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Technology Management

The use of dynamic capabilities to boost innovation in a Brazilian Chemical Company

*A utilização das capacidades dinâmicas para impulsionar a inovação em uma Empresa Química Brasileira**La utilización de las capacidades dinámicas para impulsar la innovación en una empresa química brasileña*Cristiane Froehlich^{a,*}, Claudia Cristina Bitencourt^b, Marília Bonzanini Bossle^b^a Universidade Feevale, Novo Hamburgo, RS, Brazil^b Universidade do Vale do Rio dos Sinos, São Leopoldo, RS, Brazil

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Abstract

Dynamic capabilities seek to explain how competitive advantages can be built in rapidly changing environments. This study aims to assess how the application of dynamic capabilities can contribute to the expansion of innovation capabilities. Data was collected on ten semi-structured interviews with executives from a chemical company, and analyzed using qualitative content analysis. Results indicate that the application of dynamic capabilities contributes to the development of innovation capabilities through the consolidation of the first dynamic capability (sensing), which fosters innovation. Sensing can be considered an organizational capability, resulting from the integration between organizational strategies and the innovation practices of the organization as a whole. This study brings the following contributions: the need to include a new microfoundation in the sensing capability, which in this study is called 'processes to manage innovation on a strategic level' and the need to adapt another microfoundation related to the sensing capability, called 'processes oriented toward collaboration with suppliers to complement and stimulate innovations within the company'. It is suggested that these processes should be reassessed in terms of their potential to generate and complement organizational innovation.

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Keywords: Innovation capability; Dynamic capabilities; Microfoundations

Resumo

As capacidades dinâmicas procuram explicar como vantagens competitivas podem ser construídas em ambientes que mudam rapidamente. Neste estudo tem-se como objetivo analisar como a aplicação dos microfundamentos das capacidades dinâmicas pode contribuir para a expansão da capacidade de inovação. Os dados foram coletados por meio de dez entrevistas semiestruturadas com executivos de uma empresa química, e analisados por meio da análise de conteúdo qualitativa. Os resultados indicam que a aplicação dos microfundamentos das capacidades dinâmicas contribui para o desenvolvimento da capacidade de inovação, através da consolidação da primeira capacidade dinâmica (sensing), que estimula a inovação. Sensing pode ser considerada uma capacidade organizacional, resultante da integração entre as estratégias organizacionais e as práticas de inovação da organização. Além disso, este estudo traz as seguintes contribuições: a necessidade de incluir um novo microfundamento na

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capacidade de sensing, que neste estudo é chamado de “processos para gerenciar a inovação em um nível estratégico” e a necessidade de adaptar outro microfundamento relacionado com a capacidade sensing, chamado de “processos orientados para a colaboração com os fornecedores para complementar e estimular inovações dentro da empresa”. Sugere-se que estes processos devem ser reavaliados em termos de seu potencial de gerar e complementar a inovação organizacional.

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Resumen

Las capacidades dinámicas tratan de explicar cómo ventajas competitivas pueden ser construidas en entornos que cambian rápidamente. En este estudio se analiza cómo la aplicación de los microfundamentos de las capacidades dinámicas puede contribuir a la expansión de la capacidad de innovación. Se han recogido los datos por medio de diez entrevistas semiestructuradas con ejecutivos de una empresa química, y se les ha aplicado el análisis de contenido cualitativo. Los resultados indican que la aplicación de los microfundamentos de las capacidades dinámicas contribuye al desarrollo de la capacidad de innovación por medio de la consolidación de la primera capacidad dinámica (detección), que fomenta la innovación. La detección puede ser considerada como una capacidad organizacional que resulta de la integración entre las estrategias de organización y las prácticas de innovación de la organización. Se aportan, además, las siguientes contribuciones: la necesidad de incluir un nuevo microfundamento en la capacidad de detección, que en este estudio se llama “procesos para la gestión de la innovación en un nivel estratégico”; y la necesidad de adaptar otro microfundamento relacionado con la capacidad de detección, que se traduce en “procesos dirigidos a la colaboración con los proveedores para complementar y estimular la innovación dentro de la empresa”. Se sugiere que estos procesos deben ser reevaluados en términos de su potencial para generar y complementar la innovación organizacional.

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Palavras-chave: Capacidade de inovação; Capacidades dinâmicas; Microfundamentos

Palabras clave: Capacidad de innovación; Capacidades dinámicas; Microfundamentos

Introduction

Dynamic capabilities seek to explain how competitive advantages can be achieved in rapidly changing environments. They include the capacity to: (1) sense and shape opportunities and threats; (2) seize opportunities; and (3) preserve an enterprise's competitiveness by means of improvements, combinations, protection and, when required, reconfigurations of an enterprise's tangible and intangible assets (Day & Schoemaker, 2016; Teece & Leih, 2016; Teece, Pisano, & Shuen, 1997; Teece, Peteraf, & Leih, 2016; Teece, 2007).

This approach may explain why some companies manage to identify and incorporate opportunities from the external environment into their routines and processes, by managing and assembling resources to obtain positive results while other companies are unable to develop such capabilities (Ambrosini, Bowman, & Collier, 2009).

Since dynamic capabilities include those capabilities required to address consumer changes and technological opportunities (Teece, 2007), it can also support the understanding of innovation capability application, which is one of the focus of this study – understanding the relationship between innovation, dynamic capabilities and innovation capability. Innovation capability facilitates the incorporation of knowledge and learning related to new products, services and processes. Innovation depends mostly on the way this process is conducted, i.e. it depends on the resources, routines and companies' management capability (Tidd, Bessant, & Pavitt, 2008). Thus, strong dynamic capabilities have an “orchestration dimension” that allows the organization to quickly idealize, test and implement new innovations (Teece & Leih, 2016).

Although research on dynamic capabilities is considered consistent in studies on strategic management, and are associated with organizational change, innovation and competitive advantage (Güttel, Konlechner, & Müller, 2011), the area is still under criticism since the concept is mostly theoretical and difficult to implement (Arend & Bromiley, 2009). In order to address this issue, Teece (2007) introduced the concept of microfoundations – distinct skills, processes, procedures, organizational structures, decision rules, and disciplines that will combine to allow the implementation of the dynamic capabilities of sensing, seizing and reconfiguring (Teece, 2007) – that represent an attempt to operationalize it through routines and processes.

