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THE IMPACT OF EXTERNAL COLLABORATION ON INNOVATION PERFORMANCE: DO BUSINESS STRATEGIES AND TYPE OF COLLABORATION MATTER?

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With this journey coming to an end, I feel only but proud of the path and to be able to grow with the support of so many.

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Resumo

Os determinantes do desempenho da inovação de empresas têm sido foco de diversos estudos, sendo a colaboração interorganizacional um assunto de interesse de muitos estudos.

Ao avaliar o impacto das colaborações externas no desempenho inovador empresarial, os estudos passados concentraram-se principalmente num período, geografia, setor e tipo específico de colaboração. Poucos estudos compararam criticamente como os diferentes tipos de colaborações influenciam o desempenho inovador das empresas. Adicionalmente, a relevância das estratégias de negócios e seu impacto na relação entre cada tipo de colaboração e o desempenho inovador das empresas não foi ainda devidamente explorada.

Recorrendo a estimações de modelos logísticos tendo por base uma amostra de 13701 empresas localizadas em Portugal que responderam ao Inquérito Comunitário à Inovação de 2018, constatamos que a chance (*odds)* (probabilidade de ocorrência do evento dividida pela probabilidade da não ocorrência desse mesmo evento) de inovação tecnológica é mais elevada ao colaborar com clientes, fornecedores e consultores. Já a colaboração com organizações científicas, como universidades, e concorrentes não emergiu nesta amostra como estatisticamente relevante para induzir o desempenho inovador das empresas.

As estratégias de negócios da empresa, designadamente a diferenciação aumenta significativamente a chance de uma empresa realizar inovação tecnológica. Considerando os tipos específicos de colaboração, as estratégias de negócios têm um impacto estatisticamente significativo nas colaborações de consultores e fornecedores.

Palavras-chave: Desempenho inovador; inovação tecnológica; colaboração inter-organizacional; estratégias de negócios

Abstract

The determinants of firm's innovation performance have been the focus of several studies, with inter-organizational collaboration being a subject of interest in many studies.

In assessing the impact of external collaborations on business innovative performance, past studies have focused primarily on a specific period, geography, sector and type of collaboration. Little research has critically compared how different types of collaborations influence firms' innovative performance. Additionally, the relevance of business strategies and their impact on the relationship between each type of collaboration and the companies' innovative performance has not yet been adequately explored.

Using logistic model estimates, based on a sample of 13,701 companies located in Portugal that responded to the 2018 Community Innovation Survey, we found that the chance (odds) (probability of occurrence of the event divided by the probability of non-occurrence of the same event) of technological innovation is higher when collaborating with customers, suppliers and consultants. Collaboration with scientific organizations, such as universities and competitors did not emerge in this sample as statistically relevant to induce the innovative performance of companies.

The company's business strategies, namely differentiation, significantly increase the chance of a company performing technological innovation. Considering the specific types of collaboration, business strategies have a statistically significant impact on consultant and supplier collaborations.

Keywords: Innovative performance; technological innovation; inter-organizational collaboration; business

1. Introduction

In a fast-changing, dynamic, and globalized business world, firms, academics, and governments are highlighting the necessity of relying more on external collaborations to improve innovation performance and gain competitive advantages (Popa et al., 2017). Indeed, it is increasingly difficult for firms to stay creative, updated, and innovative without connecting with external entities (Santoro et al., 2020). Hence, it is vital for firms to be embedded in a network where they can share knowledge and learn from complementary competencies of partners such as universities, research facilities, competitors, suppliers, customers, public institutions, consultants, and non-profit organizations (Najafi-Tavani et al., 2018; Santoro et al., 2020; Zeng et al., 2010).

Business innovation performance has been substantially assessed by extant studies (Crossan & Apaydin, 2010; Damanpour & Schneider, 2006; Dani & Gandhi, 2021; Mendoza-Silva, 2021; Saunila, 2020), which have pointed to external collaborations as one of its main determinants. However, when studying the impact of external collaborations on innovation performance, researchers have focused on a specific type of partnership, such as collaborations with research organizations (RO) (Skute et al., 2019), collaborations with suppliers (Sikombe & Phiri, 2019), or customers (Greer & Lei, 2012). Although most studies concluded that networks tend to promote firms' innovation, it is unclear what type of collaborations are more relevant for innovation performance (Kafouros et al., 2020; Pittaway et al., 2004; Tsai, 2009). Especially when considering the role of business strategies (e.g., costs or differentiation focus), the relationship between each type of collaboration and innovation performance is still unclear.

Thus, the research questions that the present dissertation seeks to answer are:

1) What is the impact of the distinct types of external collaboration on business innovation performance?

2) Do business strategies matter for explaining the impact of the distinct types of external collaboration on business innovation performance?

To answer these questions, we analyze a large set of 13701 firms located in Portugal, a moderate innovator characterized by some laggardness in business innovation and scanty external collaborations innovation (Teixeira & Bezerra, 2016). The database includes the firms that responded to the latest available Community Innovation Survey (CIS), CIS2018,

which comprises the innovation activities of firms in the period 2016-2018 in all sectors of activities. Based on this data and supported by Porter's Generic Strategies framework, we analyze the mediating role firms' business strategies. Specifically, we resort to a quantitative, econometric approach to scrutinize the extent to which business strategies can influence the relation between the types of external collaborations and business innovation performance.

The present dissertation is structured as follows. The next section presents the literature review: main concepts and theories. Then, in Section 3, the methodology is described, supported by the sample of chosen empirical studies that will serve as a basis for our research. In Section 4, results are presented and discussed. Section 5 concludes the study by synthesizing the main contributions, limitations of the present study and suggesting some paths for future research.

2. Literature review

2.1. Key concepts

2.1.1. Inter-organizational collaboration and types of collaboration

Inter-organizational collaboration refers to collaborative agreements between organizations using a variety of cooperative forms (Tsai, 2009), such as R&D partnerships, joint ventures, networks, collaborative manufacturing, co-marketing arrangements, co-development of products and services and other types of arrangements (Arasti et al., 2021; Lee et al., 2010; Powell et al., 1996).

When defining the concept of inter-organizational collaboration, it is crucial to clearly identify and distinguish some related but different concepts that authors tend to use interchangeably, most notably networks and Open Innovation.

Firms can be engaged in several types of inter-organizational collaborations, networks being one of these forms (Lee et al., 2010). Networks are a complex web of interconnected ties (Han et al., 2020) or simply the firm's set of relationships with different types of collaborators (Pittaway et al., 2004). The aim is to access strategic resources crucial for sustaining the business (Najafi-Tavani et al., 2018), accomplishing linked activities to create value for all actors involved (Arasti et al., 2021).

Inter-organizational collaborations lead to inflows and outflows of knowledge, also known as knowledge sharing or transfer (Balboni et al., 2017; Vaccaro et al., 2010; Wang & Hu, 2020), that together with fundamental enablers, shape the Open Innovation (OI) strategy. The concept of OI differs from inter-organizational collaborations, as it is perceived as a strategy that uses inflows and outflows of knowledge to facilitate the firm's collaboration, with diverse partners in the innovation network to integrate complementary ideas and resources (Cheng & Shiu, 2015; Han et al., 2020; Zeng et al., 2010).

2.1.2. Innovation performance

The field of innovation is vast and complex, with research in multiple areas and levels of analysis involving several aspects, such as antecedents, processes, and outcomes (Damanpour, 1991; Damanpour & Aravind, 2012). Although the concept is somewhat compartmentalized, innovation can be described as a means of changing an organization

(Damanpour, 1991) through the implementation of new products, services, methods of production, management systems and procedures to improve the firms' competitive advantage (Damanpour & Schneider, 2006; Mendoza-Silva, 2021).

Business innovation performance refers to a set of measurements that captures the benefits of firms' innovation capabilities (Mendoza-Silva, 2021; Saunila, 2020). Innovation capabilities refer to the ability to transform knowledge, experience, and ideas from different origins into new products, systems, and processes (Mendoza-Silva, 2021; Saunila, 2020). Therefore, organizational and environmental determinants are essential for firms to develop innovation capabilities that are managed and employed, leading to firms' innovation performance (Prajogo & Ahmed, 2006; Yesil et al., 2012).

Concerning innovation performance, prior research suggests that innovation is categorized in many dimensions being product/process innovations and radical/incremental innovations, the foremost articulated in the literature (Damanpour, 1991; Yesil et al., 2012).

Regarding the measurement of innovation performance, Prajogo and Ahmed (2006) state that several criteria can be transposed into two major areas of innovation: product and process innovation. Product innovation involves developing new products or services by incorporating components, features, and technologies to meet a market need (Damanpour, 1991; Laosirihongthong et al., 2014). Process innovation focuses on improving production process technologies, introducing new elements and practices into an organization's production, task specifications, workflow mechanisms, and equipment (Damanpour, 1991; Laosirihongthong et al., 2014).

