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REVIEW

Sources of knowledge in the firm: a review on influential, internal and contextual factors in innovation dynamics

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Abstract

The sources of knowledge are diverse, as each firm interacts with multiple actors in pursuing its mission: partners and strategic allies, suppliers, customers, competitors, specialist organizations such as knowledge-intensive business services, universities, technology centres, public research organizations, innovation intermediaries and public administration bodies. Different kinds of knowledge, both tacit and codified, are relevant for firms. Nevertheless, knowledge needs to be translated into the capacity to act. Hence, knowledge generation and absorption can be understood as two sides of the same coin and it is necessary to take factors that shape both facets into account, in addition to the relationship between the production, transfer and valorisation of knowledge. This article reviews crucial factors for knowledge in firms, aggregated as influential, contextual and internal. Influential factors are associated with knowledge tacitness and the existing knowledge base, whereas the internal characteristics of the firm are also crucial and concern aspects such as the existing innovation culture, leadership attributes and internal research and development capabilities. Finally, contextual factors, such as the territorial dynamics, are essential as environmental enablers for generating and absorbing knowledge. Together, these factors reinforce the dynamic capabilities of the firm and influence the decision to either engage in open innovation strategies or prioritize actions that protect and codify knowledge, thus affecting the firms' competitiveness.

Keywords Knowledge · Firm · Innovation · Networks · Territorial innovation models · Sources of knowledge

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Introduction

Knowledge is a key asset for firms. It is crucial for stimulating innovation in the form of new products and processes, as well as central to the value creation process and competitiveness of firms. The most competitive firms tend to be those that actively seek new knowledge and show a strong capacity to retain it (Bloodgood 2019; Caiazza et al. 2015). This is more so the case of firms that operate in emerging sectors and global entrepreneurial ecosystems, that require cutting-edge knowledge (Audretsch and Feldman 1996; Brito and Leitão 2021).

As such, institutions associated with knowledge production have received a greater degree of attention, namely universities, public research organizations (PROs) (Domínguez-Gómez, Pinto and González-Gómez 2021) or private research enterprises stemming from foundations or corporate research and development departments (Perkmann et al. 2013). These organizations seek to promote the utilization of their accumulated scientific and technical expertise in the form of firm innovation. Concepts such as the entrepreneurial university (Etzkowitz 2016), knowledge transfer (Bozeman et al. 2015), or science commercialisation (Wright and Phan 2018) exemplify this new paradigm for public science that emphasizes the role of knowledge transfer and open innovation in firm competitiveness.

Knowledge, however, is not only a key factor for larger firms that operate in global environments, it is also crucial for firms in medium or low-tech sectors and in less developed or peripheral regions as well (Evangelista et al. 2010). Small and medium enterprises (SME), which comprise the vast majority of the industrial fabric, are using scientific knowledge with increasing frequency (Braun and Hadwiger 2011; Wang et al. 2010), something policy-makers have been paying more attention these past few years, with mandates for open innovation and public access clauses tied with research funding (Garcia-Perez-De-Lema et al. 2017; Leonelli et al. 2015).

Therefore, to achieve a robust understanding of the role of knowledge in firms, one needs to consider the different environments, economic sectors, type, and size of firms. This article aims to provide an overview of the sources of knowledge, drawing on key strands of research that focus on the processes that shape production, transfer, and utilization of knowledge by firms in different types of organizational and territorial environments.

The article is also based on a fundamental assumption concerning the effects of knowledge on innovation. Innovation is an umbrella concept that refers to overlapping constructs such as creativity, invention, research and technology, learning, and diffusion. Innovation is a broad social process that involves a large array of actors (Corsaro et al. 2012). It can be understood as the transformation of different kinds of knowledge into value.

In this article, innovation transcends the narrow vision of a new or significantly improved product or process for the firm or market. It is also connected to social change (Fløysand and Jakobsen 2011) and the transformation of society towards a more sustainable path and a better future (Schrettle et al. 2014). This means that

innovation is not just understood as generating economic value, but rather with a qualitative improvement of the broad processes behind it, as well with the well-being of individuals that are part of the larger ecosystem (Noya 2011).

Knowledge production and knowledge absorption are two sides of the same coin. It is necessary to consider the key factors that shape both dimensions of the process and their relationships, including types of knowledge, features of firms and characteristics of the environment. The contribution of this article is to provide a holistic discussion of these dimensions that are frequently dissociated.