Nevertheless, microfoundations' definition is still too broad and require further investigation on regard to its ability to explain and put on practice dynamic capabilities. Therefore, this paper seeks to investigate two gaps observed in the studies concerning dynamic capacities: (a) the relationship between dynamic capabilities, innovation and innovation capability; (b) the understanding and operationalization of microfoundations, which have not yet been sufficiently explained in the literature.

Briefly, this article seeks to understand the role of microfoundations in the consolidation of dynamic capacities to leverage innovation in a company in the Brazilian chemical industry. Although the relationship between innovation and dynamic capabilities has already been addressed in previous studies (Day & Schoemaker, 2016; Ellonen, Wikström, & Jantunen, 2009; Ellonen, Jantunen, & Kuivalainen, 2011; Katkalo, Pitelis, & Teece, 2010; Kindström, Kowalkowski, & Sandberg, 2012; Pasian, Sankaran, & Boydell, 2012; Teece & Leih, 2016; Teece et al., 2016), we believe that dynamic capacities contribute indirectly to this relationship that is mediated by the capacity for

innovation. In other words, the operationalization of dynamic capacities, through microfoundations, contributes to the consolidation of innovation capability and this, in turn, helps to leverage innovation in the investigated company as demonstrated in this paper.

This paper thus aims to answer the following research question: how can innovation be boosted by developing and applying dynamic capabilities according to the microfoundations sensing, seizing and transforming? This study also aims to analyze how the application of microfoundations of dynamic capacities can contribute to the expansion of innovation capability. The focus on microfoundations allows the researchers to verify the applicability of the concept in a detailed way, since one of the weaknesses of the approach of the dynamic capacities is the lack of definition of units of analysis. Kindström et al. (2012) emphasize that demonstrating microfoundations are fundamental for building dynamic capacities and that it significantly affects the success of innovation. This happens through the process variation that forms the basis of the development of dynamic capacities, according to Pasian et al. (2012).

To answer the proposed question, we have chosen to develop a case study in view of the need for furthering understanding microfoundations in a specific context. Having that in mind, a chemical company – Artecola – was selected, considering that the chemical sector is a dynamic area in which innovation is essential. This company is recognized as innovative due to: (a) its recognition for innovation in different fields; (b) innovation is part of the mission and organizational values of the company; (c) its development of product and process patents; (d) the inclusion of innovation as part of the company's social reports, as well as the 30 innovation awards received in 2015. Innovation is an element that differentiates Artecola from other chemical enterprises.

The next section presents the theoretical framework on the contextualization of innovation and innovation capability, as well as the concept of dynamic capabilities and their respective microfoundations. Next, methodological procedures are listed. Section 'Results' provides an overview of Artecola and the analysis of the results of this research. Finally, the final considerations and the contributions of this study are presented.

Innovation and the innovation capability

Innovation is the search for, discovery, experimentation, development, imitation and adoption of new products, new production processes and new organizational configurations (Dosi, 1988). Innovation requires improvements and changes in the operation of complex technical and organizations systems, in a process of trial, error and learning (Tidd et al., 2008). Innovative companies are those that find the means to explore the latent potential of new ideas and combine factors in a more optimized way (Francis & Bessant, 2005).

The development of the capabilities required for innovation is the result of complex interactions between incentive structures, human resources, technological efforts and institutional factors (Lall, 1992). Companies and innovation processes can be considered path dependent, which means that companies

that were innovative in the past tend to innovate more in the present (Carrillo-Hermosilla, Del Río, & Könnölä, 2010; Horbach, 2008). Other authors (Pavitt, 2005), however, refer to the concept of path creation and minimize the role of trajectory in defining the new directions for a company, highlighting contingencies associated with the sector or the technological field. In that sense, according to Schumpeter's circular flow, economics tends toward equilibrium, and that equilibrium will not necessarily be the same point as before (Schumpeter, 2008).

In order to achieve successful innovations, companies need to combine different types of knowledge, capabilities, skills and resources, i.e. they need to develop the capability to detect and seize opportunities, not only targeting new markets but also by finding new ways to thrive in established and mature markets (Fagerberg, 2005; Knight, 1967; Schumpeter, 2008; Tidd et al., 2008). In a context of change and innovation, dynamic capabilities become an important concept to organize resources in a distinct way and increases agility to organizational processes by establishing routines and procedures that translate a company's strategies into specific actions that are accessible to all organizational levels.

Given that innovation is a result of company's specific characteristics, some authors such as Francis and Bessant (2005) classify different innovation types according to the internal capabilities required to achieve them. Innovation capability is, therefore, an ability to formulate and implement innovation strategies and it is associated with the capability to create, enlarge and modify resources employed for innovation in order to develop new products, services, processes and/or markets (Dodgson, Gann, & Salter, 2008). Innovation capability can also be understood as a type of organizational strategic capability. More specifically, it has to do with the alignment of innovation practices with organizational strategies, in order to generate value to the company, to its consumers and to other stakeholders. It usually takes place in a deliberate, systematic way and utilizes one or more models to develop radical or incremental innovation.

According to Tidd et al. (2008), innovation is a process rather than an isolated event. It must therefore be managed in a dynamic and systematic manner and not focus on specific areas only. In that sense, innovation capability should not be restricted to R&D. It should be part of the corporate culture and encompass the entire organizational environment (Tidd et al., 2008). For this to be achieved, these authors point out that innovation must be carried out in a structured manner, following routines that characterize each step in the progress of innovation (new products, services or processes). Thus, we highlight the importance of managing innovation as a dynamic capability, which is the key discussion of this paper.

Dynamic capabilities

Teece et al. (1997) disseminated the concept of dynamic capabilities, which encompasses the capacity to perceive and seize new opportunities, to reconfigure and protect knowledge resources and assets, as well as competencies and

complementary resources and assets, in order to achieve sustainable competitive advantage.

This pioneering concept remains as a basic reference to studies in the area of resources, capabilities, competences and strategy. A literature review on dynamic capabilities shows similarities and complementarities in the definitions used by different researchers that adopt this analytical approach. Since the 1990s, many theoretical efforts have been made to further develop the concept in an attempt to implement it in sectors such as tourism (Camisón & Monfort-Mir, 2012), services (Salunke, Weerawardena, & McColl-Kennedy, 2011) and the food industry (Beske, Land, & Seuring, 2014). This paper explores the development of dynamic capabilities in a chemical company.