When addressing the degree of novelty, innovation can be classified as radical or incremental (de Carvalho et al., 2017). Radical innovation comprehends the disruption of an existing technological trajectory or a clear departure from existing practices that makes current products/services obsolete (Damanpour, 1991; Mendoza-Silva, 2021). Incremental innovation represents a continuous improvement of current routines and practices (Crossan & Apaydin, 2010; Damanpour, 1991).

2.1.3. Businesses strategies

The literature on strategic management has developed several theories over the past 40 years (Bayraktar et al., 2017; Crema et al., 2014), focusing mainly on two principal typologies

(Datta, 2010; Leskovar-Spacapan & Bastic, 2007): Porter's Generic Strategies and Miles and Snow's strategic orientation typology.

According to Porter (1985), the competitive strategy aims to attain a profitable and sustainable position in an industry, enabling firms to gain a competitive advantage in the market *vis-à-vis* their competitors. Porter (1980) proposes two main classifications of business strategies (Porter's Generic Strategies): cost-leadership and differentiation, suggesting that firms pursuing one of these business strategies would gain competitive advantage (Bayraktar et al., 2017). Porter states that firms unwilling to make a strategic choice see themselves "Stuck-in the Middle", performing less well (Sumer & Bayraktar, 2012). However, recent research shows that firms can successfully pursue both strategies in parallel (Hambrick, 1983; Le & Lei, 2018; Prajogo, 2007; Reimann et al., 2010; Yamin et al., 1997). Porter (1985) incorporates another dimension to the analysis, the scope, when the firm chooses to focus on a specific target inside the market, either using a differentiation or cost strategy.

Miles et al. (1978) propose that firms develop relatively stable patterns of strategic orientation that are adjusted to the perceived environmental conditions. They divide organizations into four strategic types: *defenders, analyzers, prospectors,* and *reactors*. *Defenders* aim to create a stable domain by improving efficiency and effectiveness (Lin et al., 2014). *Prospectors* mainly focus on exploiting and examining new products and market opportunities, striving to maintain a reputation of "innovators" by continuously investing in new product development (Hambrick, 1983; Ritter & Gemünden, 2004). *Analyzers* occupy a middle position, combining defenders' and prospectors' strategies to minimize risk and maximize profitable opportunities. Lastly, *Reactors* have no long-term goals or patterns of decision, preferring to adjust to environmental circumstances.

When it comes to the similarity of the two dominant typologies, several authors highlighted the resemblance between business strategies (Frambach et al., 2003; Hambrick, 1983; Miller & Dess, 1993; Segev, 1989). Porter's cost leadership strategy can be compared to Miles and Snow's *Defenders*, and differentiation strategy resembles to *Prospectors*. Although *Analyzers* are not linked to a specific strategy, researchers found similarities between being "Stuck in the Middle" and following *Reactor*'s strategy (see Table 1).

Besides Miles and Snow's typology, Porter's Generic Strategies also share common ground with several frameworks. de Carvalho et al. (2017) highlighted that the Blue Ocean strategy can be compared to the differentiation strategy (cf. Table 1). Mintzberg (1988) considered

cost leadership strategy as a form of differentiation and divided differentiation strategy into several forms to explore uniqueness. Utterback and Abernathy (1975) state that firms differentiate either through performance or sales maximizing (Bayraktar et al., 2017). Miller and Friesen (1982) compare entrepreneurial firms to prospectors and conservative firms to defenders that ultimately can be linked to Porter strategies as well. Miller (1986) links cost leaders to Porter's cost leadership strategy, marketers to differentiators and innovators as Miles and Snow's *Prospectors*. 5

Table 1: Analyzing the overlap of distinct business strategies proposals

Study	**Business strategies**					
Porter (1980)	Cost Leadership	Differentiation				Stuck in the Middle
Mauborgne (2004)	Red Ocean Strategy	Blue Ocean Strategy				N/A
Mintzberg (1988)	Price Differentiation	Image Differentiation	Support Differentiation	Quality Differentiation	Design Differentiation	Undifferentiation
Miles and Snow (1978)	Defender	Prospector				Reactor
Utterback and Abernathy (1975)	Cost Minimizing	Performance Maximizing		Sales Maximizing		N/A
Miller and Friesen (1982)	Conservative	Entrepreneurial				N/A
Miller (1986)	Cost leaders	Marketers		Innovators		N/A

Source: Own elaboration.

The decision to employ Porter's competitive strategy as our elected framework is sustained by several factors. Firstly, studies testing the validity of the typology have generally found that successful strategies within an industry corresponded to Porter's strategy types (Banker et al., 2014; Miller & Dess, 1993). Secondly, Porter's framework is the most cited and refined (Frambach et al., 2003), widely accepted in the field of innovation research, and applicable in the digital age (Banker et al., 2014). Lastly, the framework provides a useful "shorthand" for describing complex strategies, aggregating simultaneously several typologies developed throughout the years (Bayraktar et al., 2017; Miller & Dess, 1993).

Getting into more detail on Porter's Generic Strategies, firms adopting a cost-leadership approach aim to increase efficiency in all business operations to create a low-cost position relative to competitors (Banker et al., 2014; Porter, 1980). Although it does not hinder the existence of quality, detail, service, or other attributes, the main concern for firms adopting

this strategy is to provide the product or service at a price lower than competitors (Crema et al., 2014). Therefore, firms will cut costs in practices seen as supplementary, such as advertising, salesforce, customer service or research and development.

Firms following a cost-leadership strategy can adopt a series of practices to achieve better operational efficiency and economies of scale based on high unit sales volumes (Lassar & Kerr, 1996; Prajogo, 2007). Such activities include process improvements, cost minimization in product development, production, and logistics (Jin et al., 2019), large-scale facilities (Banker et al., 2014), tight control of overheads and budgets (Lassar & Kerr, 1996), maximizing the benefits of industry experience and new technology implementation (Porter, 1985), and stability of product lines (Lassar & Kerr, 1996; Reimann et al., 2010).

When achieving a cost advantage, firms should continuously compare themselves against competitors (Bayraktar et al., 2017; Lassar & Kerr, 1996), managing rivals' efficiency and finding disruptive ways to cut costs in production, new product development and supply chain activities (Crema et al., 2014). Therefore, the strategy focuses on improving the efficiency of the existing product lines and requires manufacturers to produce standardized, mass-market products that are sold based on perceived value through aggressive pricing by distributors (Lassar & Kerr, 1996; Reimann et al., 2010).

Differentiation involves developing a unique aspect of a product or service to set it apart from competitors (Correia et al., 2021). Typically, differentiation strategy anticipates the customers' needs and behaviour to incorporate new features into a product (or create a completely new one), allowing the firm to charge a price premium (Banker et al., 2014; Crema et al., 2014; Porter, 1980). This business strategy requires being different from competitors by providing superior functions such as brand image, incorporated technologies, customer service, quality, communication, design, distribution channels and dealer network (Crema et al., 2014; Porter, 1985). So, the resultant added value perceived by the customer offsets the impact of the higher price (Porter, 1985). This perceived value creation can be achieved through advertising, pricing strategies, market segmentation and customer loyalty (Bayraktar et al., 2017; Lassar & Kerr, 1996).

2.2. Relation between (types of) external collaborations, business strategies and innovation performance: The theoretical framework and main hypotheses to be tested

2.2.1. The impact of collaboration on innovation performance

Inter-organizational collaboration does not automatically translate into innovation performance, as several mechanisms mediate the success of such collaborative agreements (Faems et al., 2005; Najafi-Tavani et al., 2018).

External collaborations are a valuable means for the creation of technological competencies. They are also a viable solution when there is a need to obtain resources that do not exist in the scope of the firm (Najafi-Tavani et al., 2018; Nieto & Santamaria, 2007) or are difficult to obtain efficiently in the market (Tsai, 2009). The main purpose of external collaborations is to allow firms to enhance their portfolio of resources and competences, exploiting complementarities from partners and integrating them within their range of capabilities (Nieto & Santamaria, 2007). Indeed, the ability to successfully integrate new resources and knowledge highly depends on firms' internal assets and prior experience. Several authors underline the fact that prior knowledge allows one to assimilate and exploit new knowledge (Powell et al., 1996; Wang et al., 2020). This is translated into the concept of *absorptive capacity* (Cohen & Levinthal, 1990), which refers to the firms' ability to use its prior knowledge to identify, assimilate and evaluate new external knowledge. Later, firms combine it with internal resources and competences (Tsai, 2009) to effectively transform knowledge into innovation (Mei et al., 2019). So, a low level of *absorptive capacity* implies incapability of capitalizing new knowledge in new products and processes (Tsai, 2009) and adding new competences into their portfolio (Najafi-Tavani et al., 2018).

