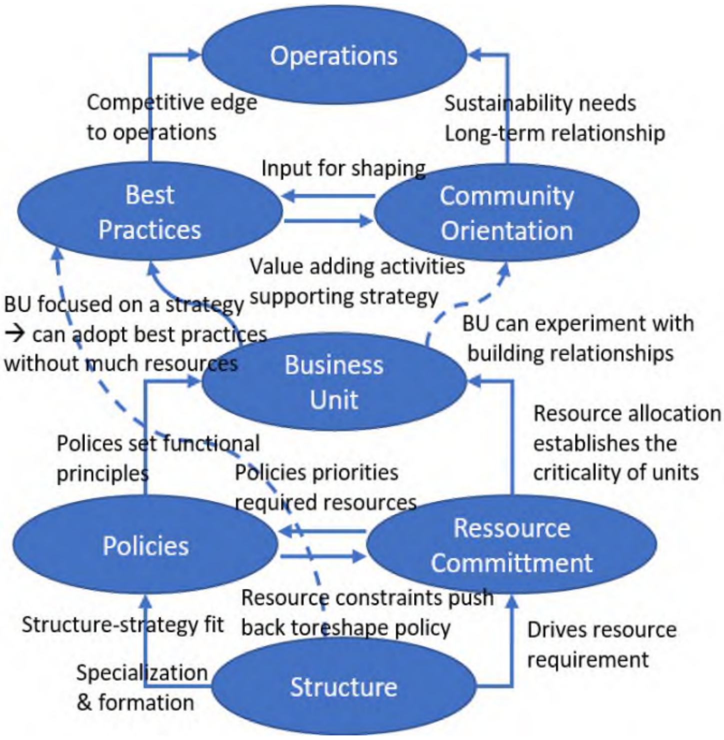

Figure 1 Model for factor alignment [19]

Besides Factor alignment, organizational alignment plays an important role. Using the Competing Value Model (CVM) Quiros [20] derived her model of organizational alignment focusing on the dominating cultural and structural alternatives of the CVM represented in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

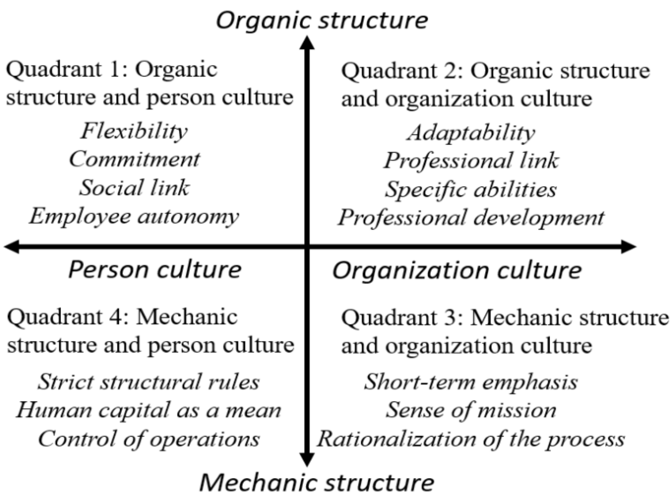

Figure 2 Organizational Alignment Model [20]

Decision Making

One of the critical steps in the OODA Loop is decision making. Frequently the OODA Loop gets stuck when decision makers feel uncomfortable with uncertainty and highly dynamic not predictable market environments. To overcome this obstacle, decision makers must be able to measure or benchmark the uncertainty, control what is manageable and minimize the part which is not. If not, there is a high risk to end up with a poor decision and to lose the competitive advantage in the mid or long run [21]. Therefore, it is essential to make decisions more effective and more reliable [22]. However, many scholars researched on making decisions under deep uncertainty, such as for climate change researches. Over time they developed several valid instruments, such as Robust Decision Making (RDM) or Dynamic Adaptive Policy Pathways (DAPP), seen in Fig. 3, to evaluate such effects aiming at making decisions more robust [23]. Compared to RDM, DAPP offers more robustness resulting in more potential scenarios [24].

Figure 3 Dynamic Adaptive Policy Pathways Approach [25]

DAPP, as shown in Fig. 3, delivers prognoses of weaknesses and offers possible actions to mitigate the risks. Therefore, it identifies Adaption Tipping Points (ATP), which are the points from where the system will fail, and you cannot do anything to change it anymore [26]. Further, it creates scenarios to highlight challenges and opportunities, which are further illustrated in a pathways map. This map guides decision makers in rating and evaluating pathways, whether they are cul-de-sacs or if they still provide opportunities even when a tipping point is reached. [25]

Summary

With the models and instruments described in the sections above, we have obtained powerful tools which enable organizations to adapt to changes in highly dynamic environments. Besides others, culture is one key element and plays a critical role in the entire strategy process. During strategy definition, culture significantly influences the orientation and the decision phases of the OODA loop. It strongly influences decision making based on individual cultural traditions and beliefs. In the long run, intensified training in decision making can help to reduce the risk to take bad decisions associated with different cultures [27]. Moreover, implementing a strategy means always implementing change, which fosters fear and uncertainty within the involved people. For a successful strategy implementation, it is important to consider the induvial culture of the involved parts [28]. According to Schein [29] there are three dimensions of culture:

- Artifacts, which are the visible things, such as the process, structures, technologies, languages and so on.

- Espoused Beliefs and Values, which represent things, that cannot be seen at first sight, such as the strategy, targets and convictions.
- Underlying Assumptions, which are beliefs, which are not questioned and taken for granted.

The next section gives a short overview of the underlying research methodology used in this paper.

Methodological Procedures

As a part of wider research regarding strategy definition and execution and suggested by Martinez-Moyano and Richardson [30], this paper also relies on a modified version of Forrester's six stages approach for SD modeling. Former studies conducted by the authors of this paper [31] [32] focused on the first two stages of the suggested approach of Martinez- Moyano and Richardson: "problem identification and definition", and "system conceptualization". As a result, we obtained two initial conceptual models. In a next step, this paper now focuses on the "Model formulation" including the structure, the variables, and the interdependencies and a first "Model testing". To achieve a first calibration, this first "Model testing" relies on action researches of previous cases by the authors, as well as on some initial integrated literature information as explained in section 2. Thus, the model explained and the results illustrated in section 4 of this research are conceptual. The final model results und testing will be part of future research and will refer to a detailed representative data set consisting of onsite semi-structured interviews with selected employees and managers of different levels of the German automotive industry. The research design of this future research will follow the suggested research design by Cooper and Schindler [33] for an exploratory multiple-case study.

The next section focuses on the formulation of the initial conceptual model focusing on strategy definition and implementation obtained in former research.