Dynamic capabilities are alternatively defined as a process (Eisenhardt & Martin, 2000; Eriksson, 2014; Galunic & Eisenhardt, 2011; Shuen, Feiler, & Teece, 2014), as a skill (Al-Aali & Teece, 2014; Andreeva & Chaika, 2006; Augier & Teece, 2008; Davies, Dodgson, & Gann, 2016; Helfat & Peteraf, 2015; Teece et al., 1997; Teece, 2007, 2012, 2016) and as the capability (Winter, 2003; Zahra & George, 2002; Zahra, Sapienza, & Davidsson, 2006) to integrate, combine, build, reconfigure and change organizational resources and routines to foster change and achieve competitive advantages. Thus, the dynamic capability can be conceptualized as a process or skill or capability to integrate, combine, build, reconfigure and transform organizational resources and routines to generate changes and gain competitive advantage.

Also, with reference to the diversity of concepts of dynamic capabilities, it is possible to identify similarities related to: (a) rapid changes in the environment; (b) processes, skills, capabilities, resources, routines and assets; (c) capability to integrate, combine, build, reconfigure, modify and change resources; (d) path and position dependence; and (d) competitive advantage. The combination of these expressions, as presented by Teece et al. (1997), has become the basis for dynamic capabilities approach.

This study is grounded on the discussion on dynamic capabilities proposed by Teece (2007), whose framework has influenced

many other authors (Day & Schoemaker, 2016; Ellonen et al., 2009, 2011; Katkalo et al., 2010; Kindström et al., 2012; Pasian et al., 2012; Teece & Leih, 2016; Teece et al., 2016) who aim of integrating strategy and innovation and provide ‘a model that highlights the most critical capabilities management needs to sustain the evolutionary and entrepreneurial fitness of the business enterprise’ (2007, p. 1322). Teece’s framework (2007) presents three dynamic capabilities: (a) the capacity to identify ecosystem contexts (sensing); (b) the capacity to seize and incorporate opportunities (seizing); and (c) the capacity to manage threats and transformations (reconfiguring).

These dynamic capabilities are supported by microfoundations, an extremely relevant concept in this context, given that they refer to routines and processes that will allow the implementation of dynamic capabilities. Teece (2007) emphasizes the importance of distinguishing between these concepts because different processes in a company can represent important elements for dynamic capabilities. In other words, equal routines and processes in different companies may or may not become dynamic capabilities facilitators. These processes and routines are the elements that can sustain innovation in a competitive environment to increase a company’s competitive advantage over time (Day & Schoemaker, 2016; Pasian et al., 2012; Teece et al., 2016). Table 1 presents the dynamic capabilities and its microfoundations.

In line with the concept of dynamic capabilities proposed by Teece (2007), which is required to align organizational strategies with innovation, the main assumption of this study, which will be investigated in the case of Arteccla, is presented: dynamic capabilities, as proposed by Teece (2007), can boost the development of innovation capability through its microfoundations.

Fig. 1 shows the conceptual map of the study.

Fig. 1 shows the framework employed in this study to investigate the application of the three dynamic capabilities by means of their respective microfoundations. These microfoundations are necessary because they create the routines and processes that support the development and application of dynamic capabilities. Once dynamic capabilities are put into practice, it is

Table 1
Dynamic capabilities and their corresponding microfoundations.

Dynamic capabilities	Microfoundations
Capability to identify environmental contexts (sensing)	(1) processes to direct internal R&D work; (2) processes to tap supplier and complement innovations; (3) processes to tap developments in exogenous science and technology; and (4) processes to identify target market segments, changing customer needs and customer innovation.
Capability to seize/incorporate opportunities (seizing)	(1) customer solutions and business models (selection of target customers, value delivery and capture; selection of technologies, customer orientation); (2) selection of enterprise boundaries (definition of the scope of activities – definition of norms and limits that allow the advantage of first movers, even in the presence of imitators); (3) routines for the selection of decision making protocols (how to allocate resources, balance in the investment portfolio); (4) routines to build loyalty and commitment (alignment of the innovation culture to ensure the employees’ loyalty and commitment).
Capability to manage threats and transformations (reconfiguring)	(1) decentralization and decomposability (the decentralization of decisions increases agility and capability to respond to customers’ demands and to new technologies that may be acquired); (2) cospecialization (shared used of unique assets that are not easily identified by competitors and add value – the skill of the manager in identifying and using this combination is of particular importance); (3) governance and knowledge management (development of the processes of integration of external and internal knowledge and learning, formation of alliances and joint ventures to facilitate the governance of technology transfer and intellectual property).

Source: Adapted from Teece (2007).

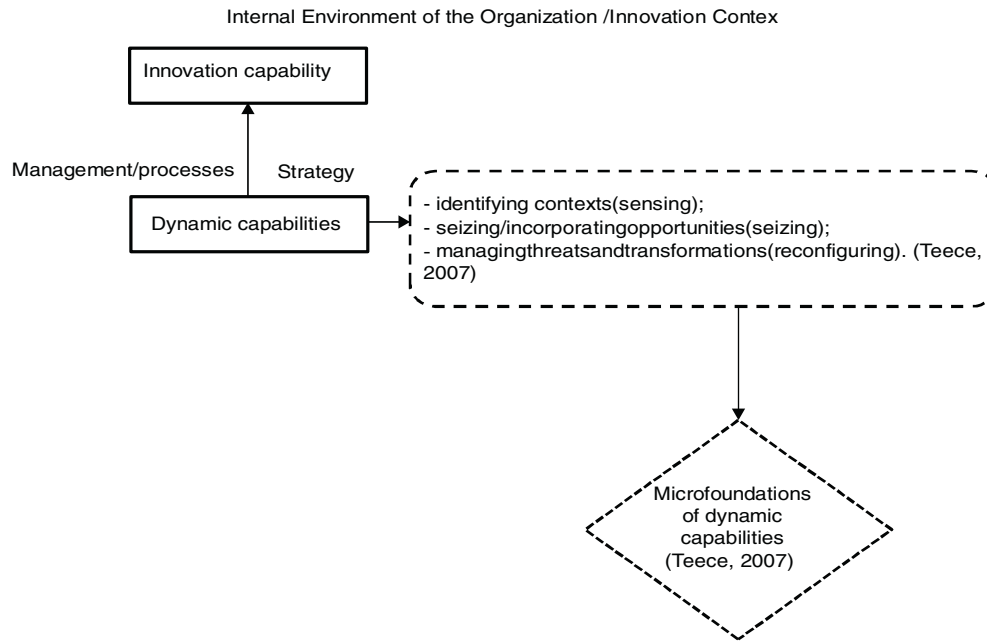


Fig. 1. Conceptual map.