Besides being able to assimilate and create knowledge, firms should have the ability to transfer knowledge within the organization (Kafouros et al., 2020). Such transfers are easier when knowledge is explicit and easily codified rather than tacit and difficult to communicate (Love et al., 2014). For that reason, in the context of collaborative innovation, firms need to provide the correct incentives, mindsets and mechanisms that enable individuals to integrate tacit knowledge from partners into explicit knowledge within the firm (Balboni et al., 2017; Un & Asakawa, 2015) and diffused throughout network members (Wang & Hu, 2020). These knowledge integration mechanisms can have either a formal or informal nature, and more importantly, must ensure that they are able to effectively capture, analyze and integrate

external knowledge (Balboni et al., 2017; De Luca & Atuahene-Gima, 2007). Formal integration mechanisms focus on transferring pieces of knowledge through formal representations and low-depth communication channels, such as reports or standard data. Informal mechanisms encompass a more direct communication, establishing learning spaces where partners can share practical experiences through direct contact and observation of behaviours (e.g., design-building teams, manufacturing audits), reducing the potential for conflicts and providing on-time feedback (Balboni et al., 2017; Mokhtarzadeh et al., 2020).

Building relationships upon an innovation climate of mutual trust, cooperation and commitment are crucial to engaging in knowledge transfer activities (Najafi-Tavani et al., 2018; Popa et al., 2017), especially in more informal personal interactions. Knowledge transfer is viable when firms are transparent, seek to reduce information asymmetry and share their long-term goals to ultimately create a shared vision that encourages knowledge transfer (Zahoor & Al-Tabbaa, 2020). Moreover, the literature highlights the crucial role of trust in the creation and integration of knowledge efficiently (Pittaway et al., 2004). Trust represents partners' genuine interest in the firm's welfare, making them committed to cooperate in good faith rather than acting opportunistically (Liu et al., 2017). However, firms develop formal legal protection to protect themselves against opportunistic behaviours. This comprehends proper appropriation mechanisms, such as patents, copyrights, and trademarks, used to prevent knowledge leakage and imitations (Liu & Atuahene-Gima, 2018; Radziwon & Bogers, 2019). Kobarg et al. (2019) suggest that developing networking capabilities can effectively mitigate appropriability behaviour. Firms develop their networking capabilities when establishing different types of partnerships by learning how to structure and explore each type of partnership (Powell et al., 1996).

Thus, firms gain collaborative experience and reputation from interacting with a wide range of partners, integrating different knowledge bases, behaviours, or ideas used to expand to other formal or informal partnerships (Pittaway et al., 2004).

Additionally, managers discover how to manage existing partnerships more effectively, developing partner-specific routines that will serve as a basis for consequent partnerships (Pittaway et al., 2004). Indeed, networking capability is based on prior patterns and collaborative agreements, as collaborative experience influences the firm's future collaborative path (Kafouros et al., 2020). Collaboration depth can facilitate the emergence of trust and effective coordination, mitigating opportunistic behaviours (Love et al., 2014).

From this perspective, innovation capabilities depend on firms' embedded network (Najafi-Tavani et al., 2018) while managing the breadth (i.e., number of partner types) and depth (i.e., the intensity/quality of the interactions with these partners) of its inter-organizational relationships over time (Arasti et al., 2021; Kobarg et al., 2019). These capabilities will improve the quality of collaborations and the ability to manage and integrate the several contributions of different partners into product or process innovations (Arasti et al., 2021).

Lastly, one of the main pillars seems to be the Open Innovation approach. The inbound dimension of this mechanism incorporates the inflows of knowledge that allow firms to transfer new knowledge and resources from external partners (Faems et al., 2005; Popa et al., 2017; Rauter et al., 2019), expanding the firm's existing knowledge base that in turn improves firm's innovation capabilities (Najafi-Tavani et al., 2018).

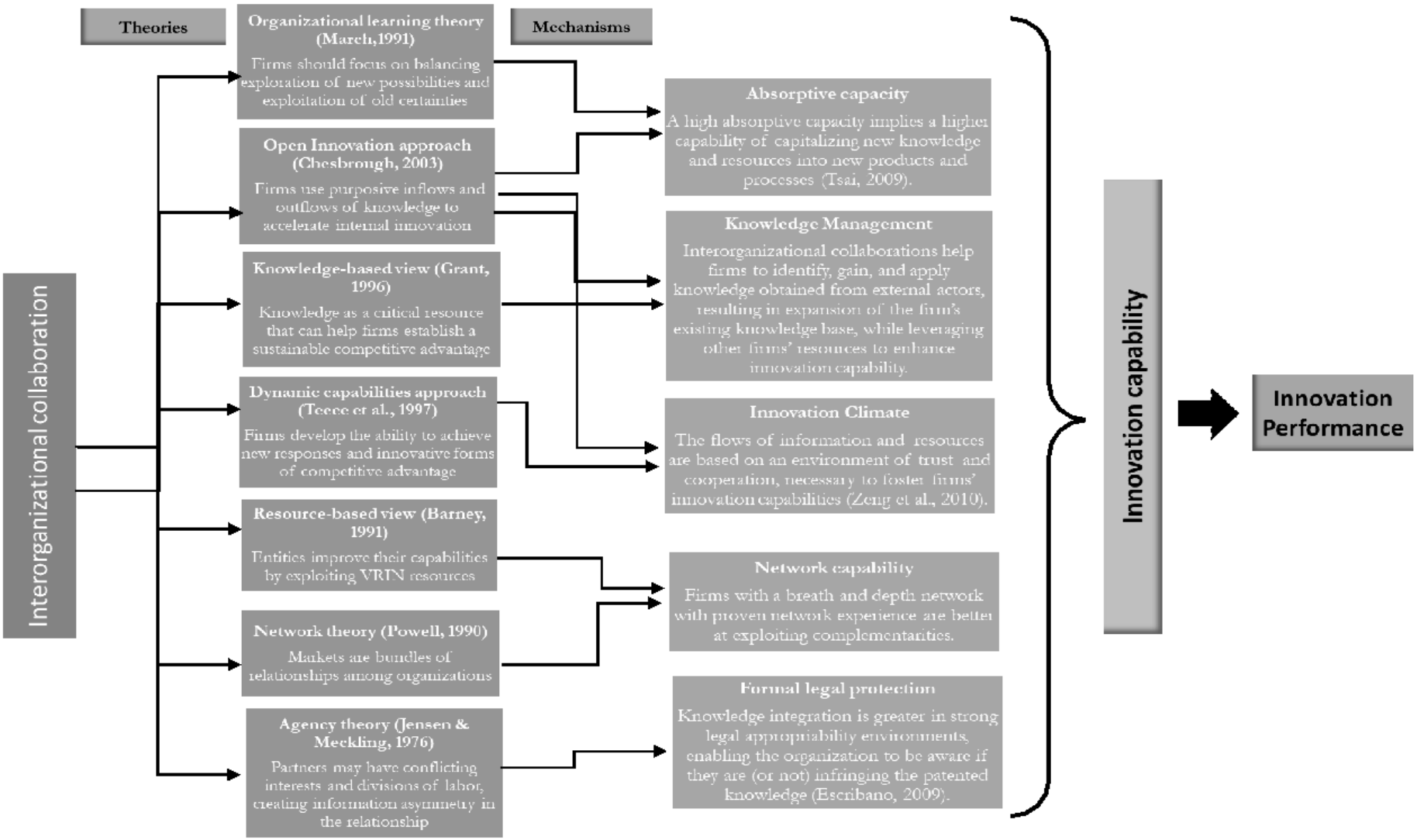


Figure 1: Theories and mechanisms through which external collaborations impact on innovation performance

Firms engage in inter-organizational collaborations to access new technologies and markets (Pittaway et al., 2004; Popa et al., 2017; Zeng et al., 2010), and share the risk of activities (Nieto & Santamaria, 2007; Pittaway et al., 2004; Zeng et al., 2010), gain access to complementary skills (Pittaway et al., 2004) and facilitate the inter-firm exchange of tacit knowledge (Najafi-Tavani et al., 2018). Moreover, firms may enhance productivity and quality (Mokhtarzadeh et al., 2020), increase design speed (Vaccaro et al., 2010), accelerate innovation processes (Mokhtarzadeh et al., 2020), reduce the time to launch products in the market (Tsai, 2009; Zeng et al., 2010), predict future trends (Santoro et al., 2020; Tsai, 2009) and benefit from economies of scale in joint R&D (Mokhtarzadeh et al., 2020; Zeng et al., 2010).

Based on the above, we conjecture that

H1: Inter-organizational collaboration has a positive impact on the innovation performance of firms.

2.2.2. The impact of the different types of collaboration on innovation performance

Although most authors agree that inter-organizational collaborations positively affect innovation performance, the impact of each type of collaboration on innovation capability seems unobjective (Kafouros et al., 2020; Pittaway et al., 2004; Tsai, 2009).