Results

Considering the findings of the literature review for strategy definition or designing led in former research [31] to the first causal feedback loop diagram, illustrated in Fig. 4. All the model formulations and simulation results presented in this section are obtained using Vensim software [https://vensim.com/].

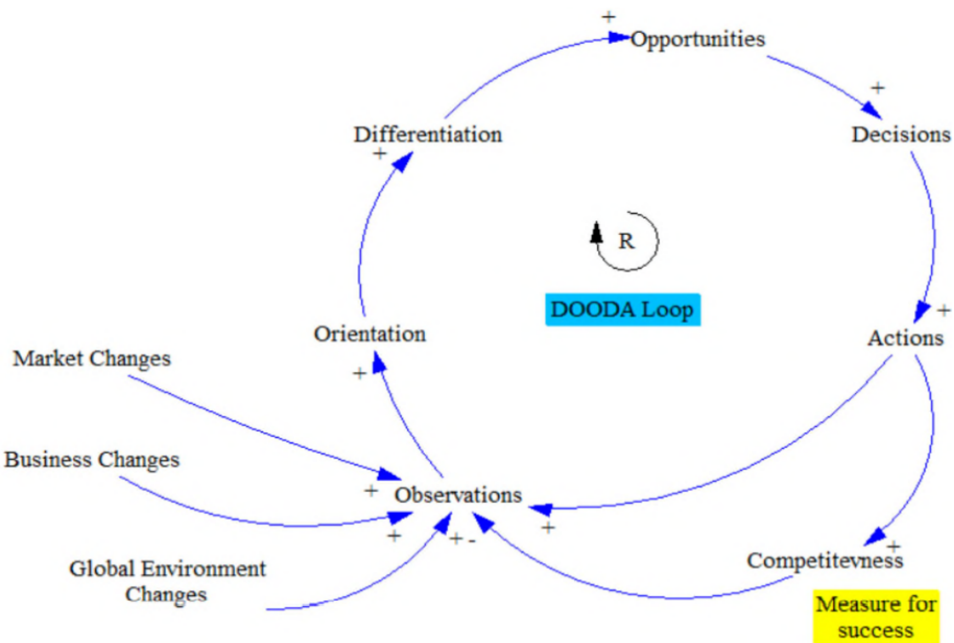

Figure 4 Enhanced DOODA Feedback Loop [31] adapted from Bremer and Weissenberger-Eibl et al.

According to Sterman [34], in this figure positive and negative causal relationships are shown as arrows and their polarity (+/-). Furthermore, the arrow in the middle indicates if it is balancing or reinforcing and if the loops direction heads clockwise or counterclockwise. The formulated underlying dynamic hypothesis of Fig. 4 was, “the faster organizations can adapt to changing market conditions in a structured manner, the more sustainable their success will be”. Following Weissenberger-Eibl, Almeida and Seus, the level of differentiation determines the success of a company with respect to a underlying market demand [14]. Given the causal loop diagram in Fig. 4 results in the initial stock and flow diagram (SFD) for strategy definition in Fig. 5 as developed in the research for this paper.

Table 2 Key model equations for strategy definition illustrated in Figure 5

Formulations and Comments	**Units**
Core Competencies = Integ (New Competency Rate-Competencies Decay) The stock of Core Competencies holds the number of available core competencies. This determines the overall capacity of a company to create competitive advantages. It increases and decreases by the ability to develop new core competencies minus the decay rate over time. Building up new core competencies has a negative impact on the available budget.	Dimensionless
Competitiveness = Integ ((Actions*x-Observations)/Decay of Competitive Advantage) Competitiveness represents the stock of competitive advantage, which enables companies to increase their available budget. It increases with the amount of successful implemented actions with respect to the time necessary to implement. Obviously not all actions will increase the competitiveness, which is reflected by the factor x. However, in reality competitors will keep up and competitiveness will erode over time.	Dimensionless

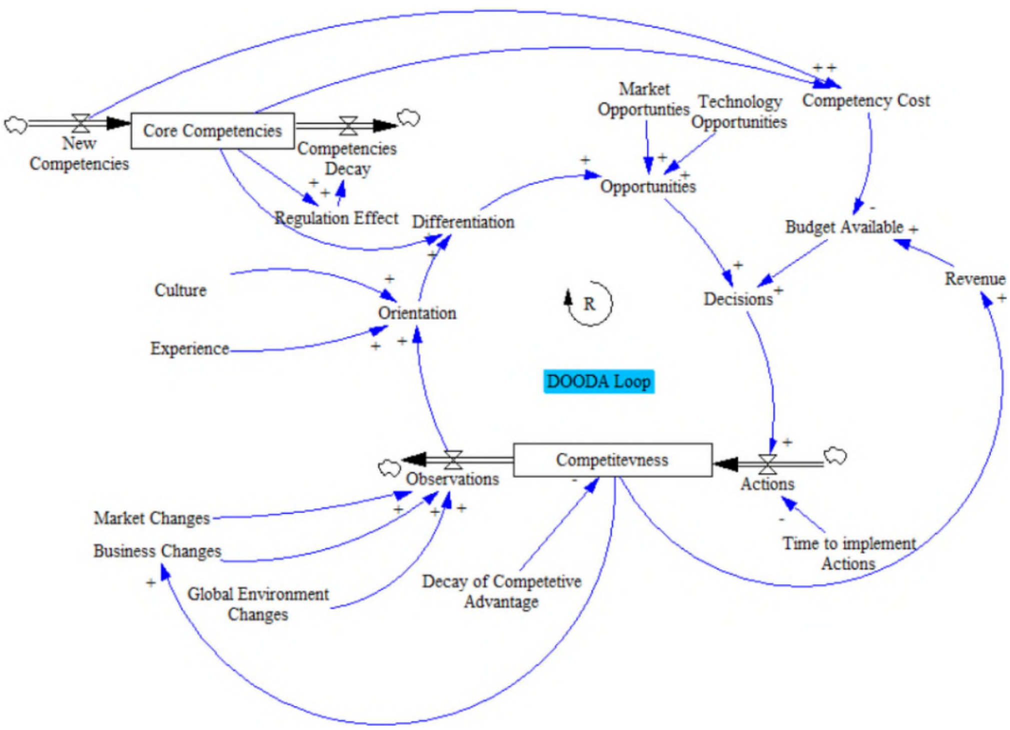

Figure 5 Initial Enhanced DOODA loop stock and flow diagram

The rectangles in Fig. 5 represent stocks. As stated by Sterman [34], every stock cumulates the differences of its inflow rates and its outflow rates, starting from a defined initial level, as indicated in equation (1). Some other equations developed and used in the model of Fig. 5 are shown in Table 2.