Source: By the authors.

possible to boost a company's innovation capability. Moreover, we believe that innovation capability could leverage innovation. However, we prefer consider this relationship indirectly since there are many other factors that could influence or leverage innovation such as absorptive capacity, learning based on practice (internal context), knowledge transfer and interorganizational learning (external and relational context) among others. This last level of analysis will not be addressed in the present paper, which focus on understanding the development of innovation capability based on dynamic capabilities and their respective microfoundations.

Method

A qualitative case study was carried out for this study, since this approach contributes to enhance an existing theory, being influenced by social context, allowing the establishment of new relationships to be investigated and revealing complex processes (Shah & Corley, 2006). Therefore, this case study aimed to analyze the contribution of dynamic capabilities and their respective microfoundations to the development of the innovation capability. In this regard, the chosen company should meet the following selection criteria: (a) be recognized in the market for its innovation capability; (b) have innovation as a deliberate organizational strategy; (c) embody an innovation-oriented culture (innovation should be part of company's mission, vision and organizational values).

This led to the selection of Artecola Indústria Química. This company stands out because (a) it is widely recognized in the different segments it operates; (b) innovation is part of its mission and values; (c) it produces product and process patents; (d) innovation is part of its social reporting.

A protocol was developed to guide data collection, as a recommended strategy for increasing the reliability of the case study (Yin, 2005). In view of the exploratory/descriptive character of the study, the protocol was designed using the two categories identified in the theoretical framework: innovation capability and dynamic capabilities. The former focuses on understanding the innovation context while the latter tries to identify the three dynamic capabilities and its respective microfoundations, as proposed by Teece (2007).

Interviews and document analysis were carried out in the data collection stage to complement the information collected. Semi-structured, in-depth interviews were conducted with managers of different levels and areas, indicated by the company. Data on the different areas represented by the managers was validated using triangulation. All interviews were recorded with the consent of the participants and then transcribed for analysis so that any doubts could be clarified and potential misinterpretations eliminated. This contributes to ensuring the integrity and reliability of data analysis.

To protect participants' identity, they were randomly assigned a sequential identifier (Participant 1 – E1, Participant 2 – E2 and so on). Table 2 summarizes the participants' profiles.

The total number of interviews (10) fulfilled the saturation criteria, i.e. the repetition of the data collected indicated that further interviews were not required. An additional methodological precaution was the triangulation of data, which in this study was based on the participants' different managerial areas and positions and on the different data collection formats used (interviews and documentary analysis).

Secondary data were obtained from documents supplied by the company. Documental data is relevant in case study approaches (Yin, 2005), as the main purpose of information obtained from documents is to strengthen and support other

Table 2
Participants' profiles.

Job/position	Length of service in the company	Education
Technology Manager	13 months	Chemistry technician. BSc Chemistry. MSc Organic Chemistry. PhD Materials Engineering.
Technology Projects Coordinator	7 years	Chemistry technician. BSc Chemistry. MBA Business and Project Management.
Occupational Health, Safety and Environment Coordinator	3 years	Chemistry technician. BSc Environmental Engineering. BSc OSH. International MBA Environmental Management.
Management and Innovation Analyst	5 years	Chemistry technician. BSc Production Engineering (in progress).
Planning and New Businesses Manager	17 years	BSc Commercial Engineering.
Coordinator of the Francisco Xavier Kunst Foundation	3 years	BA Social Science. Specialist, HR Planning and Management. MA Education.
Environmental Analyst	2½ years	Chemical Engineering.
Internal and Institutional Marketing Coordinator	1 year	Journalism.
Development Consultant	6 years	BA Business. MBA Strategy and Innovation.
Organizational Development Director	3 years	BSc Accounting. MBA Business Management. MBA Social Technology.

Source: By the authors.

Table 3
Categories of analysis.

Category	Subcategory
Innovation capability	(a) Contextualization. (b) Innovation types.
Dynamic capabilities	(a) Capabilities and respective microfoundations: - capability to identify environmental contexts (sensing); - capability to seize/incorporate opportunities (seizing); - capability to manage threats and transformations (reconfiguring).

Source: By the authors.

sources of evidence, particularly to supply details. The following Arteccla documents were examined: (a) the company's social report; (b) book "60 anos: soluções inovadoras que unem" (60 years of innovative solutions that bind); (c) company's website; (d) environmental management system handbook; (e) articles printed in the company's monthly newsletter.

All data collected were processed using qualitative content analysis, a method by which key elements are broken down into categories that match the theoretical framework adopted. Categorization is identified by [Selltitz, Jahoda, and Cook \(1965\)](#) as an effective technique for data organization and reduction as the information is grouped into a limited number of categories. The following categories were used in this study: (1) innovation capability – taking into account organizational contexts and innovation types; (2) dynamic capabilities – the three capabilities (sensing, seizing and reconfiguring) and their respective microfoundations were analyzed to determine how they contribute to boosting the innovation capability at Arteccla Indústria Química ([Table 3](#)).

These categories were created following [Bardin's recommendations \(2010\)](#), by which elements are first isolated and then grouped together according to the following characteristics: (a) mutually exclusive, i.e. each element belongs to a single category; (b) homogeneity: the mutually exclusive principle depends of the homogeneity of the categories, so a single criterion should be used to determine how the category is organized; (c) pertinence: a category is considered pertinent when it is adapted

to the material of analysis selected and when it belongs to the selected theoretical framework, i.e. it is suitable to the research aim; (d) objectivity and reliability, i.e. the categories should be clearly defined to eliminate any doubts concerning the allocation of elements; (e) productivity: a set of categories is productive if it provides elements that are rich in inference indexes, new assumptions and concrete data.

To ensure the validity of the study, in addition to the procedures listed above (protocol, triangulation and saturation), content analysis was carried out using the NVivo 10 software to compare previously analyzed qualitative data. Therefore, data analysis was carried out in three phases: (a) pre-analysis; (b) exploration of the material; and (c) data treatment, inference and interpretation.

Results

This chapter offers an overview of the Arteccla group and contextualizes the company's innovation capability according to the analysis of the interviews conducted in the study. Next, the innovation capability is analyzed in terms of dynamic capabilities and their respective microfoundations. Finally, contributions from the first dynamic capability (sensing) are highlighted as the major theoretical and practical implication in this research.