When addressing the impact of each type of collaboration, several studies revealed that cooperation with customers and suppliers may provide a more stable and productive relationships when compared to competitors (Zeng et al., 2010). Vertical integration with suppliers and customers plays a more distinct role in innovation performance than horizontal cooperation with research institutions, universities, and research organizations (Nieto & Santamaria, 2007).

Moreover, the type of collaboration appears to be related to the kind of innovation. Incremental innovators rely more frequently on their customers as innovation sources, whereas firms with more novel and radical products are more likely to collaborate with suppliers and consultants (Pittaway et al., 2004). This is consistent with the arguments of Nieto & Santamaria (2007) that added supplier collaborations help bring products to the market more quickly. Collaborating with competitors turns out to be the least productive way of conducting innovations, and in fact, its impact is negative for more novel innovations (Nieto & Santamaria, 2007).

Collaborations with customers

According to the Open Innovation approach, customer experience is valued as a major source of knowledge translated into improved innovation capabilities (Urban & Von Hippel, 1988; Wang & Hu, 2020). When partnering with users and adopting a *customer-centric* approach, firms incorporate their unsatisfied needs into newer ideas with added commercial value, mitigating the uncertainty of developing new products or services (Najafi-Tavani et al., 2018; Pittaway et al., 2004; Wang & Hu, 2020) and enhancing their design and technical feasibility (Chesbrough & Appleyard, 2007; Lin et al., 2014; Wang & Hu, 2020). Several authors reinforce the importance of engaging users in the innovation process to discover new market opportunities faster than the competition and benefit from their expertise to avoid the trap of creating an overpriced or over-engineered product (Pittaway et al., 2004; Tsai, 2009).

However, supported by the Dynamic Capabilities approach, managers might want to launch products quickly in the market, spending less time interacting with customers and learning about their needs, sometimes leading to the risk of misfit between the actual customer needs and the product launch in the market (Najafi-Tavani et al., 2018).

Collaborations with suppliers

Overall, firms with a strong network of suppliers register higher productivity levels than those with weak alliances (Laosirihongthong et al., 2014; Sanchez & Perez, 2003). Indeed, collaborating with suppliers tends to be productive because both parties belong to a similar organizational and industry context, facilitating the knowledge transfer process mechanism (Un & Asakawa, 2015).

Moreover, suppliers gain expertise on firm-specific knowledge, processes, and targets, making them knowledgeable enough to recommend innovations and improvements of manufacturing processes to increase efficiency (Un & Asakawa, 2015). By working closely with other firms, suppliers are aware of the best practices in the industry, providing firms with advice on the processes that need to be updated (Un & Asakawa, 2015). From the network theory perspective, supplier collaborations tend to explore the depth rather than the breadth of partnerships, investing in long-term relationships with few partners and introducing practices such as just-in-time or co-designing products (Wang & Hu, 2020).

Regarding product innovations, suppliers enable firms to reduce risks and lead times, enhancing responsiveness, flexibility, and market adaptability (Nieto & Santamaria, 2007; Tsai, 2009; Zeng et al., 2010). Indeed, suppliers have great expertise in the components and materials that are crucial for a firm's technological development (Laosirihongthong et al., 2014; Lin et al., 2014). They make it easier to identify possible technical problems, costly design changes, improved solutions, and new methods for product development (Lin et al., 2014; Tsai, 2009).

Collaborations with competitors

Collaborating with competitors seems to be the least frequent and impactful type of collaboration to improve innovation performance (Tsai, 2009; Zeng et al., 2010). Indeed, several authors alert to the difficulty of establishing stable and trustful partnerships with competitors, as opportunistic behaviour, such as information leakage, is higher (Najafi-Tavani et al., 2018; Nieto & Santamaria, 2007). For that reason, the formal legal protection mechanism and the innovation climate mechanism are even more relevant in the context of coopetition (Liu & Atuahene-Gima, 2018).

However, firms have several reasons to collaborate with competitors. In the product innovation context, competitors may bring along complementary resources and knowledge for the creation of new products and optimization of existing ones (Devece et al., 2019; Faems et al., 2005); and develop new technical innovations from R&D partnerships or co-development of products (Devece et al., 2019). Additionally, firms may share the costs and risks associated with innovations, achieving economies of scale and scope by combining activities (Devece et al., 2019; Tsai, 2009). Therefore, according to Tsai and Wang (2009), firms that collaborate with competitors may gain better innovation performance than working isolated, either by carrying out basic research, establishing standards, or sharing common problems regarding regulations (Nieto & Santamaria, 2007).

Collaborations with research organizations

Research organizations (RO), such as universities and public or private research institutes, can provide complementary resources and skills to help firms develop new technologies and apply them to commercial ends (Faems et al., 2005; Sjoo & Hellstrom, 2019; Wang et al., 2020). Several studies show that technological innovation relies deeply on knowledge from

RO, as firms may fall behind state-of-art technology, unable to adapt to new markets and segments (Nieto & Santamaria, 2007; Tsai & Wang, 2009). Indeed, more than being focused on the innovation process of firms, RO tackle the development of a firm's product innovation, aiming to increase the firm's stock of knowledge inputs, provide firms with problem-solving activities, and conduct research on a particular technology (Jones & de Zubielqui, 2017; Kang & Park, 2012; Wang et al., 2020).

With the increasing encouragement of governments to establish U-I partnerships and the pressure of acquiring additional funding by selling intellectual property, universities have been increasingly relying on industry partners (de Wit-de Vries et al., 2019; Nieto & Santamaria, 2007; Zeng et al., 2010). However, some structural cultural differences in terms of goals, visions, expected outcomes, management styles, allocation of resources, time management and terminology used indicate that partners must make additional efforts to develop the appropriate knowledge transfer mechanisms (de Wit-de Vries et al., 2019; Un & Asakawa, 2015).

Collaborations with consultants

According to Pittaway et al. (2004), third parties such as consultants positively impact the development of external collaborations and innovation, acting as relevant conduits for enlarging the network of informal relationships. Furthermore, firms can also count on consultants' experience in dealing with similar innovation projects and, therefore, help firms avoid past mistakes and catch up to market innovations, particularly in improving innovation processes (Back et al., 2014; Tether & Tajar, 2008). However, difficulties may occur while collaborating with consultants, such as slower decision-making, opportunistic behaviour, poor quality control and too much dependence (Back et al., 2014).

Based on the above, we conjecture that:

H2: The type of collaboration distinctively influences innovation performance.

2.2.3. The impact of business strategies in the relation between collaboration and business innovation performance

The nature of collaboration partners and the impact on innovation performance depends on many factors, such as the overall business strategy of firms (Pittaway et al., 2004; Popa et al., 2017; Zeng et al., 2010). Our research study will focus on how the two generic strategies -

cost leadership and differentiation – affect collaborative innovation. In fact, business strategies may be influenced by the different mechanisms (addressed in Section 2.2.1), as some mechanisms may have a more significant impact if the firm follows a cost leadership or differentiation strategy (Figure 2).

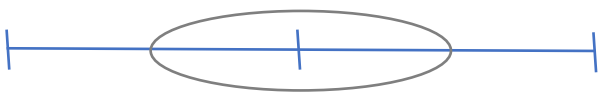
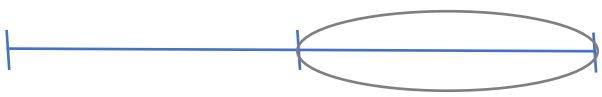
Firms following a differentiation strategy show higher levels of *absorptive capacity*, as combining several types of knowledge through organizational learning allows firms to provide valuable goods and services to customers with a higher degree of quality (Lane et al., 2001; Le & Lei, 2018).

Regarding knowledge management, Le and Lei (2018) highlight the mechanism contributes considerably to both business strategies by minimizing costs to provide a low-cost advantage or increasing the quality of products and customer satisfaction, providing a differentiation advantage.

Furthermore, cost leaders maintain arm's length relationships based on financial outcomes with little coordination and cooperation (Lassar & Kerr, 1996). Indeed, cost leaders may feel reluctant to devote time and resources towards collaboration initiatives that seek to improve innovation performance, as it may carry uncertain returns. Differentiators tend to maintain a closer involvement, control, and behaviour monitoring (Lassar & Kerr, 1996).

Differentiators seek to make the best use of their collaborative capability, creatively exploiting every partner's potential (Jin et al., 2019). This business strategy demands a highly differentiated technology portfolio, inducing firms to search for broader networks and build up higher levels of network competence (Crema et al., 2014; Laosirihongthong et al., 2014).

Considering formal legal protection, cost-oriented firms place more importance on appropriability mechanisms than differentiation-oriented firms (Crema et al., 2014; Desyllas et al., 2018).