$$A(t) = A(0) + \int_0^t B(s)ds \quad (1)$$

where,

A(0) = initial stock level
B(s) = stock
t = time (1,..,n)

During SFD formulations, there are some obstacles that needed to be reflected on to obtain a fully operational model. Senge [35], for instance, highlighted some challenges and possible fixes, such as:

- Fixes that fail, which means that a short-term solution for a problem will reappear in the mid- or long term, but with much higher negative intensity. A good approach to mitigate this problem, is increasing the input rate / flow of the fix, which prevents the stock falling below zero before the inflow rate of the problem stock will exceed the outflow rate [36].
- Shifting the burden, which means that a short-term solution reducing a problem immediately, initiates a side effect leading the short-term solution to ineffectiveness. The problem can be reduced by adding another positive feedback loop to the model, as the symptom of the problem is dynamic [36].
- Drifting goals, which describes a model architecture, which is resulting over time in weaker and weaker performance. To mitigate this problem, either the goal could be lowered, or another corrective delayed feedback loop can be added [37].
- Limits to success, which means describes a situation, in which initially leads to a increasing performance. At some stage, it hits its limit, and the performance will decrease or in the worst case totally decline. To mitigate this problem, it is important to identify the limiting factors in order to eliminate them [37].

To initiate a first test of the SFD, some assumptions in the model were defined as part of setting up the relations and or dynamic hypotheses represented in Fig. 5. As indicated in section 3, these assumptions in this initial test and variable formulation are based on the evidence received from literature in section 2, as well as on practical experience in an action research setting of the authors:

Competitive Advantage does not last forever and erodes over time. It needs continuous technical improvements to keep the same level to not loose market share [38]. Usually, there exist a period of competitive advantage [39]. Therefore, we assume in this model a period of competitive advantage of 12 months until erosion begins. This means, that new core competencies must be developed [10], as over time, they turn into basis competencies. Nevertheless, this leads to additional costs, which reduce the available budget. Further, improving the own competitive position will lead to further actions and reactions of the competitors [40]. This means, the higher the competitiveness will be, the more observations from the business side will occur. Additionally, we implemented an adjustment factor if the core competencies exceed a pre-defined level to reflect on, that too many core competencies may increase the risk to lose focus and future performance. The considered test time simulated in the research for this paper is 60 periods or months. An initial dimensionless stock level of 100 for competitiveness is also assumed for these initial SD simulations.

The first initial results, illustrated in Fig. 6, support the underlying dynamic hypothesis of the causal loop diagram of the DOODA loop in Fig. 4. Thus, Fig. 6 shows the development of competitiveness in order to the implementation time of the defined decisions. The longer the implementation persist the lower the level of competitiveness is. To further validate these first results, additional sources of data are needed to create a representative data set.

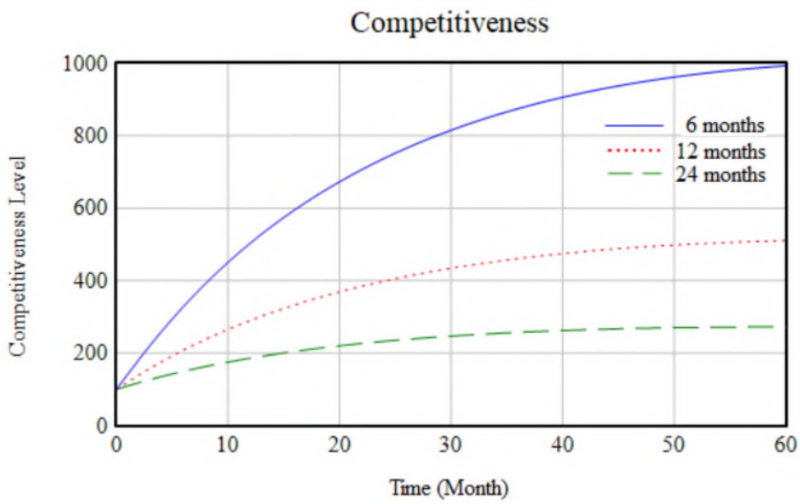

Figure 6 Dependencies of implementation time and competitiveness

The second part of the literature review aimed at strategy implementation and resulted in the second causal feedback loop diagram, shown in Fig. 7. Based on the results of factor alignment and organizational alignment, discussed in section 2 of this paper, and the first results of the SFD for strategy definition, the feedback loop for implementation aims at implementing a new strategy as soon as possible. Thus, as the key to steer the implementation process most efficiently, all actions are gathered in an agile backlog. A frequently meeting steering group decides the next steps with respect to the overall implementation progress. Based on the results of Srivastava and Sushil [19], the factor operations influence the implementation most significantly as long as enough resources are available, and the structure is aligned.

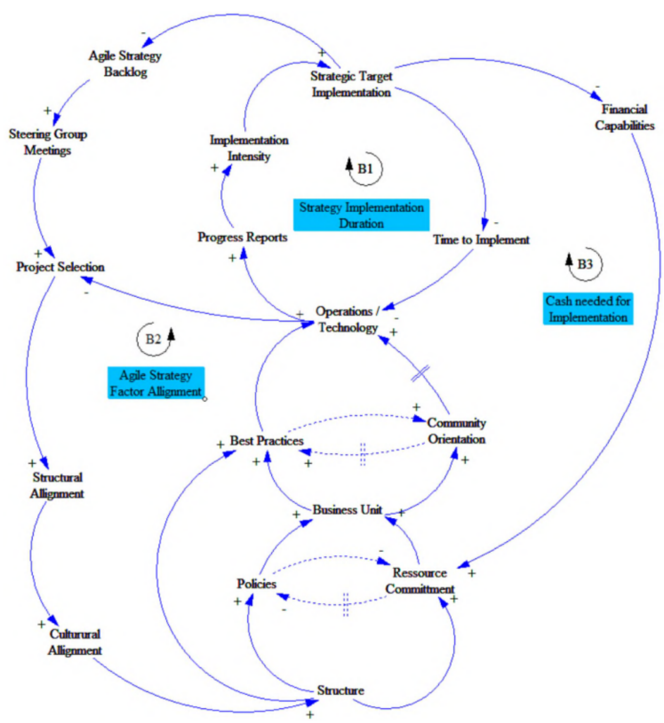

Figure 7 Enhanced Strategy Implementation Feedback Loop [31] adapted from Srivastava and Sushil, Quiros, Nicholas and Steyn [41]