Company overview and its innovation capability

Arteccla was founded in 1948 and it is, still today, a privately held family business that is managed by a Shareholders' Council and a Board of Directors. The company's headquarters are located in the state of Rio Grande do Sul, in Southern Brazil. The company has 11 units in Brazil and 8 overseas (Latin America and China). Arteccla Indústria Química manufactures adhesives and laminates for the footwear, furniture, textile and automotive sectors.

Even though innovation has been an important development strategy and a cornerstone of the company from day one, it was only formalized as a strategic guideline in 1997, when the first strategic plan of the organization was issued. At the time, the

company defined its mission statement as follows: ‘delivering innovative solutions to the value chains where it operates to generate optimal returns to all stakeholders’.

This strategic alignment and the formalization of the innovation concept resulted in a number of benefits, including an increase in gross revenues year after year (Participant 5), materializing the company’s major innovation goals to deliver complete solutions by adding value and generating results (Participant 2). Innovation also facilitated other strategic processes, such as company’s international insertion (Participant 5).

Including innovation in the strategic plan was crucial to promote an ‘innovation culture’ within the company. As a result, the company gradually put into place routines that, over time, generated learning on innovation. In fact, innovation is said to be part of Arteccla’s DNA and it features in the company’s mission statement and values (Participant 1).

In order to foster and disseminate a culture of innovation, an initiative called ‘program of ideas’, whose aim was to encourage the participation of all employees, was created and implemented in the 1990s. According to Participant 2, ‘[the program] has a specific operation process and it is run by the planning and new businesses area, which coordinates [the program] to optimize results and foster innovation among staff’. Participant 1 underscores the fact that ‘innovation is present in all messages, speeches and welcome discourses address at the beginning of each semester. [...] it reflects the attitude of top management, and the top-down characteristic of the cultural process of innovation is. Innovation is pervasive because of the characteristics of the company’.

It is worth mentioning that the company’s strategic innovation guideline points out at two different types of innovation: innovation in solutions (products and services) and innovation in processes. According to Participant 2, ‘innovation in solutions is innovation that generates results and value to consumers, it is innovation in market-oriented products and services, innovation that improves quality for consumers, increases their productivity, reduces costs or makes their lives easier, [these] may be breakthrough or incremental innovations’. For Participant 1, ‘product innovations are pursued by means of partnerships and joint ventures’, which ‘boost learning and the development of new routines’ (Participant 2). Innovation in services is complementary to innovation in products and is identified by the main areas of the company (commercial, marketing, technical and organizational development) for further assessment by the Strategy and Innovation Committee (Participants 1 and 2). Innovation in processes, which refers to internal process, seeks to ‘provide improvement leaps in productivity, efficiency, cost reduction, simplify processes and improve internal quality’ (Participant 5) and it is implemented by work teams that work to foster continuous improvements and provide solutions to one-off problems.

It was observed that innovation is not limited to a single area of the company. Tidd et al. (2008) point out that the innovation capability should not be limited to research and development (R&D) but it should be part of the corporate culture and encompass the whole of the organizational environment. To achieve this, these authors emphasize that innovation has to be conducted

in a structured format, according to routines that characterize each step in the development of innovation (new products, services or processes).

Data indicates that Arteccla has developed its innovation capability by directing its strategic alignment toward innovation processes, which corroborates the concept of innovation capability proposed by Dodgson et al. (2008). These authors state that innovation capability can be understood as a strategic organizational capability. More specifically, it is related to the alignment of innovation practices with organization’s strategies to add value to the company and its consumers and other stakeholders.

According to the interviews, innovation at Arteccla is a result of organizational processes that are aligned with their business strategy, i.e. innovation is not restricted to an organizational process. It is rather a strategy that is part of the company’s strategic plan, culture and routines. It is possible to claim that the company generates new products, services and processes through the innovation capability accumulated along its history.

This section contextualized innovation capability at Arteccla and highlighted the fact that innovation is aligned with company’s strategy and integrated into the company’s strategic plan. It was possible to confirm that innovation is seen by participants as a consolidated strategy that is part of the corporate culture. It was observed that innovation at Arteccla is divided into innovation in solutions (products and services) and innovation in processes. The next section offers some reflections on innovation capability vis-à-vis dynamic capabilities and their respective microfoundations.

Identification of dynamic capabilities and their respective microfoundations

The first dynamic capability is the capability to identify environmental contexts (sensing). In this regard, Arteccla has been observing and analyzing products, processes and services of multinational chemical companies since the 1970s to identify and create new needs for its consumers. After some time, the process to identify opportunities was formalized and, in the words of Participant 4, ‘the greater the stakeholders’ involvement, the more likely we are to identify environmental contexts, due to company’s interaction with them, allowing to facilitate to identify new needs’.

Table 4 lists the major managerial and operational processes identified at Arteccla for each microfoundation associated with the sensing capability.

The four microfoundations listed by Teece (2007) can be identified in the managerial and organizational processes at Arteccla and are listed in Table 4, with the respective emphasis on each of them, according to the participants’ perceptions. When new opportunities are identified, they need to be incorporated. To achieve this, Teece (2007) recalls that it is necessary to develop the seizing capability, which directs the opportunities identified.

The second dynamic capability proposed by Teece (2007) is the capacity to seize/incorporate opportunities (seizing). Seizing

Table 4
Major managerial and organizational processes that undergird the sensing capability.

Microfoundations (Teece, 2007)	Managerial and organizational processes at Arteccla
(1) Processes that direct internal R&D work	Technology group – interdisciplinary team that works to translate stakeholders' needs in quarterly meetings which analyze the technologies controlled by the company and latent market needs. Findings from this group are widely publicized in the company's R&D Intranet, a custom application developed by SAP to facilitate communication and oversight of project flow by employees – Participants 1 and 2; Clark and Wheelwright's funnel methodology (1993) of innovation for the development of new products; Project management methodology (PMI).
(2) Processes to tap supplier and complementary innovations	Strategic guideline 'growth with alliances'. To fulfill this guideline, the company permanently looks for partnerships (with suppliers, customers and universities) to develop new products (Participants 5 and 6); The importance of international alliances to fulfill the 'result-oriented innovation guideline' was highlighted by Participant 4, while Participant 1 recalled the definition of strategies related to international alliances, which contributed to the development of technological product innovations.
(3) Processes to tap developments in exogenous science and technology	Partnerships with local and international university research centers (Participant 1); projects in progress, mainly those of basic research (Participant 2); international recognition as a result of partnerships with leading players (Participant 10); Participation of representatives of the technology, commercial, technical and marketing areas in local and international fairs where relevant state-of-the-art innovations and technologies are presented (Participant 2).
(4) Processes to identify target market segments, changing customer needs and customer innovation.	Market intelligence group that 'carries out studies, surveys on trend, monitors the new products of the competition, together with the technology area to identify new needs that can yield new products, services and markets (Participant 8); Events created by the company: (i) Consumer Office (where consumers can present their requirements and representatives of different areas in the company can discuss solutions – Participant 1), (ii) Inovarte (building proximity with consumers by means of visits and presentation of the whole range of products and services – Participant 1), (iii) Technology forum (two-day event with Brazilian and Latin American teams to foster synergies between different areas of the company, suppliers and customers, and identification of needs and opportunities – Participant 2), (iv) In3 Blog (open channel of communication with the market, under the coordination of the marketing area; (v) Local and international fairs.