The article is structured as follows: "Methodology" explains the methodological options made and the criteria used for the selection of subjects and works cited. "Influential factors for knowledge in the firm" presents key notions concerning the nature and types of knowledge, modes of innovation, that constitute crucial influential factors. "Internal factors for knowledge in the firm" deals with specific internal factors that shape knowledge sources from the perspective of the firm. It covers frameworks that refer to absorptive capacity, technological intensity, ambidexterity, open innovation, and other key aspects, such as culture, human capital and skills, and leadership. "Contextual factors for knowledge in the firm" highlights the environmental characteristics that create a supportive context for firms and is organized according to relevant territorial innovation models and related concepts, such as clusters, and ecosystem. The article ends with some concluding remarks and broader implications for researchers and practitioners.

Methodology

Sources of knowledge constitute a far too broad and complex subject to be extensively discussed in a single article. For instance, many of the current approaches are grounded in cognitive, theoretical, and disciplinary bases that are difficult to combine. Perhaps the only common factor in the related literature is the acknowledgement that all firms acquire and process knowledge and incorporate it into their activities. Therefore, it is essential for every firm to pay attention to the sources of knowledge and their related dynamics, regardless of size, sector, and location.

There is no single structured research endeavour under which research on sources of knowledge can be slotted. Sources of knowledge constitute a *constellation* of pluridisciplinary issues that should be examined and combined strategically, depending on the conditions of different types of firms. To give meaning to the different approaches, this article selects a range of topics that are considered important for a wide audience of scholars, practitioners, and firms and offers a concise and open interpretation of their definition and application.

Since the goal of this article is to provide an overview of a rather broad and complex subject, grounded in multiple disciplinary backgrounds and diverse (and often competing) theoretical contributions, our selection of subjects related to sources of knowledge was based on how relevant the subjects are to the field and how easily they can be understood by an audience not as familiar with sources of knowledge.

A work of this nature can never be comprehensive nor delve into specific contributions in great depth: a limitation we fully acknowledge. But it is our hope that this

work might prove useful for those seeking a point of entry into this rather complex field of research. And we stress that this complexity steams from multiple disciplinary backgrounds that seldom engage in multidisciplinary dialogue, thus promoting a fragmentation of the field of sorts.

We attempt to provide an overview of sources of knowledge that breaks the disciplinary divides and combines contributions from several disciplines and fields into a cohesive and concise explanation of the issues deemed essential for researchers and practitioners. Due to our goal, we tried to simplify the language and present definitions more easily accessible to a broader audience than the specialized literature does, while balancing the scientific complexity of the debate.

The selection of works cited was based on how relevant they are in the field, namely on the account of their historical contributions, theoretical landmarks and ground-breaking research outputs. We used Scopus and Web of Knowledge databases, as well as Google Scholar to identify the most cited works on the subjects discussed. For the most part, this was a rather straightforward endeavour. But in some cases where the research was too specific or topical for the aim of the article, we opted to attribute less attention to them or even focus on other articles that were more adequate for the purpose at hand.

Influential factors for knowledge in the firm

The conceptual space of knowledge

Most common definitions of knowledge in modern scholarly works refer to a combination of intellectual faculties, stocks of information, and capabilities. Essentially, it can be said that major advances in management and organization studies have been associated with the so-called *procedural knowledge* (also labelled *knowing how*) or, in other words, the knowledge exercised when carrying out a specific task that requires an understanding of how to perform an action correctly, or exercise a skill for a specific purpose. Procedural knowledge usually differs from other notions such as *descriptive* (or propositional) knowledge. Unlike descriptive knowledge (also labelled *knowing-that*), which involves knowledge of specific facts or propositions, procedural knowledge involves the ability to do something independently of the verbal articulation and codification required for it to count as knowledge.

Procedural or practical knowledge is a useful point of departure for discussing knowledge in firms because of the implications for practices. The main assumption of the emphasis on practical knowledge is encapsulated in the definition of knowledge as the *capacity to act* (Adolf and Stehr 2017), rooted in culture and personal skills, and translated into organizations by virtue of knowledge management. Nevertheless, it is important to consider other approaches to knowledge as complementary and equally important. Descriptive, conceptual, and common-sense knowledge have gradually been incorporated into scholarly work on knowledge management and have been found essential for business innovation.

The next section introduces conceptual elements that are useful for understanding the complexity posed by different types of knowledge and helps delineating the

basic conceptual space. It selects notions that can be used as tools when reviewing the main frameworks.

The explicit and tacit character of knowledge

Contemporary approaches to the study of the role of knowledge in firms have largely been influenced by Michael Polanyi's seminal work Personal Knowledge (Polanyi, 2005 [1958]), which differentiates between explicit and tacit knowledge. This proposal was highly influential in social sciences and management, with many authors building on Polanyi's original proposal. One such seminal contribution is Nonaka and Takeuchi's study (1995), which updates and provides a more formal definition for explicit and tacit knowledge.