Mechanisms	**Cost Leadership**	**Differentiation**
Absorptive capacity		
Knowledge Management		
Innovation Climate		

Network capability	
Formal legal Protection	

Figure 2: Mechanism effectiveness in the two generic strategies

Jin et al. (2019) pointed out that collaboration impacts firms pursuing both low cost and differentiation, but the extent to which they benefit may differ, with differentiation benefiting more from collaborating with partners.

Based on the above, we conjecture that:

H3: Business strategies influence the impact of external collaboration on innovation performance.

H3a: In firms pursuing differentiation strategies, the impact of external collaboration on innovation performance is higher than that of focusing on cost leadership strategies, for all types of collaborations.

2.2.4. Other determinants of business innovation performance

Innovation is a means to change an organization, either due to alterations in its internal or external environments or by actively influencing the environment (Damanpour, 1991). Apart from business strategies, the introduction of innovation in firms is influenced by environmental or external factors and other organizational/ internal determinants (Crossan & Apaydin, 2010; Damanpour & Aravind, 2012; Khosravi et al., 2019).

To better systematize the determinants, we divided them into organizational and environmental.

Organizational determinants relate to internal factors that can be managed by the company and can lead to an improvement or decrease in the ability to adopt innovations (Mendoza-Silva, 2021). These factors reflect knowledge production, *absorptive capacity*, organizational practices, and size, only to name a few (Khosravi et al., 2019). Some authors point out internal resources as a critical factor in improving firm's innovation capabilities, such as human capital (Prajogo & Ahmed, 2006) or wide availability of financial resources to invest in R&D (Damanpour, 1991; Damanpour & Schneider, 2006; Dani & Gandhi, 2021). Others may

relate to the size of the company, the intensity of R&D or the firm's *absorptive capacity* (Damanpour & Schneider, 2006; Radziwon & Bogers, 2019).

Environmental determinants contextualize the opportunities of transferring information, resources and technology with external parties and the limitations imposed by the social or political context, market, or sector, such as regulations and uncertainty (Crossan & Apaydin, 2010; Damanpour & Schneider, 2006). Scholars suggest that although organizational variables have been the most studied, the primary stimulus of innovation derived from the external environment (Damanpour & Schneider, 2006).

From an environmental perspective, firms may be inserted in more favourable environments for innovating than others. For example, market structure and industry characteristics can push firms to improve their innovation capabilities and firms networks' depth and breadth (Crossan & Apaydin, 2010; Pittaway et al., 2004). From the network theory, this relationship is not linear, as the diversity of partners and the multiplicity of interactions between them are also relevant in explaining the different innovation outcomes (Arasti et al., 2021; Ritter, 1999). Public and private financial incentives for innovation are also critical factors in firms' innovative capabilities (Jugend et al., 2020; Kang & Park, 2012).

Figure 3 summarizes de theoretical framework of analysis, highlighting the main hypotheses tested in Section 4.

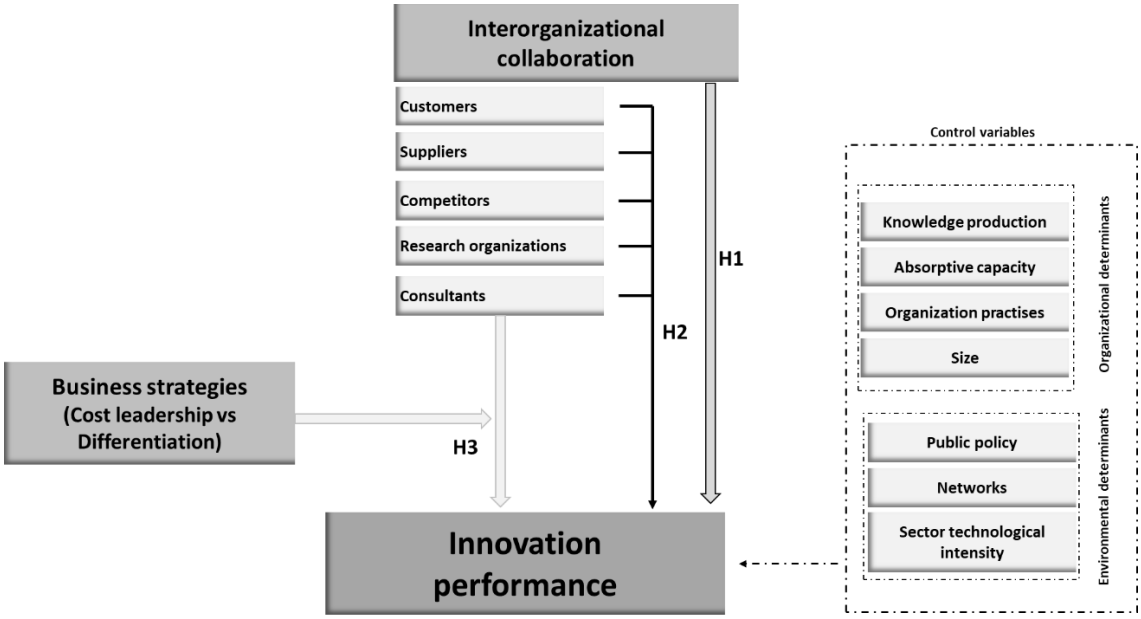


Figure 3: Theoretical framework and main hypotheses to be tested

3. Methodology

3.1. Sample and data

Our empirical analysis is based on the data collected in the Community Innovation Survey (CIS), which refers to the innovative activities that firms developed in the period 2016-2018 (CIS2018). The CIS survey is published by Directorate General for Education and Science Statistics (DGEEC) and Statistics Portugal (INE) with the purpose of disseminating updated information and indicators on business innovation in firms. With a biennial frequency, CIS is performed at a European level, allowing data comparisons and international statistics on innovation across all sectors of economic activity.

The sample is representative of the population of Portuguese firms, stratified according to firm size (considering the number of employees), industry sector (according to CAE) and geographical regions (in terms of NUTS II). CIS2018 also provides information on firms engaged in cooperative activities to achieve product and process innovations, including specifications on the type of partnerships. The starting point of our analysis is the 13701 firms that responded to CIS2018.

Following the approach of Nieto and Santamaria (2007), all firms, innovating and non-innovating, were included in the analysis.

3.2. Methodology of data analysis and estimation technique

Given the nature of our research questions – 1) What is the impact of the distinct types of external collaboration on business innovation performance? and 2) Do business strategies matter for explaining the impact of the distinct types of external collaboration on business innovation performance? –, which involves assessing the causality effect between inter-organizational and innovation performance and the role that business strategies and type of collaboration play in this relationship, we resort to quantitative methodologies (Yin, 2018).

While qualitative research aims to gain in-depth insight into a phenomenon without pre-defining hypotheses, quantitative research focuses on testing a pre-defined theory or hypotheses (Creswell & Creswell, 2017).

Quantitative research methods encompass objective measurements and statistical data analysis, through surveys, polls, or questionnaires (Black, 1999; Creswell & Creswell, 2017). As our aim is to identify factors that influence an outcome, rather than understanding a concept or phenomenon, quantitative methodologies are the adequate choice (Creswell &

Creswell, 2017). However, qualitative approaches should not be discarded for future research agenda, as they provide valuable and deeper understanding of the phenomenon, complementing quantitative studies (Black, 1999).

The relevant literature in the area (see Table 2) uses quantitative related methodologies, most specifically econometric methods, such as the Bivariate Probit model (Nieto & Santamaria, 2007), Ordered Logistic Regression (Nunes et al., 2019), Tobin model (Faems et al., 2005), Hierarchical Regression (Sanchez & Perez, 2003; Tsai, 2009; Wang & Hu, 2020), Panel Regression model (Kafouros et al., 2020; Powell et al., 1996; Un & Asakawa, 2015), and Structural Equation modeling (Najafi-Tavani et al., 2018; Weber & Heidenreich, 2018; Zeng et al., 2010).

The choice of the estimation model to be used should be based on the research questions and the corresponding variables analyzed (Wiersema & Bowen, 2009).

Table 2: Synthesis of the empirical literature according to the methodology of analysis

Authors	Type of collaboration *	Type of innovation**	Years	Location	Number of observations /firms	Methodology
Nieto and Santamaria (2007)	Networks	Product Innovation	1998-2002	Spain	6500	Bivariate probit model
Nunes et al. (2019)	Networks	Technological Innovation	Survey (End of 2010- Beginning of 2011)	Portugal	397	Ordered logistic regression
Faems et al. (2005)	Inter-organizational collaboration	Technological Innovation	1994-1996	Belgium	2164	Tobin model
Wang and Hu (2020)	Networks	Technological Innovation	Survey (July 2014-September 2015)	China	236	Hierarchical regression
Tsai (2009)	Networks	Product Innovation	2002	Taiwan	753	
Sanchez and Perez (2003)	Inter-organizational collaboration	Technological Innovation	Survey (January-June 2005)	Spain	156	
Powell et al. (1996)	Inter-organizational collaboration	Technological Innovation	1990-1994	Global (but mostly US based)	225	Panel Regression model
Kafouros et al. (2020)	R&D Collaborations	Technological Innovation	2003-2011	Spain	8800	
Un and Asakawa (2015)	R&D Collaborations	Process Innovation	1998-2002	Spain	781	
Najafi-Tavani et al. (2018)	Networks	Technological Innovation	Survey	Iran	258	Structural equation modeling
Zeng et al. (2010)	Networks	Technological Innovation	Survey	China	137	
Weber and Heidenreich (2018)	Inter-organizational collaboration	Technological Innovation	Survey (End of 2012- Beginning of 2013)	Germany	154	

Notes: * Type of collaboration: As stated in section 2.1.1, inter-organizational collaboration can be evaluated in general or a specific type of collaboration, namely networks or R&D collaborations; ** Type of innovation: As stated in section 2.1.2, technological innovation or innovation performance can be conceptualized in general or a specific type, either product or process innovation.