Source: By the authors.

is associated with the development of new products, processes, services and business models by means of the creation of organizational frameworks and the development of routines. It is possible to claim that this capability is developed once the previous capability (sensing) is consolidated, i.e. once the company has clear managerial and organizational processes in place.

Table 5 list the major managerial and organizational processes identified that correspond to each microfoundation of the seizing capability.

Data collected showed that the company needed to improve its organization structure along the path to seize and incorporate opportunities that were identified in order to address market needs and foster the creation of innovations in products, processes and services. This was achieved by the creation of new areas to manage processes, such as new businesses planning, R&D, the strategy and innovation committee and the technology group, all of which were described above, in the section on the sensing capability. In addition, 'internal programs were developed to foster a culture of innovation and engage employees in the dissemination of innovation on all levels of the organization', as Participant 4 explained. It can thus be claimed that the creation of processes to assist the identification of environmental contexts (sensing capability) required the creation of new areas and improvements in existing areas to develop the seizing capability.

For Teece (2007), once an enterprise has defined managerial and organizational aspects to identify (sensing) and incorporate (seizing) opportunities, it is necessary to develop the capability to manage threats and modifications (reconfiguring).

This third, and last, capability refers to the activities required to maintain adjustments over the life of an enterprise, as its assets and structures are realigned (Teece, 2007).

Table 6 lists the main managerial and organizational processes that were identified for each microfoundation of the reconfiguring capability.

In spite of the alliances mentioned, Participant 7 reiterated that, as far as the management of internal knowledge is concerned, 'some information is still departmentalized, we could improve cooperation in terms of information sharing; this would improve innovation management'. To achieve this, actions such as the implementation of Arteccla Integrated Management System (SIGA) were conceived with the aim of 'reconfiguring information flows and information sharing in a virtual environment' (Participant 8). However, this system is still in the final adjustments phase.

For the management of threats and transformations, it was observed that management plays a key role on the reconfiguring capability. In addition to identifying (sensing) and incorporating (seizing) opportunities, companies need to learn how to manage these capabilities to protect their internal assets. To achieve this, committees, groups and teams were set up at Arteccla to manage and make decisions related to their department. The company developed the capability to manage technological assets by establishing alliances with a number of partners and implemented an integrated management system to manage information and knowledge.

Thus, the aim of this section, which dealt with data description and analysis, was to present each of the dynamic capabilities

Table 5

Major managerial and organizational processes that undergird the seizing capability.

Teece's microfoundations (2007)	Managerial and organizational processes at Arteccla
(1) Customer solutions and business model	- The company's business model includes a set of interrelated activities to add value to consumers (Participant 3) which was based on the strategic guidelines of the strategic plan (Participant 10).
(2) Selection of enterprise boundaries	- Establishing alliances with consumers, suppliers, research centers and universities.
(3) Routines for the selection of decision-making protocols	- Routines are developed by means of regular meetings (Participant 1) to assess the viability of new products and services; (b) formal meetings conducted by the strategy and innovation committee; (c) meetings conducted by the technology area to assess the stages of the innovation funnel model.
(4) Routines to build loyalty and commitment	- Regular actions and activities, such as: (a) 'Welcome' event (held in January with all employees to direct and inform strategic intentions, the results of the previous year and new aims for the current year); (b) internal campaigns to reinforce DNA points (innovation, international insertion and sustainability), under the coordination of the organizational development area, which publishes newsletters, handbooks, magazines and leaflets to provide up-to-date information); (c) management and human resources training initiatives to build staff loyalty and commitment; (d) organization of teams with staff from different areas to build commitment. This is associated with fostering innovation in processes; and (e) program of ideas (since 2004, a communication channel that engages staff, stimulates creativity and participation in the business and contributes to promote a culture of innovation (Participant 5).

Source: By the authors.

Table 6

Major managerial and organizational processes that undergird the reconfiguring capability.

Microfoundations	Managerial and organizational processes
(1) Decentralization and decomposability	- Formation of strategic committees that make decisions relevant to their field of work, with a focus on the transition from a family managed to a professionally managed business. Creation of shareholders' councils and a board of directors, which led to the creation of decision-making committees.
(2) Cospecialization	- Capability to manage technological assets and alliances to mobilize resources and innovation capabilities (Participant 4).
(3) Governance and knowledge management	- Governance to contemplate the development of internal and external knowledge integration processes and learning. - Arteccla Integrated Management System (SIGA); - Alliances with consumers, suppliers, multinational companies and partnerships with research centers and university to gain access to expertise and learning in order to improve and facilitate the innovation capability of the organization, as discussed above, and joint ventures.

Source: By the authors.

and their respective microfoundations, as proposed by Teece (2007). It can be observed that these capabilities contributed to the development of the innovation capability at Arteccla through the creation of managerial and organizational processes.

It should be highlighted that complementarities between these capabilities were identified. Most of the actions identified in the first capability (sensing) are seen again in the other two. It is possible to say that a given action or activity identified in the first capability becomes the foundation for the development of the second capability and so on. This redundancy is an important element in the analysis as it reflects efforts to identify relevant points and converging actions. The next section presents and discusses the major contributions of dynamic capabilities to boosting innovation in the case studied, with a focus on the microfoundations of the first capability.

Contribution of the sensing capability for boosting innovation – implications for theory and practice

Innovation goes far beyond developing products – it includes the capability to renew a business and the expansion and creation of new markets (Teece, 2007). Therefore, the ability to sense and

shape opportunities and threats, represented by the first dynamic capability, must be fully developed.