Explicit knowledge refers to forms of knowledge that have been codified, systematized and documented and are thus grounded in formal language, enabling them to be more easily shared and transmitted in the form of words, numbers, formulas, and other visual representations. Most of what is taught in schools and universities falls into the explicit knowledge category, which is ingrained in Western philosophy and Western management and labour theories. This later point was paramount in Nonaka and Takeuchi's work (1995: pp. 8–9), as they argued that since Frederick Taylor and Herbert Simon's endeavours, Western countries have focused on explicit knowledge as the key to performance and productivity.

Conversely, tacit knowledge, also referred to as implicit knowledge, is grounded in practice and is not readily available for sharing. Many activities, such as fishing, mechanics, construction, and carpentry are examples of tasks that cannot be mastered simply by reading a manual. They are learnt through praxis, practical first-hand experience, which was how professional skills were passed on throughout most human history: a master taught the apprentice, who worked closely with him, learning while performing certain tasks. In the context of firms and organizations, this knowledge first needs to be codified so that it can be "communicated and shared within organizations" (ibid: p. 9) and learnt by others.

However, not all knowledge can be codified. The greatest football, baseball, basketball, or tennis players, for example, do not always succeed as coaches, clearly not because they lack knowledge, but because they are unable to convey this knowledge to others. Hence why Nonaka and Takeuchi stress the intangible dimensions and the idea that not all learning is conscious or deliberate.

New things are learnt through contact with others, whether this is recognized and intentional or not. The formal aspects of the culture, procedures, and processes of firms can be taught to new employees, but direct contact and experience is important if they are to completely adopt the mindset and become a fully fledged part of the company. The authors highlight this aspect as a key notion in Japanese management which they attribute to Eastern philosophy, more specifically to Zen Buddhism, thus explaining why Japanese management contrasts with Western management practices (while highlighting the importance of cultural differences behind how knowledge is understood). For these reasons, tacit knowledge is usually considered a deeper and more

fundamental set of abilities, skills, and mentalities, and is often seen as more important than explicit knowledge.

A complementary vision of the knowledge base

Twelve years later, Asheim (2007) reformulated the old philosophical analytic-synthetic distinction into a conceptual framework for studying knowledge bases in innovation processes. This approach is a useful conceptual tool for addressing sources of knowledge in organizations and firms. Focusing on how knowledge relates to innovation, Asheim introduced three knowledge-based types: analytical, synthetic, and symbolic, all indicating different blends of tacit and explicit knowledge, thus breaking with the theory/practice divide that defined the field for decades (cf. Table 1).

Analytical knowledge is more commonly found in highly scientific settings where rational processes are common. The emphasis on research and technical processes requires a greater degree of codified knowledge. Tacit knowledge plays a less prominent role, although craftsmanship is also important for performing research and development. Universities, research driven industries, and laboratories are examples of such settings, where the documentation and transmission of the knowledge created are essential for their activities.

Synthetic knowledge occurs in settings in which innovation is frequently the result of combinations of pre-existing knowledge. It is often an attempt to solve problems or respond to specific needs that may arise in everyday operations. Examples include most industrial machinery, which was developed as a way to address particular needs identified in the production process or improve/expand on existing solutions. The same can be said about mechanical builds, such as vehicles or transportation methods and other applied research settings. Hence, synthetic knowledge "emerges less through either deduction or abstraction, but rather inductively through testing, experimentation, computer-based simulation or practical work" (Asheim 2007: p. 225). As a result, tacit knowledge plays a greater role in synthetic knowledge than in analytical knowledge.

Symbolic knowledge is related to aesthetics and creativity. It is a staple of the creative and cultural industries, including film, publishing, music, design, and art forms in general. Innovation plays an intrinsically central role in these industries, since they are less dependent on material aspects and rely instead on ideas and images. Symbolic knowledge is therefore more reliant on tacitness than both analytical and synthetic knowledge, as the immaterial and intangible dimensions are more prevalent in art and culture, and can seldom be codified.

Innovation and knowledge

Innovation is the other element in the basic conceptual space required to address the sources of knowledge in firms. Modern views of innovation are a combination of the two important streams of thought represented by the Schumpeterian view and the diffusionist view (Godin 2017). Both are based on understanding innovation as a recombination of knowledge as value, although they focus on different parts of the entire process.