Table 3 Key model equations for strategy implementation illustrated in Figure 8

Formulations and Comments	**Units**
Agile Strategy Backlog = Integ (Actions Input-Backlog Decay) The stock of Agile Strategy Backlog consists of the actions defined in the strategy definition process. It increases by the number of new defined actions and decreases by the ability and speed of the company to implement them.	Dimensionless
Financial Capabilities = Integ(Cash in-Cash Out) Financial Capabilities is the balance of Cash in and Cash out. It increases with the amount of new strategic targets implemented and decreases with money spend on structural alignment, as well as the budget needed for the resources to implement the targets. It is assumed to have a initial positive balance.	EUR
Structure = Integ (IF THEN ELSE(Agile Strategy Backlog<0, Structure, IF THEN ELSE(Structure>0, Structure Adjustment-Structure Decay, Structure Adjustment))) The stock of Structure reflects on the adjusted and dynamic structure that is mandatory to create competitive advantage. It increases with the potential alignment and adjustment of the existing structure and decreases over time.	Dimensionless

Given the findings from Srivastava and Sushil, as well as from Quiros leads to the first SFD for strategy implementation, shown in Fig. 8 and developed as part of the research for this paper. Some equations developed and used in the enhanced SFD model of Fig. 8 are again shown in Table 3.

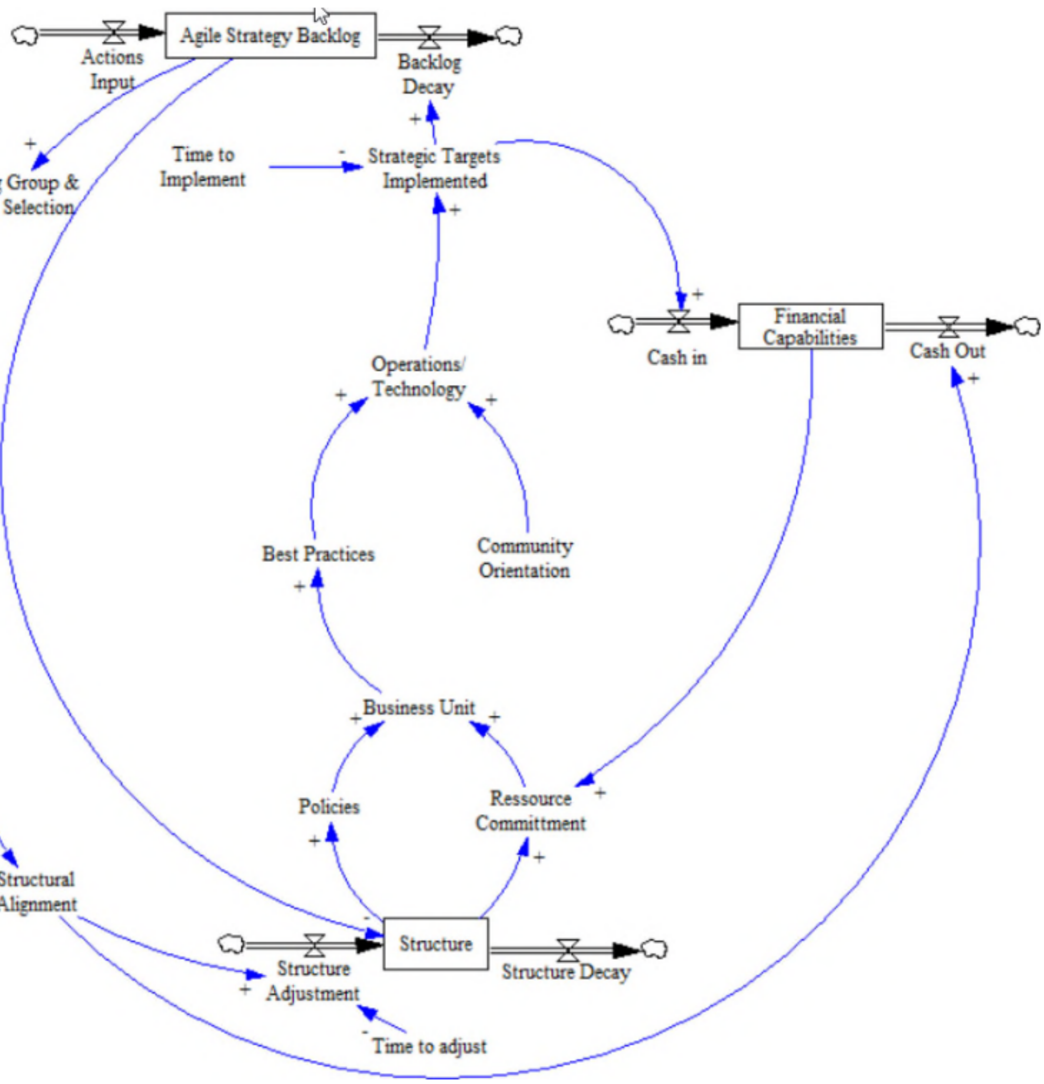

Figure 8 Initial Enhanced Strategy Implementation stock and flow diagram

For a first initial simulation test run of the SFD in Fig. 8, the following assumptions as part of the dynamic hypotheses were made for illustration purposes:

Actions are reflected as an external pulse, that inputs two new actions per period. Further, the agile strategy backlog should not be less than zero. If zero is reached, no further implementation actions are necessary unless new tasks are added. This influences structure as well, as the implementation structure is available for other business needs. The test duration simulated for the research results in this paper is again 60 periods/months.

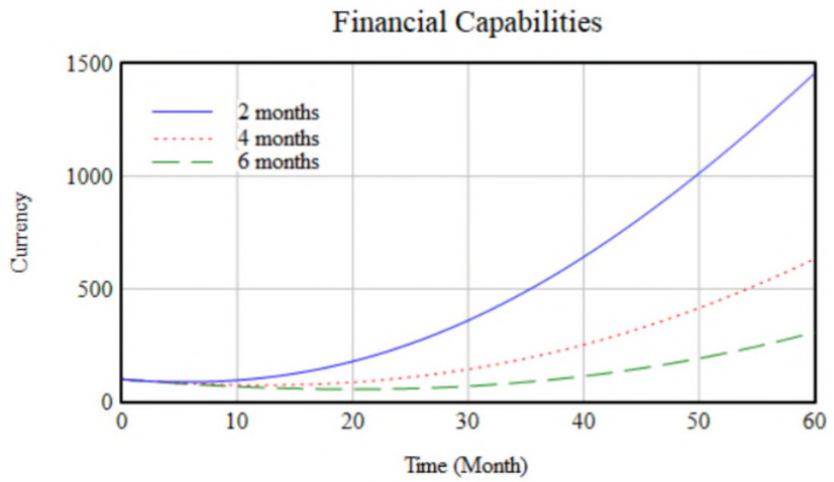

Figure 9 Dependencies of time and financial capabilities

As a first finding from SD simulation results in Figure 9, we can indicate that the development of the financial capabilities is highly dependent on the duration of the implementation. The longer the implementation lasts the less money is available. Therefore, a high alignment of the involved factors that decreases the duration of the strategy organizational implementation process is needed as this benefit the availability of financial resources.