Data indicated that the first dynamic capability (sensing) is consolidated at Arteccla, as a number of routines are in place to support the creation and interpretation of new opportunities through the establishment of organizational and managerial processes to incorporate these microfoundations (Day & Schoemaker, 2016; Ellonen et al., 2009; Ellonen et al., 2011; Katkalo et al., 2010; Kindström et al., 2012; Pasian et al., 2012; Teece & Leih, 2016).

Sensing involves proactively creating hypotheses about the future implications of new products, services and business models and the process of scenario planning can assist organizations in preparing for change across multiple dimensions (Teece et al., 2016). This section highlights major theoretical developments and proposes a revised version of the second microfoundation as well as a new microfoundation for the sensing capability in order to expand the innovation capability of the company.

Teece's second microfoundation (2007), described as 'processes for partnerships with suppliers to complement an organizational innovation is of paramount importance to Arteccla, which attempted to answer the following question when incorporating seizing to its routine: how can we compete in

an increasingly globalized world, with large-scale competitors that have advanced R&D capabilities and a global presence? The prevalent strategy in this case has been the creation of international alliances, which is illustrated by partnerships with Germany (Rhenoflex, Jowat), Italy (G.O.R.), France (Protechnic, AEC Polymers), Switzerland (Forbo), USA (Spray Lock) and China (Orisol). The establishment of strategic alliances is an agreement between two or more companies for the co-development of a new technology or product (Tidd et al., 2008). It is considered an effective mechanism for access to external sources of knowledge (Capaldo, 2007; Gulati, 1998).

In the case of Artecola, the search for partnerships is not limited to complementing innovations, as suggested by Teece (2007) but it is also used to introduce new products in the market. Chesbrough (2006) stresses that external knowledge can be integrated throughout the innovation process through incipient ideas to deepen applied research, through concepts ready to be developed in products, through products ready to the market or through distribution channels. The intentional use of inflows and outflows of knowledge aims to accelerate innovation and expand markets (Chesbrough, 2006).

The company is not limited to partnerships with suppliers. Collaborations with suppliers, competitors, customers, end users, institutions, partners from other industries facilitate the ability to perceive and interpret the future and to innovate (Kyläheiko & Sandström, 2007). Thus, this study suggests that Teece's second microfoundation (2007) should be rewritten as follows: 'processes to identify and establish partnerships to manage or complement organization's innovations'.

In addition to the four microfoundations that undergird the sensing capability, as suggested by Teece (2007), a new microfoundation was identified from the empirical data collected, which in this study is defined as 'processes to direct innovation on a strategic level'. Quadros (2005) highlights the importance of the institutionalization of processes and routines for a structured practice of innovation from a strategic perspective. Tidd et al. (2008) emphasize that innovation is not an isolated event but rather a process that must be managed in a dynamic and integrated way. In other words, it is not enough to manage or develop skills in some isolated areas of the company, such as R&D, but a culture for innovation should be developed (Dobni, 2008).

Pisano (2015) stresses that without an innovation strategy, innovation efforts can become a set of centralized practices in R&D. Still, he says that companies rarely articulate strategies to align their innovation efforts with their business strategies, generating performance problems. The problem is that an organization's innovation capability results from a system of innovation, that is, it refers to a coherent set of interdependent processes and structures that indicates how the company addresses new problems and solutions. For this it is necessary the institutionalization of innovation processes from the strategic level of the organization to promote the alignment among the different areas and teams.

This new microfoundation is justified by the establishment, in 2007, of a 'strategy and innovation committee' at Artecola, whose aim is to plan and manage innovation strategies. Committee membership includes shareholders, counselors and managers specialized on the topic on innovation. The committee's role,

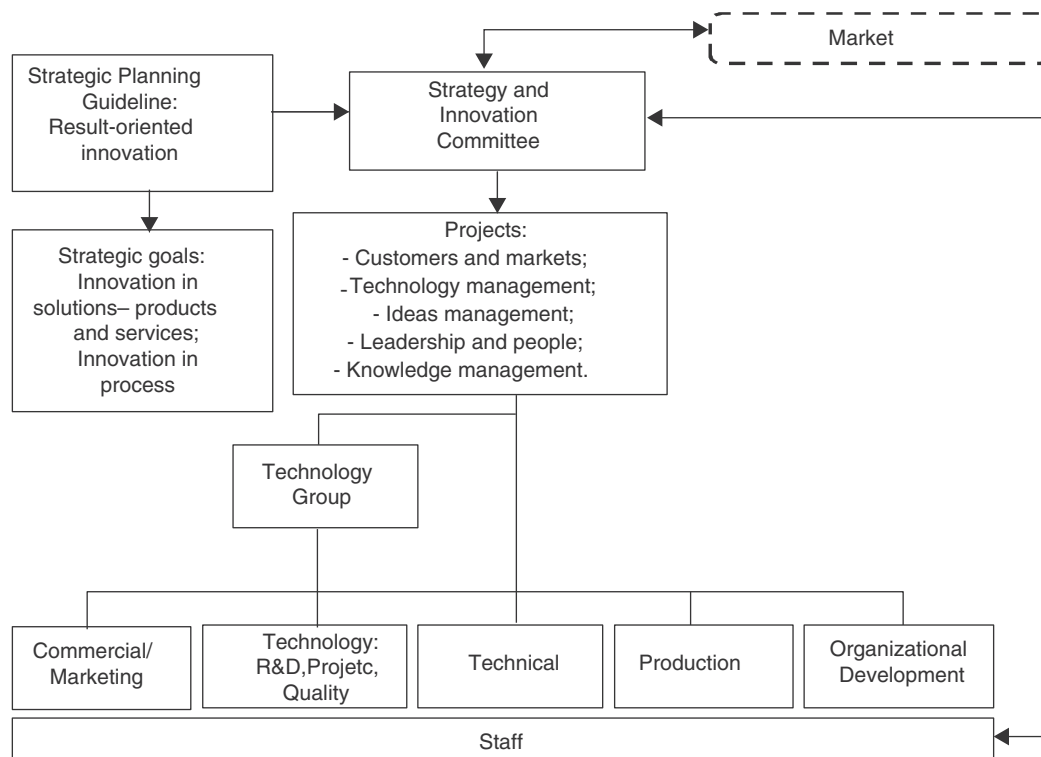


Fig. 2. Roles of the strategy and innovation committee.