In this case, our interest is to know whether different types of collaborations enhance (or not) innovation performance in firms (mediated by business strategies). In line with Nieto and Santamaria (2007), as dependent variables are binary innovative/non-innovative, the most adequate method will be logit or probit estimation models (Wiersema & Bowen, 2009). As the dependent variable assumes values of 0 or 1, conventional linear models (e.g., OLS) are inadequate as the underlying assumptions are not met (Ardito & Petruzzelli, 2017; Wiersema & Bowen, 2009).

3.3. Proxies for the relevant variables and main descriptive statistics

To test our hypotheses, we need to define the variables analyzed. Table 3 presents a description of all variables in our model based on the responses given by the firms to the CIS2018 survey. Technological innovation, which includes product and process innovation, is the proxy of innovation performance and, thus, the dependent variable in all hypotheses.

In H1, the objective is to assess whether collaborations have an impact on firms' technological innovation. In H2, we investigate whether different types of collaboration (clients, competitors, suppliers, consulting, and research organizations (including universities and R&D labs)) impact distinctively on firms' technological innovation. In H3, the aim is to evaluate if the business strategies influence the impact of collaborations on technological innovation. For testing the latter hypothesis, it was necessary to include interaction variables, namely 'Collaboration×Type of business strategy' and 'Type of collaboration×Type of business strategy'.

As previously stated, some variables, other than collaboration and business strategies, may impact technological innovation, and thus need to be controlled for. These control variables include knowledge production, measured by both intellectual property endowments and intramural R&D; *absorptive capacity*, which provides for human capital, training, new machinery acquisition, external technical knowledge, and external R&D. Other organizational control variables include flexible organizational practices, size, and multinationalism. As for environmental control variables, we consider public policy, reflected by public financial support (namely grants and fiscal incentives to innovation activities, grants and fiscal incentives to other activities), network intensity and sector technological intensity.

Table 3: Determinants of technological innovation performance

Group of variables	Variable	Description of the proxy [the constructs of the variables are computed for the period 2016-2018]	Mean	Std dev	Min	Max
Dependent Variable	Technological innovation	Dummy-variable that assumes the value 1 when the firm introduced new or significantly improved products and processes and 0 otherwise.	0.357	0.479	0	1
Collaborations		Dummy-variable that assumes the value 1 when the firm collaborated with other firms or institutions in R&D, innovative activities, or other activities and 0 otherwise.	0.141	0.348	0	1
Type of collaboration	Clients	Dummy-variable that assumes the value 1 when the firm collaborated with client firms in Portugal or other countries and 0 otherwise.	0.037	0.189	0	1
	Competitors	Dummy-variable that assumes the value 1 when the firm collaborated with competitors in Portugal or other countries and 0 otherwise.	0.012	0.108	0	1
	Suppliers	Dummy-variable that assumes the value 1 when the firm collaborated with supplier firms of equipment, materials or software in Portugal or other countries and 0 otherwise.	0.057	0.232	0	1
	Consulting	Dummy-variable that assumes the value 1 when the firm collaborated with consulting firms, private laboratories, or private investigation centres in Portugal or other countries and 0 otherwise.	0.049	0.215	0	1
	Science – Universities and R&D labs	Dummy-variable that assumes the value 1 when the firm collaborated with universities or public research organizations in Portugal or other countries and 0 otherwise.	0.048	0.213	0	1
Collaboration*Strategy	Collaborations* Differentiation	Interaction variable that considers the dummy-variable 'Collaborations' and the dummy-variable 'Differentiation' (which assumes the value 1 when the firm follows a differentiation business strategy and 0 otherwise).	0.067	0.250	0	1
	Collaborations* Cost	Interaction variable that considers the dummy-variable 'Collaborations' and the dummy-variable 'Cost' (which assumes the value 1 when the firm follows a cost business strategy and 0 otherwise)	0.017	0.128	0	1
Type of collaboration*Strategy	Clients* Differentiation	Interaction variable that considers the dummy-variable collaborations with 'Clients' and the dummy-variable 'Differentiation'	0.022	0.148	0	1
	Competitors* Differentiation	Interaction variable that considers the dummy-variable collaborations with 'Competitors' and the dummy-variable 'Differentiation'	0.006	0.079	0	1
	Suppliers* Differentiation	Interaction variable that considers the dummy-variable collaborations with 'Suppliers' and the dummy-variable 'Differentiation'	0.032	0.176	0	1
	Consulting* Differentiation	Interaction variable that considers the dummy-variable collaborations with 'Consulting' and the dummy-variable 'Differentiation'	0.026	0.160	0	1
	Science* Differentiation	Interaction variable that considers the dummy-variable collaborations with 'Science' and the dummy-variable 'Differentiation'	0.027	0.163	0	1
	Clients* Cost	Interaction variable that considers the dummy-variable collaborations with 'Clients' and the dummy-variable 'Costs'	0.004	0.063	0	1
	Competitors* Cost	Interaction variable that considers the dummy-variable collaborations with 'Competitors' and the dummy-variable 'Costs'	0.002	0.044	0	1
	Suppliers* Cost	Interaction variable that considers the dummy-variable collaborations with 'Suppliers' and the dummy-variable 'Costs'	0.007	0.083	0	1
	Consulting* Cost	Interaction variable that considers the dummy-variable collaborations with 'Consulting' and the dummy-variable 'Costs'	0.006	0.074	0	1
	Science* Cost	Interaction variable that considers the dummy-variable collaborations with 'Science' and the dummy-variable 'Costs'	0.005	0.070	0	1

Group of variables	Variable	Description of the proxy [the constructs of the variables are computed for the period 2016-2018]	Mean	Std dev	Min	Max
Knowledge production	Intellectual property endowments	Dummy-variable assuming value 1 when the firm did one of the following activities: i) Requested a patent; ii) Registered a right to industrial design; iii) Registered a trademark; iv) Claimed copyright; v) Used trade secrets, and 0 otherwise.	0.147	0.354	0	1
	Intramural R&D	Dummy-variable assuming value 1 when the firm performed R&D activities indoors and 0 otherwise.	0.114	0.318	0	1
Absorptive capacity	Human capital	Natural logarithm of a scale variable that ranges from 1 (0% of workers with tertiary academic degree) to 7 (75%-100% of workers with tertiary academic degree)	1.054	0.605	0	1.946
	Training	Natural logarithm of the amount (in euros) the firm spent on the job training (including internal costs, salaries while employees are being formed and costs with the external services).	4.878	4.681	0	18.12
	New Machinery acquisition	Dummy-variable assuming value 1 when the firm acquired new machinery, equipment, and software, that were not yet used in-house and 0 otherwise.	0.389	0.488	0	1
	External technical knowledge	Dummy-variable assuming value 1 when the firm acquired technical, scientific, or engineering services and 0 otherwise.	0.368	0.482	0	1
	External R&D	Dummy-variable assuming value 1 when the firm contracted R&D from external firms or institutions and 0 otherwise.	0.063	0.243	0	1
Flexible organizational practices		Dummy-variable assuming value 1 when the firm gave high importance to one of the following items: i) Rotation of employees across functional areas; ii) Regular brainstorming sessions; iii) Cross-functional teams and 0 otherwise.	0.111	0.314	0	1
Size	Medium	Dummy-variable assuming value 1 when the firm is medium size (50-249 workers) and 0 otherwise.	0.194	0.395	0	1
	Large	Dummy-variable assuming value 1 when the firm is large size (250+ workers) and 0 otherwise.	0.127	0.333	0	1
Multinational		Dummy-value assuming 1 when the firm has headquarters located outside of Portugal and 0 otherwise.	0.106	0.307	0	1
Public policy	Financial support	Dummy-variable assuming 1 when the firm received at least one of the following financial supports: i) Local government; ii) Administrative Government; iii) Program Horizon 2020; iv) European Union and 0 otherwise.	0.178	0.382	0	1
	Grants and fiscal incentives for innovation activities	Dummy-variable assuming 1 when the firm received fiscal subsidies or credits to support R&D activities and 0 otherwise.	0.080	0.271	0	1
	Grants and fiscal incentives for other activities	Dummy-variable assuming 1 when the firm received fiscal subsidies or credits to support other activities and 0 otherwise.	0.099	0.299	0	1
Networks	Gathering of external knowledge	Natural logarithm of the number of distinct sources of knowledge resorted by the firm, including: i) Conferences, fairs, or exhibits; ii) Technical, scientific or commercial magazines; iii) Information about professional and industrial associations; iii) Information about published patents; iv) Information about published patents; v) Information about documents or standardization committees; vi) social networks based on web or crowdsourcing; viii) Open platforms for B2B transactions or open-source software; ix) Information on reverse engineering.	0.966	0.715	0	2.197
Sector technological intensity	Medium	Dummy-variable assuming value 1 when firm operates in a medium technological intensive sector and 0 otherwise.	0.556	0.497	0	1
	High	Dummy-variable assuming value 1 when firm operates in a high technological intensive sector and 0 otherwise.	0.024	0.152	0	1

Notes: Variables description according to CIS Survey.