Discussion and Conclusions

This paper focused on the research aim of an initial model formulation regarding strategy definition and strategy implementation based on initial conceptual models developed in former research by the authors. It aimed at gathering first insights and in-depth information about the behavior and dependencies of the involved SD model variables. As a result, we obtained two SFD models - one with two stocks for the strategy definition and one with three stocks for the strategy implementation. For each variable or stock of the model we formulated equations, capturing the dynamics of strategy processes in a highly dynamic and complex environments. It underlined the criticality of the duration of the two processes. On the one side, the faster strategies can be adapted to market, business or environment changes the more competitive an organization is. However, in practice often the definition process gets stuck in environments with deep uncertainty [21], as managers feel uncomfortable to decide. On the other side, once the strategy is adapted, crafted, or designed, it is important to implement it as fast as possible. If not, there is a high risk that resources are tied up for a too long period and the organization is still heading towards the old targets.

However, although this paper led to important results about the dynamic behavior of strategy processes, it didn't reflect on all objectives of the development of an SD model. For instance, it focused only on the third part of the modified version of Forrester's six stages approach proposed by Martinez-Moyano and Richardson [30]. Moreover, the first or preliminary tests presented in this paper are not based on a detailed representative data set, as well as it separated the strategy process into two independent models - strategy definition and strategy implementation. It reflects a first initial model and results based on the practical experience as action research of the authors as well as of evidence integrated from literature. Future research therefore needs to further address the topics which were not covered by this paper, to obtain a fully operational SD model, calibrate and validate it based on a qualitative data as suggested by Luna-Reyes and Andersen [42]. Therefore, it will include a full dataset through additional empirical research obtained in a real world study. Furthermore, the two separated SFD models should be merged into one SFD model, to obtain one fully capable model. As highlighted earlier, decision making under deep uncertainty may be addressed as well, as it is critical for the success and robustness within the strategy definition process. Nevertheless, the authors are part of such future research in order to reflect on these limitations.

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Designing a Systematic Technology Application Selection Process to Unlock the Potential of Technologies

Abstract ID#136 | Full paper ID#389

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Abstract: The competitiveness of technology-oriented companies depends on their ability to identify opportunities from technological developments and turn them into innovations. Particularly young university spin-offs or technology-based startups built upon an existing technology waiting for its commercialization in the market. But also, for technology-based companies, it is becoming increasingly crucial to identify innovative applications for new or existing technologies. Since future success depends on the recognition and coordination of opportunities of such, technology-push innovations become essential. Still, oftentimes technologies remain unexploited and their potential unused, which is also caused by the fuzzy front end, involving the technology application selection (TAS). However, although several TAS approaches exist, they lack consistency and scientific evaluation. Within a design science research (DSR) project, a systematic TAS process was iteratively developed. Since the evaluation is essential, the focus of this paper lies in the evaluation of the second design cycle of the systematic TAS process. Using the FEDS framework, an evaluation strategy was developed for five workshops (N=75), with the data collection carried out by a survey in form of a questionnaire, analyzed with SPSS and the Gioia method. At the end of the evaluation, the potential for improvement of the artefact is identified, to be integrated into the subsequent design cycle.
Keywords: Technology-Push Innovation; Technology Application Selection Process; Design Science Research; Evaluation Strategy; FEDS; Survey

Introduction

Innovations have a tremendous impact on economic growth (Broughel & Thierer, 2019) and can be defined as the basis of economic change and prosperity (Schumpeter, 1939). The ever-shorter life cycles of product offerings and periods in which innovations emerge confirm that Schumpeter's observation is not only still relevant but also manifests itself to an evergreater extent (Weiber et al., 2006). Therefore, it is increasingly crucial for technology-based companies to identify innovative applications for new or existing technologies and bring them successfully into the market (Danneels & Frattini, 2018). Moreover, young university spin-offs or technology-based startups built upon an existing technology waiting for its commercialization in the market (Kivimaa et al., 2017). Thus, following the Technology Push (TP) innovation strategy, high levels of uncertainty, unknowable factors, and uncontrollability come into play, as usually, potential applications for the underlying technology are unknown (Kostoff & Schaller, 2001). Consequently, many technologies remain unexploited and numerous research results e.g., in the form of patents, remain untouched (Manthey et al., 2022).

While studies already focus on innovation processes in companies (e.g. Cooper et al., 2002; Florén & Frishammer, 2012) or the emergence of new companies (e.g. Vohora et al., 2004; Rasmussen, 2011), these studies do not provide guidelines or processes to identify potential applications for new or emerging technologies, which represents a crucial step in the TP innovation process. Research shows that the decisions in the early phase of the front-end innovation, particularly during application identification and selection, determine the later success of companies (Koen et al., 2001; Markham, 2013). Still, many companies neglect to select the most promising idea for their technologies by not considering new markets, thereby wasting opportunities, growth, and potential profit (Danneels & Frattini, 2018).

In general, entrepreneurs nowadays have various methods and tools that serve as support in the start-up process of innovations such as business planning, valuation, or market analysis (Duening et al., 2021), but few focus on the technology application selection (TAS) phase in the process (Terzidis & Vogel, 2018; Manthey et al., 2022). While several approaches exist, e.g., the 'Technology-Push Lead User Concept' (Henkel & Jung, 2009) or the 'Advanced Technology Innovation Mapping Tool' (Felkl, 2013), they still lack consistency and scientific evaluation (Manthey et al., 2022).

Aiming to fill this gap, we explore the following research question: How to design a systematic TAS process to support the identification and selection of promising applications for new or emerging technologies? We address this research question by conducting a design science research (DSR) project and developing a systematic TAS process in a workshop setting at a university. DSR was chosen as a methodology, as it is used to develop new artefacts or optimize existing artefacts to increase and make use of the efficiency and effectiveness of groups or individuals in a customized and innovative way (Hevner et al. 2004). Since the evaluation of such an artefact is essential (Venable et al. 2016), as it represents an iteration step to ensure the rigour of a DSR process and ideally leads to a significantly improved version of the contemplated artefact (Hevner et al. 2004), the focus of this paper lies on the evaluation of the second design cycle of the systematic TAS process. Using the FEDS framework (Venable et al. 2016), an evaluation strategy for the artefact at hand was developed for five workshops (N=75), with the data collection carried out by a survey based on a questionnaire. At the end of the evaluation, the potential for improvement of the artefact is identified, to be integrated into the subsequent design cycle.