Source: By the authors.

Table 7

Microfoundations of the sensing capability.

Capability to identify environmental contexts (sensing)

- (1) Processes to direct innovation on a strategic level (new);
- (2) Processes to direct internal R&D tasks;
- (3) Processes to tap supplier and not only complement but generate innovation (new);
- (4) Processes to tap developments in exogenous science and technology;
- (5) Processes to identify target market segments, changing customer needs and customer innovation.

Source: By the authors.

which is shown in Fig. 2, is ‘to organize and make innovation systematic in order to understand and anticipate market changes and exceed customer expectations’ (Participant 9) and ‘to align different innovation initiatives with our organizational strategies’ (Participant 2).

Fig. 2 shows that in order to meet the guideline and the strategic aims of innovation, the Committee works to identify and interpret market signs, as well as capture, in a systematic manner, the ideas proposed by employees. All selected signs and ideas are classified into five dimensions for the development of projects: consumers and markets, technology management, ideas, leadership, and people and knowledge management. After classification, these requests are transferred to the technology group, which allocates tasks, according to the required competencies, to implement the project.

It was then possible to analyze, from the data collected, that the company’s innovation capability originates in the alignment of strategic guidelines with the innovation and strategy committee, which identifies, together with different company areas, market opportunities and captures and assesses ideas from internal and external sources. The inception of the strategy and innovation committee underscores the key role played by innovation on the business of the organization and facilitates the identification of environmental contexts to learn, interact and assess information on external ecosystems expectations. The committee is also responsible to disseminate innovation throughout the company (Participant 1).

For this reason, it was important to add a new microfoundation to the sensing capability, which in this study was defined as ‘processes to manage innovation on a strategic level’. This microfoundation was not identified by Teece (2007), but was based on the empirical data collected, which showed these to be an essential element in the conception and dissemination of innovation strategies. This microfoundation spurs the process of translating strategies into innovative actions.

This analysis of sensing at Arteccla demonstrates its emphasis on the implementation of the guidelines proposed by the innovation and strategy committee, which works to ensure that operational aspects are addressed swiftly. As a result, the company faces no hurdles when implementing strategies. On the contrary, it is quite agile in this aspect.

An analysis of the data on the sensing capability at Arteccla suggests that this capability is supported by the following microfoundations (Table 7).

Conclusions

In the literature review on dynamic capabilities, sensing, seizing and reconfiguring capabilities proposed by Teece (2007) were identified as potential contributors to the development of innovation capabilities. This study showed that this theoretical framework is a key element in the development of innovation capabilities, and it is recommended for the study of organizational strategies, being associated with transformation and innovation contexts. It is also characterized by the ongoing mobilization of resources to address changing business strategies in a dynamic environment. Because of these characteristics, dynamic capabilities approach offers a different perspective on innovation capabilities and highlights their potential to generate opportunities for business renewal.

In the specific case of Arteccla, it can be said that dynamic capabilities and their respective microfoundations have contributed to developing innovation capabilities by means of routines and managerial and organizational processes. The company established a system to innovate and pursue its strategic guideline.

Therefore, it is possible to highlight that (1) the major elements that improve and contribute to expanding innovation in this case are the strategic alignment and the formal innovation strategy of the company, which led to the development of a culture of innovation. Another relevant point is (2) the consolidation of the first dynamic capability (sensing) to boost innovation. This ensures sensing becomes a capability of the company, the organizational strategies and the innovative practices of the whole company are systematically arranged in a process that permeates all areas and staff.

In this sense, the major theoretical contribution of this study is (3) the addition of a new microfoundation to the sensing capability, namely ‘processes to manage innovation on a strategic level as a microfoundation of the sensing capability’, i.e. processes that precede the processes to direct internal R&D tasks suggested by Teece (2007). The analysis of empirical data showed that innovation at Arteccla is not restricted to R&D. The creation of the strategy and innovation committee and of the technology group, which comprehend managerial and organizational processes that foster the capability to identify environmental contexts, is quite relevant in this context. Actions in progress at Arteccla point out at the need for processes to direct innovations on a strategic level.

The need (4) to adjust the second microfoundation of the sensing capability was identified, and it was defined as ‘processes to identify and establish partnerships to manage or complement an organization’s innovations’. It is suggested that this process should be rethought to take into account its relevance to generate (and not only complement) innovation at the organization.

In the case of Arteccla, it was observed that the search for partnerships takes place not only to complement innovation but also to introduce new products in the market. In addition, (5) partnerships are not limited to suppliers. Arteccla has the ‘growth with alliances’ strategic guideline, whose strategic aim is the development of alliances. To comply with this strategic

planning guideline, the company is always searching for partnerships that can lead to the development of new products. These may take the form of partnerships with suppliers, customers, universities, research centers or Brazilian and international firms to generate or complement innovations.

It was observed that most of the actions identified in the sensing capability feature again in the other two dynamic capabilities. It is possible to say that (6) a given action or activity identified in the first capability operates as the foundation for the development of the second capability and so on. (7) Redundancy is, therefore, an important element in this analysis as it reflects the effort to highlight what is relevant and the convergence of actions, all of which amount to a process-oriented complementary view of dynamic capabilities.

It was also observed that dynamic capabilities consist of skills, processes and routines that enable the organization to manage and mobilize its resources and assets to address market needs and changes. Therefore, the dynamic capabilities found in the internal environment promote organizational development and support innovation capabilities.

As a final contribution, (8) the implementation of dynamic capabilities by means of organizational practices and routines that are grouped according to their microfoundations should be highlighted. This effort aimed to address the gap found in dynamic capabilities' literature, which is considered extremely theoretical and hard to understand given its application.

A limitation of this study refers to the fact that these findings cannot be extended to other situations, as this is a unique case study based on the perceptions of the company's executives. In addition, the focus of the study was the internal environment and did not extend to other stakeholders, such as consumers and suppliers, who could have contributed to widen the scope and the result of the study. At last, we did not directly address the relation between innovation capability and innovation. Our focus was on the operationalization of innovation capability based on dynamic capabilities and their microfoundations.

We suggested that further research on this topic could (1) address the contribution of dynamic capabilities to leverage innovation (focus on strategic level) and also, understanding innovation capability taking on board the perceptions of different stakeholders (focus on operational level but considering organizational external perceptions). This would improve the theoretical framework and pave the way to quantitative studies that could validate the constructs adopted.

Conflicts of interest

The authors declare no conflicts of interest.

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