Taking into consideration the data from the CIS Survey, we can extract relevant information on the contextual paradigm of Portuguese firms' innovation performance between 2016 and

2018 (see Table 3). From an overall perspective, only 36% of the firms have managed to generate technological innovations by implementing new products or processes during the period of analysis. Moreover, only 14.1% of the total firms have collaborated with external entities for performing innovation activities, either through vertical collaboration (with suppliers and clients) or horizontal collaboration (with competitors, consulting firms and research organizations).

Analyzing the specific types of collaboration in detail, supplier collaboration has been the most frequently reported, with 5.7% of the firms stating they collaborated with suppliers for performing innovation activities between 2016 and 2018. As expected and aligned with Nieto and Santamaria (2007), collaboration with competitors for performing innovation activities is the least frequent type of collaboration, with only 1.2% of firms.

Regarding the business strategies, a higher percentage of firms point out that they are particularly focused on differentiating and delivering new products or services to the market (23% of the total), as compared with the focus on costs and price reductions (13% of the total).

The control variables can also provide insights into the Portuguese context, a moderate innovator characterized by some laggardness in business innovation (Teixeira & Bezerra, 2016). Indeed, on the one hand, only 11.4% of firms performed internal R&D activities and only 6.3% implemented external R&D activities. As for flexible organizational practices, only 11.1% gave high importance to the rotation of employees across functional areas, regular brainstorming sessions or cross-functional teams. Regarding the size, small companies represent around 68% of the sample, and only 2.4% of firms operate in a high technology sector. The percentage of employees with academic degrees remains a bottleneck, as, on average, firms have only between 1 to 10% of employees with a tertiary academic degree. On the other hand, 38.9% of the sample acquired new machinery, equipment, and software between 2016 and 2018.

3.4. Empirical results

To better understand if the model has a good fit, we undertook some diagnosis tests for investigating issues of heteroscedasticity and multicollinearity. According to the results of the Breusch–Pagan test, which show that the hypothesis of having constant variance in the residuals is rejected, there are heteroscedasticity problems. Therefore, the heteroscedastic errors must be corrected by estimating the relevant coefficients with robust standard errors. As for the multicollinearity, there is no evidence of this problem, as the mean and maximum VIF are low and below 5. Furthermore, the LR chi2 suggests that the models estimated are statistically significant. The Pseudo R2 indicates that 28.9% of the variance is explained by the included variables. Summing up, the models present a reasonable goodness of fit.

The estimations presented in Table 4 evidence that inter-organizational collaboration has a significant and positive impact on the firm's innovation performance. Specifically, according to our data, with all the other factors remaining constant, the odds of technological innovation are 1.44 ($e^{0.366}$) higher in firms that collaborate with external entities. In short, H1 ("*Inter-organizational collaboration has a positive impact on the innovation performance of firms*") is validated. Although only 14,1% of the total firms collaborated with external entities, inter-organizational collaboration substantially increases the technological innovation/ performance of Portuguese firms, which is in line with the argument by Nunes et al. (2019). Indeed, for most of small enterprises, which represent 68% of firms of our sample, the only way to innovate and ensuring competitiveness is by cooperating with external organizations, as in-house resources tend to be scarce.

Additionally, estimates suggest that collaborating with distinct entities yields to distinct impacts on innovation performance, which validated hypothesis 2 (H2). Specifically, we found that the odds of technological innovation, our proxy for innovation performance, come significantly higher in the case of vertical collaboration with clients and suppliers, respectively 2.4 ($e^{0.872}$) and 1.9 ($e^{0.658}$) higher.

Such results are in line with the literature, as vertical collaborations (i.e., with clients and suppliers) have been proven to be more efficient than horizontal linkages (Nieto & Santamaria, 2007; Zeng et al., 2010). Clients are especially relevant to adopt new practices and improve products and services, particularly in sectors (e.g., services) where clients contribute extensively to new product development (Fernandes et al., 2017). Furthermore, Portuguese firms obtain production improvements through arrangements with suppliers (de

Carvalho et al., 2017; Teixeira & Bezerra, 2016) that are substantially developed via new machinery. It is interesting to note that in the period of analysis (2016-2018), almost 40% of firms claimed to have acquired new machinery, an important channel through which firms located in moderate innovators countries innovate (Leitão et al., 2020), which explain the strong ties Portuguese firms have with suppliers.

Collaborating with consulting firms also has a positive but smaller impact on innovation performance, with firms establishing this type of partnership being 1.5 more likely to produce technological innovations. Thus, consultants seem to influence firms' practices and help the firm establish product and process innovation, which is in line with Simao and Franco (2018) but differs from the work of de Faria et al. (2010). Our results suggest that consultants can be highly relevant in the Portuguese context, as in a context of relative scarcity of qualified human capital, consultants can be requested to perform highly skilled activities and provide access to unique knowledge (Simao & Franco, 2018).

Also sustained by the literature, collaboration with competitors has shown to produce fewer results, and in this case, there is no indication that it directly impacts firm's innovation performance. As competitors continue to be rivals, it is necessary to protect knowledge and avoid opportunistic behaviours, investing in monitoring systems and close interactions. This comes with a cost, which may offset many Portuguese firms to pursue this type of collaboration and opt for other types of partnerships (Simao & Franco, 2018).

Similarly, no evidence was found that collaborating with research organizations (RO) induces higher probabilities of producing technological innovations in the Portuguese context. Portuguese firms don't seem to realize the potential of scientific sources for their innovation performance (Teixeira & Bezerra, 2016). Indeed, researchers point out a polarization of collaborative approaches between universities that opt for formal R&D processes and firms that prefer a more interactive approach (Fernandes et al., 2017; Simao & Franco, 2018).

Regarding the interaction between business strategies and collaboration, estimation results validate H3 ("*Business strategies influence the impact of external collaboration on innovation performance*"). In fact, firms following a differentiation strategy are 1.7 more likely to generate technological innovations through collaborations, when compared to firms that pursue cost strategies. Similarly to Jin et al. (2019), the differentiation strategy is proven to be more efficient than the cost leadership strategy when it comes to collaborative innovation. The authors claimed that both strategies impact collaboration, but to a different extent. However, in our study,

no evidence was found that following a cost leadership strategy can lead to a more productive partnership in terms of innovation performance. Accordingly, our results suggest that business strategies influence the impact of external collaboration on innovation performance, with differentiation strategy inducing higher probabilities of fruitful collaborative innovation. Firms focusing on cost leadership strategies tend to pursue collaborations that will bring immediate returns to efficiency, through superficial interactions that sometimes do not even aim to develop their innovation capabilities, whereas firms following a differentiation strategy are committed to utilize partners' full potential and improve their innovation capabilities (Jin et al., 2019).

Analyzing the mediating effect of business strategies in the relationship between each type of collaboration and innovation performance, estimation results partially verified H3a ("*In firms pursuing differentiation strategies, the impact of external collaboration on innovation performance is higher than of that focusing on cost leadership strategies, for all type of collaborations*"). For the sample of Portuguese firms that answered to CIS2018, firms that pursued differentiation strategies showed a higher impact of external collaboration on innovation performance than of firms focusing on cost leadership strategies, but only in the case of supplier and consulting collaboration. Firms increase their odds of innovation performance by 1.7 ($e^{0.542}$) in supplier collaboration and 1.8 ($e^{0.605}$) in consulting collaboration if they follow a differentiation strategy instead of a cost leadership strategy. This is in line with the work of Pittaway et al. (2004), that suggest in firms that have products new to a market will more likely collaborate with suppliers and consultants. As previously stated, supplier collaboration tends to be deeper than other forms of partnerships, as there is a supreme understanding of the business necessities. Therefore, to exploit the best of these types of collaborations, firms invest in the depth rather than the breath of their network with the aim of improving their innovation capabilities and gaining insights on the components, the design adaptations and new methods of product development (Tsai, 2009). Therefore, it is more likely that differentiation firms nurture the relationship when compared to cost leadership firms, which will probably choose suppliers according to the price. Furthermore, consulting firms may bring more distinctive inputs to market or product development projects (Back et al., 2014; Tether & Tajar, 2008), with knowledgeable consultants studying current trends to analyze if the market is ready or not for new products or services.