Theoretical Background (Foundations and related Work)

To address the before mentioned research gap, Manthey et al. (2022) proposed seven functional requirements to design a systematic TAS process (STAS), combining the current theoretical and practical findings in this field. Requirements are defined as "a property of an artefact that is deemed as desirable by stakeholders in a practice and that is to be used for guiding the design and development of the artefact. […], a requirement can concern the functions, structure, or environment of an artefact as well as the effects of using the artefact." (Johannesson & Perjons, 2014). As Manthey et al. (2022) proposed in their research only functional requirements, the DSR projects by Lau (2021) and Hatzijordanou (2019), specifically their proposed requirements, were taken as inspiration. In total, 16 functional, environmental, and effect requirements were derived for the design of the STAS artefact.

Based on the requirements of Manthey et al. (2022), Lau (2021) and Hatzijordanou (2019), the STAS Process was developed, to support the identification and evaluation of technology-based ideas to further develop the technology and form a basis for prototyping and product creation. For the development and evaluation of the STAS process, an iterative process of design, demonstration, and evaluation of the artefact is developed in several versions, until the requirements are fully met. Thereby, new insights from reflection and learning (Sein et al., 2011) of evaluation activities as well as the created (and if needed enhanced) knowledge base are used to develop the next version of the artefact.

The STAS process consists of three segments: Technology characterization; opportunity identification and application selection which are building upon specific building blocks (Manthey et al., 2022). The segments collectively comprise five phases, whereby each phase aims to achieve different goals. The goal of the first phase 'Understand' is to gain a fundamental and deep understanding of the underlying technology, which should be achieved through a technology characterization. The second phase 'Ideate' aims to explore potential applications for the underlying technology, with the support of different ideation anchors. Furthermore, by sorting the ideas, duplicates should be eliminated and clustered thematically. In the third phase 'Decide' the focus lies on the primary evaluation of the identified applications with the support of pre-defined evaluation criteria.

This is complemented by an evaluation with experts from different fields within the respective idea scope, to elaborate on the most promising idea in detail at the end of this phase. The purpose of the fourth phase 'Define' is to understand customers and their needs with the support of different methods. Finally, critical hypotheses need to be determined and scored out of quantified risks and impacts to test and compare the critical assumptions aligning with the development of the idea. The last phase 'Sharpen' intends to identify competitors and to compare the developed idea based on relevant dimensions with those. Subsequently, the value proposition, a customer value created by products or services (Clark et al., 2012), is to be determined and defined. Consequently, the outcome of the STAS process is a validated value proposition based on technology.

For the second design cycle evaluation, the STAS process is applied in a workshop environment in form of a seminar, which consists of several sessions in the timeframe of five months, to enable further work between the sessions. The seminar offers participants the opportunity to gain experience as an entrepreneur by going through a startup process from the development of an idea to the business pitch accompanied among others by the STAS process. Following an action-based approach (Rasmussen & Sørheim, 2006), the workshops consist of input phases and group work phases. Providing theoretical input first, the group work phase is designed to elaborate on the input. The application takes place in the online platform MURAL, a digital whiteboard, enabling the simultaneous usage of digital canvases in groups. In between the workshop days, the participants have consultation hours with mentors with entrepreneurial experience introduced to them, to reflect upon their progress and ask questions. Additionally, they receive homework that must be done until the next workshop day.

Methodological Procedures

DSR was originally used for the development of information systems to assist in emerging knowledge processes (vom Brocke et al., 2020). The target of DSR is to develop new artefacts or optimize existing artefacts to increase and make use of the efficiency and effectiveness of groups or individuals in a customized and innovative way (Baskerville et al., 2018). Meanwhile, DSR is also an established approach in entrepreneurship to implement practical knowledge with scientific precision.

Seckler et al. (2022) metaphorically describe design science as a bridge that connects basic science to practice in entrepreneurship. The DSR approach is used as a guideline for developing a usable artefact in the form of a construct, model, method, or instantiation that supports the innovation process (Hevner et al., 2004). The STAS Process can be defined as a method, as it is expressing "prescriptive knowledge by defining guidelines and processes for how to solve problems and achieve goals" (Johannesson & Perjons, 2021, p. 31). Peffers et al. (2007) highlight six steps to developing a usable DSR artefact: Problem identification, the definition of the objectives for a solution, design and development, demonstration, evaluation, and communication of research.

Evaluation of the artefact is crucial in a DSR approach (Hevner et al., 2004), as it is necessary to verify the utility, quality, and effectiveness and thus the fulfilment of the artefact's stated requirements. In addition to a better understanding of the artefact, evaluation provides feedback through which both the quality of the artefact and the design process can be improved. Evaluation thus justifies the artefact by demonstrating the added value that the artefact contributes (Hevner et al., 2004).

To evaluate the STAS process, an evaluation strategy was developed based on the existing FEDS framework by Venable et al. (2016), applying the Human Risk & Effectiveness approach as the basic strategy, as it has a strong formative and naturalistic character while being well feasible to evaluate with real users in their real context. In several design cycles, field experiments were conducted as an essential method for evaluating the artefact. The artefact was tested in workshops with participants of various backgrounds to identify applications for new or emerging technologies. Field experiments have high internal and external validity, but also present difficulties associated with manipulating treatments and controlling for extraneous effects in a field setting (Bhattacherjee, 2012). A standardized questionnaire supplemented the field experiments to uncover these manipulations and extraneous effects and filter them out to evaluate the artefact itself. It is structured in different instrument scales, which are in total ten different scales, covering 77 items. The first nine scales capture the user's impressions through a five-point Likert scale. The last scale comprises four open-text questions. However, within the content of this paper, the focus lies on scales 8 and 10, as they are focusing on the evaluation of the requirements and enable potential feedback for improvement by the open questions. As Lau (2021) and Hatzijordanou (2019) developed questionnaires for evaluating concrete DSR artefacts in a workshop environment, their approach was adapted towards the set requirements and further developed.

To evaluate the second design cycle of the STAS process, the questionnaire was created digitally and sent out to the participants of six similarly designed workshops. Of 90 participants 75 filled out the questionnaire, which corresponds to a completion rate of about 83,33 %. The statistical analysis of the data collected is executed in SPSS, while scale 10 will be considered in the qualitative analysis by applying the Gioia-Method (2013), as it consists of free open-text fields.

Results

The artefact is applied in a total of six workshops, each lasting several days. They were conducted in the context of three different seminar programs. In line with the formative nature of the evaluation design, the questionnaire aims to validate the STAS process against the defined requirements and, if possible, to identify potential points for improvement that can increase the degree to which the requirements are met. The scales 1 to 7 and scale 9 of the questionnaire evaluate the artefact's application environment without explicitly assessing the fulfilment of the requirements. They thus evaluate under which conditions the artefact itself is evaluated. Scale 8 is then used to validate the framework itself against the list of requirements, verifying whether and, if so, to what extent the framework meets the previously defined requirements. Further, the qualitative data of scale 10 enables a deeper understanding of the respective issues.

Quantitative Analysis

The statistical analysis presented in this paper only refers to scale 8 and is analyzed using SPSS. The four open questions at the end of the questionnaire are qualitatively evaluated separately. The analysis is based on the three standard main criteria by Rammstedt (2004), objectivity, reliability, and validity to determine the quality of multi-item-scales.

Scale 8 is part of the survey questionnaire that explicitly asks about the STAS framework and its application in the workshop environment, and the items represent the requirements of the STAS framework. By evaluating the items, conclusions can be drawn as to whether the requirements are fulfilled. Table 1 shows the results of scale 8 "evaluation of the framework" with items 8.1 - 8.14. Cronbach's Alpha has a value of $\alpha8 = 0.917$ thereby indicating that the scale has a very high internal consistency or reliability. However, this can only be interpreted as an estimate.

#	Item	M_i	SD_i	α_{i_ex}
8.1	The framework itself is easy to use.	4,160	0,907	0,91
8.2	The framework itself is easy to understand.	4,000	0,876	0,911
8.3	The framework helped us to enhance our knowledge of markets.	4,000	1,034	0,91
8.4	The framework helped us to enhance our knowledge of technology.	3,960	0,971	0,913
8.5	The framework helped us to understand the underlying function of the technology and to connect this to potential markets.	3,970	1,02	0,909
8.6	The framework supported us to make use of and extend our human capital.	3,780	1,05	0,916
8.7	The framework guided how to explore multiple and alternative applications.	4,200	0,811	0,909
8.8	The framework enhanced us to consider potential customer and their needs.	4,240	0,857	0,911
8.9	The framework enabled us to do the ideation within limited resources.	4,040	0,818	0,914
8.10	The framework enabled us to evaluate our ideas.	4,260	0,812	0,915
8.11	The framework supported all our relevant purposes for the Systematic Technology Application Selection.	3,970	0,827	0,91
8.12	The framework contained all the necessary information to complete our Systematic Technology Application Selection.	3,930	0,849	0,905
8.13	The framework provided clear guidance on the process of Systematic Technology Application Selection.	3,970	0,86	0,909
8.14	Using the framework enhanced the effectiveness (quality of goal achievement) of our Systematic Technology Application Selection.	4,010	0,958	0,909
Scale 8: M_8 = 4.037, SD_8 = 0.629, Cronbach's Alpha α_8 = 0.917 Note: N = 75. Scale code: 1 (strongly disagree), 2, 3, 4, 5 (strongly agree). M_i item mean value, SD_i item standard deviation, α_{i_ex} Cronbach's Alpha if an item is excluded				

Table 1: Item analysis of Scale 8

Scale 8 shows the following characteristic values with a sample size of N = 75. The mean value is M8 = 4.037 with a standard deviation of SD8 = 0.629. The participants thus give a positive evaluation of the framework. They agree that the framework is easy to use and understand. The survey results also show that the framework helped the participants to enhance their knowledge of markets and technologies as well as understand the function of the technologies and connect them to potential markets. In general, the participants agree that it supported making use of and extending their human capital. For exploring and considering multiple and alternative applications throughout the process, the participants agree that the framework provided guidance. They claim that considering potential customers and their needs was enhanced through the framework. Also, ideation within limited resources was enabled and the generated ideas were evaluated. Regarding the STAS process, the participants agree that the framework supported all relevant purposes, contained all necessary information, provided clear guidance on the process, and enhanced effectiveness, therefore, the quality of the goal achievement.

With the statistical results, the items of scale 8 can be transformed back into the functional, environmental, and effect requirements to check whether the requirements for the artefact have been met. Table 2 shows the transformation of the items and whether they are fulfilled. The environmental requirement ER_7 (Customizability) relates to four different items. The presented mean value, and therefore the fulfilment, is made of the average of these four items. A requirement will be considered fulfilled if the mean value of the corresponding item exceeds M = 3.0. However, a distinction is still made between acceptable and in need of improvement. With mean values between M = 3.1 and M = 3.99, the fulfilment of the requirements should be improved further (shown in the table with ~). For values higher than M = 4.0, there is also still room for improvement in some cases, but they are already accepted as completely fulfilled (shown with + in the table).

		Mean	Fulfil ment	Related item
FR	**Functional Requirements**			
FR_1	Enhance users' knowledge of markets	4,000	+	8.3
FR_2	Enhance users' knowledge of technology	3,960	~	8.4
FR_3	Enable users to understand the underlying function of the technology to connect this to potential markets	3,970	~	8.5
FR_4	Support users to make use of and extend their human capital	3,780	~	8.6
FR_5	Guide how to explore multiple and alternative applications	4,200	+	8.7
FR_6	Enhance users to consider potential customer and their needs	4,240	+	8.8
FR_7	Enable users to do the ideation within limited resources	4,040	+	8.9
FR_8	Enable users to evaluate their ideas	4,260	+	8.10
ER	**Environmental Requirements**			
ER_1	Usability (Easy to use)	4,160	+	8.1
ER_2	Comprehensibility (Easy to learn/ comprehensible)	4,000	+	8.2
ER_3	Completeness	3,930	~	8.12
ER_4	With adequate complexity	4,040	+	8.9
ER_5	Efficiency	3,970	~	8.13
ER_6	Suitability	3,970	~	8.11
ER_7	Customizability	3.928	~	8.3, 8.4, 8.5, 8.6
EfR	**Effect Requirements**			
EfR_1	The advantage to the status quo	4,010	+	8.14
Note: Requirement is not fulfilled = -, requirement is fulfilled but should be improved further = ~, requirement is completely fulfilled = +				

Table 2: Verification of the fulfilment of the functional, environmental and effective requirements

Given the areas of requirement fulfilment defined above, all functional, environmental, and effect requirements are fulfilled. With further distinction, the functional requirements FR_2, FR_3 and FR_4 have a mean value slightly below the limit of M = 4.0 and should therefore be improved further. Regarding the environmental requirements ER_3, ER_5, Er_6 and ER_7, they should also be investigated further to increase the users' satisfaction. All the other requirements are already accepted as completely fulfilled however, there is still room for improvement,

Qualitative Results

Unlike the other scales, scale 10 consists of open-text questions. The four items ask about weaknesses, strengths, and suggestions for improvement, as well as other general comments about the framework and its application. The answers to these open-text questions are analyzed with the Gioia method (Gioia et al., 2013). However, it must be emphasized that this analysis by itself cannot be regarded as robust, since the 2nd-order categories partly only have one 1st-order category subordinated to them due to the small amount of data (Gioia et al., 2013). The interpretation objectivity including the category formation is given by the application of the four-eye principle and thus two interpreters (Himme, 2009). The qualitative data analysis of scale 10 results in 16 aggregated dimensions. In total, there are 29 2nd-order categories and 101 1st-order categories, of which some were mentioned more than once.