Table 4: Determinants of firms' technological innovations, 2016-2018 (logistic estimations)

		All collaborations	Types of collaboration				
			Clients	Competitors	Suppliers	Consulting	Science
	Collaborations	0.366*** (0.094)					
Type of collaboration	Clients		0.872*** (0.265)				
	Competitors			0.475 (0.447)			
	Suppliers				0.658*** (0.203)		
	Consulting					0.423* (0.233)	
	Science						0.035 (0.245)
Collaboration *Strategy	Collaborations* Leadership	0.527*** (0.141)					0.314 (0.327)
	Collaborations* Cost	-0.082 (0.199)					
Type of collaboration*Strategy	Clients* Leadership		0.221 (0.382)				
	Competitors* Leadership			0.807 (0.762)			
	Suppliers* Leadership				0.542* (0.290)		
	Consulting* Leadership					0.605* (0.342)	
	Science* Leadership						0.314 (0.327)
	Clients* Cost		-0.441 (0.541)				
	Competitors* Cost			-0.679 (0.857)			
	Suppliers* Cost				-0.043 (0.430)		
	Consulting* Cost					0.207 (0.556)	
	Science* Cost						-0.069 (0.456)
Knowledge production	Intellectual property endowments	0.727*** (0.065)	0.731*** (0.065)	0.733*** (0.065)	0.724*** (0.065)	0.728*** (0.065)	0.734*** (0.065)
	Intramural R&D	1.854*** (0.107)	1.879*** (0.106)	1.921*** (0.105)	1.864*** (0.106)	1.882*** (0.105)	1.916*** (0.105)
Absorptive capacity	Human capital	-0.010 (0.042)	0.009 (0.042)	0.012 (0.042)	0.006 (0.042)	0.008 (0.042)	0.010 (0.042)
	Training	0.037*** (0.005)	0.038*** (0.005)	0.039*** (0.005)	0.038*** (0.005)	0.038*** (0.005)	0.039*** (0.005)
	New machinery acquisition	0.995*** (0.047)	0.998*** (0.047)	1.004*** (0.047)	0.994*** (0.047)	1.000*** (0.047)	1.005*** (0.047)
	External technical knowledge	0.335*** (0.049)	0.360*** (0.049)	0.365*** (0.049)	0.346*** (0.049)	0.353*** (0.049)	0.365*** (0.048)
	External R&D	1.071*** (0.152)	1.142*** (0.151)	1.180*** (0.148)	1.105*** (0.150)	1.123*** (0.151)	1.174*** (0.149)
	Flexible organizational practices	0.234*** (0.070)	0.240*** (0.070)	0.246*** (0.069)	0.240*** (0.070)	0.244*** (0.069)	0.247*** (0.069)
	Multinational	0.176** (0.075)	0.183** (0.075)	0.176** (0.075)	0.178** (0.075)	0.176** (0.075)	0.175** (0.075)
Size	Medium	-0.138** (0.059)	-0.133** (0.059)	-0.139** (0.059)	-0.132** (0.059)	-0.138** (0.058)	-0.142** (0.059)
	Large	- 0.126* (0.075)	-0.120 (0.075)	-0.118 (0.074)	-0.122 (0.075)	-0.124* (0.075)	-0.121 (0.075)

(…)

		All collaborations	Types of collaboration				
			Clients	Competitors	Suppliers	Consulting	Science
Public policy	Public financial support	0.319*** (0.061)	0.335*** (0.061)	0.344*** (0.061)	0.331*** (0.061)	0.333*** (0.061)	0.345*** (0.061)
	Grants and fiscal incentives to innovation activities	0.342** (0.115)	0.369*** (0.114)	0.394*** (0.113)	0.356*** (0.114)	0.371*** (0.114)	0.386*** (0.114)
	Grants and fiscal incentives to other activities	0.256*** (0.077)	0.293*** (0.077)	0.299*** (0.077)	0.296*** (0.077)	0.298*** (0.077)	0.295*** (0.077)
Networks	Sources of external knowledge	0.543*** (0.038)	0.557*** (0.038)	0.563*** (0.038)	0.554*** (0.038)	0.555*** (0.038)	0.562*** (0.038)
Sector technological intensity	Medium	-0.040 (0.046)	-0.038 (0.046)	-0.037 (0.046)	-0.041 (0.046)	-0.035 (0.046)	-0.038 (0.046)
	High	-0.114 (0.163)	-0.113 (0.163)	-0.102 (0.161)	-0.123 (0.163)	-0.113 (0.163)	-0.102 (0.161)
	Breusch–Pagan/Cook–Weisberg test (p-value)	64.80 (0.000)	63.44 (0.000)	65.79 (0.000)	63.28 (0.000)	64.35 (0.000)	65.09 (0.000)
	Mean VIF [Max]	1.27 [1.82]	1.40 [2.73]	1.37 [2.38]	1.38 [2.58]	1.38 [2.53]	1.40 [2.72]
	LR chi2 (p-value)	2747.21 (0.000)	2747.28 (0.000)	2792.77 (0.000)	2718.72 (0.000)	2729.67 (0.000)	2797.55 (0.000)
	Pseudo R2	28.3%	28.1%	27.9%	28.2%	28.1%	27.9%

Note: N=13701. Robust errors in brackets; *** (**) (*) statistically significant at 1% (5%) (10%). Grey cells identify statistically significant estimates.

Organizational determinants seem to have an overall positive impact on technological innovation. The odds of achieving technological innovation are higher by having intellectual property endowments, performing intramural R&D, training employees, acquiring new machinery, acquiring external technical knowledge, performing external R&D, having flexible organizational practices and being a multinational. However, when controlling for all the remaining factors, no evidence was found of a statistically significant relationship between human capital proxy and innovation performance of Portuguese firms. In line with results obtained in Teixeira and Bezerra (2016), one can conjecture that human capital might be relevant for innovation performance is not necessarily reflected in having a higher percentage of workers with tertiary academic degrees.

Regarding the environmental determinants, public policies seem to positively impact on technological innovation, together with network intensity. The firm size and sector's technological intensity seems to have an ambiguous relationship with innovation performance, with no evidence that operating in a technological intensive sector per se leads to higher technological innovations.

4. Conclusions

When studying the impact of external collaborations on innovation performance, researchers have mainly focused on a specific type of partnership, overlooking the issue of how the different types of collaborations interact with innovation performance. Furthermore, the role of business strategies as a mediator of the relationship between each type of collaboration and innovation performance is still unclear.

Seeking to address these literature gaps, we resort to logistic estimations based on a sample of 13701 firms located in Portugal that responded to the Community Innovation Survey (CIS), which analyzes firms' innovation activities and performance over the period 2016-2018.

Four main results are worth highlighting. First, inter-organizational collaboration significantly contributes to innovation performance. Second, vertical collaborations (i.e., collaborations with clients and suppliers) emerged as more productive than horizontal collaborations in achieving technological innovations. Third, firms following a differentiation strategy amplify the impact of external collaborations on innovation performance. Fourth, the mediating effect of business strategies is only statistically relevant for collaboration with suppliers and consulting firms.

Regarding the contributions to the literature, the present proposal introduces the concept of business strategies in the impact of the different types of collaborations on innovation performance. Although the impact of the various types has been previously addressed, business strategies were for the first time considered in this relationship. Therefore, business strategies emerge as an important factor of collaborative innovation.

Our study has important managerial implications. Firstly, collaborating with external entities is a great opportunity to improve firms' innovation capabilities. Secondly, firms may choose to partner with entities that better fit their expectations and necessities, having in mind that the more productive partnerships for firms located in Portugal, a moderate innovator, are clients, suppliers, and consultants. Thirdly, if a firm follows a differentiation strategy and aims to introduce a new product or service in the market, partnering with consultants and suppliers will likely produce amplified results in terms of innovation performance.

Notwithstanding the contributions and novelties of the present study, this research has some limitations, which are likely to constitute interesting and challenging paths for further and

future research. First, we analyze a single context of moderate innovators, Portugal. It would be interesting to include in the analysis other moderate innovators as well as strong innovators to investigate eventual specificities. Second, the period in analysis, covering 2016-2018, is a period of recovering from the 2011-2014 crises and austerity program. It would be an interesting path for further research to undertake a longitudinal study to assess the extent to which external collaboration and business strategies distinctively impacted on innovation performance.

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