Many positive comments emphasize the clear structure of the STAS process, the segmentation into different phases, and the respective tasks in between. Furthermore, having a holistic approach including many practical parts is mentioned as a positive factor supporting identifying and developing ideas. Moreover, the personal interaction between the team, but also with external stakeholders is highlighted. Hence, scheduling and time management is acknowledged. On the application of the STAS process, comments about the interactive design are made, as practical thinking was required and the filling out of the framework required many practical parts where input and support were given.

The underlying technologies are stated several times as too complex and too technical, whereby the participants struggle to understand them properly to exploit potential applications. Furthermore, some mention that the technologies are limited in application and too inconvenient. Consequently, complaints about time management arise, as the unfamiliarity with technology takes away too much time.

Moreover, understanding the process is mentioned as difficult, as the difference between specific steps is unclear and the respective canvasses are too complex to understand. Hence, restrictions of the process are mentioned as a weakness, including repetitive tasks, limited freedom with the use of provided methodologies and missing guidance.

In addition, the digital collaboration tool MURAL is approved for the opportunity of great collaborations in teams butstated as not ideal. It is several times mentioned as a weakness. Avoiding the use of mural is stated as a suggestion for improvement.

Discussion

Summarizing the analysis of the survey, the main results of the quantitative and the qualitative analysis are presented. Scale 8 highlights a positive evaluation of the designed STAS process with a mean value of $M8 = 4.037$ and a standard deviation of $SD8 = 0.629$.

Furthermore, the analysis showed that the specified functional, environmental, and effect requirements are considered to be completely fulfilled. Still, the functional requirements FR_2, FR_3 and FR_4 and the environmental requirements ER_3, ER_5, Er_6 and ER_7 are slightly below the set mean of $M = 4.0$ and should therefore be improved.

The qualitative analysis concerned a scale of 10, which asked for direct feedback on the strengths, weaknesses, and suggestions for improvement of the STAS process and the seminar in general. Regarding the process, the interactive design, and the structure, which offered adequate guidance throughout the process, were positively highlighted. Hence, the underlying methods were perceived as very helpful and inspiring. However, some participants felt restricted by the framework or felt compelled to fill in things they did not consider necessary. Many comments have affected the selection of the underlying technology. Given the complexity of the technologies, critics mentioned the inconvenience of the technologies and missing application options. Furthermore, more time and technical support were needed to deal with the technology. Hence, the relevance and possibilities of the individual process steps were asked to be clear as well as providing supplementary explanations and examples to the process so that it can also be used independently.

Overall, the evaluation reflects the positive impact of the artefact and the workshop in general on users. The STAS process has served as a supporting guideline, bringing structure to the process, serving as common group documentation, and providing methodologies for TAS at each step of the process. The process not only contributed to an innovative result but also showed new approaches and promoted the user's personal development.

Consolidating these results, the overall goal of fulfilling the requirements was mostly met, while there is still room for improvement. Especially the functional requirements to enhance the user's knowledge of technology, to enable the users to understand the underlying functions of the technology to connect this to potential markets as well as supporting the users to make use of and extend their human capital need a further investigation and be refined. Moreover, the environmental requirements completeness, efficiency, suitability, and customizability need to be revised.

Conclusions

As a crucial part of an artefact's DSR process, this paper addressed the evaluation of the STAS process. The STAS process supports users in developing technological innovations by enabling an effective TAS process. For evaluating the artefact an evaluation strategy was chosen, following the FEDS framework of Venable et al. (2016). Functional, environmental and effect requirements were derived and used as evaluation criteria. Based on field experiments, accompanied by a survey questionnaire, the evaluation of the STAS process was carried out with 75 participants from six different workshops. The collected data was analyzed to check whether the requirement criteria were met. Based on the evaluation, suggestions for improvement were derived for the next iteration of the DSR evaluation. This evaluation represents a valid case study of how technology management tools can be developed and validated before they are used in practice.

Overall, the results of the evaluation indicate that exploiting the value of technologies based on the STAS process can engage users and guide them going through the specific steps of the process. Not only the process itself is important, but also its application in a practical context. Further, the requirements build on insights from theory and practice (Hatzijordanou, 2018; Lau, 2021; Manthey, 2022). The results revealed that even though the process already works very well, there is still a need for improvement of the STAS process, especially in the areas of technical knowledge and understanding, connecting the technology to markets, and making the users aware of the exploitation of human capital. Moreover, as the qualitative analysis revealed the need for more flexibility, more instructions, less redundancy, and the difficulty of timing, aligning with the need for improvement of the environmental requirements completeness, efficiency, suitability, and customizability, special attention should be also drawn to this part.

However, various limitations that may have an impact on the results of the evaluation must be considered. As the STAS process is solely applied in workshop settings at university and building upon given technologies by the university in form of patents, this needs to be considered when designing the next version of the artefact.

Hence, as the evaluation is based on a survey questionnaire in different field experiments, insights might be limited, as the participants cannot explain their rating or specify their wishes. Therefore, interviews with the participants, as well as with experts who are working with new and emerging technologies, should be considered for further evaluation.

In addition, the STAS process is tested in a startup simulation, so most of the participants were not pursuing starting a business based on the exploited technology. Thereby also a different kind of motivation may lead to different individual evaluations of the process.

These limitations also point the way for future research activities in the next cycle of the DSR project. The third design cycle based on the improvement suggestions should be conducted and further tested, by conducting a field study within the same setting. Also, in further research, specific experts for interviews could be identified, to explore the applicability of the STAS process in the real world. Additionally, workshops could be conducted with researchers and their developed patents, to foster them finding potential applications to establish a spin-off. Hence, further testing should be expanded to the industry, as real hard technology choices are made continuously there.

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