Table 1 A typology of differentiated knowledge bases

Explicit	Tacit	
Analytical (science-based)	Synthetic (engineering-based)	Symbolic (arts-based)
Developing new knowledge about natural systems by applying scientific laws; knowing why	Applying or combining (in novel ways) existing knowledge; knowing how	Creating meaning, aesthetic and affective qualities; critical know-how
Scientific knowledge, models, deduction	Problem-solving, inductive, custom production	Creative process
Collaboration within and between research units	Interactive learning with customers and suppliers	Learning-by-doing in studio, project teams
Strong codified knowledge content, highly abstract, universal	Partially codified knowledge, strong tacitness, more context-specific	Strong semiotic knowledge content, some forms highly context-specific
Typical example: Pharmaceutical developments	Typical example: Engineering	Typical example: Fashion industry, advertising

Source: Adapted from Asheim (2007)

Schumpeter's (1983 [1934]) view is rooted in economic development and technological change, and centres on technical invention and its application in commercial entities. Innovation involves the development and launch of new technology-based products and processes by entrepreneurs and established organizations, realized at the level of product class or market. Innovation is defined as novel outputs, whether in the form of new goods or new quality goods, new sources of supply or new markets. This view of innovation prevailed during the twentieth century and was widely adopted by policymakers and many corporations and scholars in business and management. The idea of innovation as a technology-based, commercial phenomenon was later expanded and translated into organizational practices, although organizational innovation also draws on diffusionist theory.

A different view of innovation that can be traced to sociologist Gabriel Tarde (1903) emphasized imitation rather than invention, social change rather than technological change, and social progress rather than economic growth. The key representative of this school is Everett Rogers, with his framework for the diffusion of innovation (Rogers 1995 [1962]). Studies on the diffusion of innovation used to focus on scientific discoveries and their role in driving invention, which in turn leads to innovation in the form of new products and practices disseminated within a given social system and adopted by individuals and collective actors. The main actor in this process is the adopter, hence innovation can be defined as an object or practice that is perceived as new by a unit of adoption. This view also considers other social components, such as the influence of ideas, social practices, and networks in the diffusion of innovation.

Both views are important in understanding innovation as a process that provides economic and other benefits to creators and adopters, and leads to organizational improvement, social opportunities, and advancement. When considering the sources of the firm's knowledge, it is important to pay attention to both dimensions. On the one hand, the sources of knowledge that drive innovation can be technological and economic and are based on the capacity to generate new processes, products, and services, as well as organizational and social practices. On the other hand, as diffusion and adoption are fundamental aspects of the process, sources of knowledge depend on their adoption by entrepreneurs, providers, workers and ultimately clients. Therefore, cultural openness, social networks, capabilities, and organizational arrangements shape the identification and realization of sources of knowledge, whether internal or external to the firm.

Current research on innovation often distinguishes between product innovation, the attempt to generate new products that address the costumers' demands –, and process innovation, processual alterations that seek to reduce delivery time or operational costs (Damanpour 2010; Leiponn and Helfat 2010). Yet both aspects of firm innovation cannot be dissociated and an approach that seeks to make most of both aspects stands as desirable. Nonetheless, some sectors end up focusing more in one particular aspect, depending on the products and services rendered. In all cases, knowledge management will always play a major role in how innovation is sought and implemented (Darroch 2005), as we elaborate in the next sections.

It should be noted that size plays a role in innovation as well, with studies supporting that smaller firms are more effective at innovating than larger firms, when

proportional research investment is considered (Fritsch and Meschede 2001). Others have shown that smaller firms invest more on product innovation, while larger firms prefer to focus on process innovation (Damanpour 2010). Countless studies have addressed the relation between innovation, firm size, and other dimensions as well, such as the presence of networks (Gronum et al. 2012), innovation heterogeneity (Akcigit and Kerr 2012) or even firm age (Petruzzelli et al. 2018). And it is quite common to find contradictory findings in such studies, which highlights the lack of a unified or consensual approach to measure innovation.

Internal factors for knowledge in the firm

A stylized view on sources of knowledge

When studied from the perspective of the firm, sources of knowledge are commonly classified as either internal or external. This division was heavily influenced by the well-known Oslo Manual, promoted, and widely adopted by international organizations (OECD 2015), which provides a standard set of guidelines for research and development statistical surveys of firms that are representative of regions and countries (Poveda et al. 2019), and for measuring activities and outputs related to innovation.

Arundel (2001), for example, follows this distinction by classifying sources of innovation as internal when they emerge as the output of in-house research, or external when they are derived from technical literature, existing patents, customers and parent firms, cooperative research. Arundel and Geuna (2004) later highlighted the role of public research organizations and universities as significant external sources of innovation, and the importance of proximity and clusters in the diffusion of knowledge.

The latest edition of the Oslo Manual (OECD/Eurostat 2018) provides further details on inbound flows of knowledge, dividing them into four categories: business enterprises, affiliated enterprises and other (unrelated) firms, including suppliers, customers, competitors, and knowledge service providers; the state, comprising government research institutes, other departments and agencies; higher education institutions, consisting not only of official departments and research units, but also graduates; and private not-for-profit organizations, such as private non-profit research institutes, other non-profit organizations, households, and individuals.

In addition, other sources associated with internal resources are cited in the international guidelines, such as those provided by specialized departments (marketing, production, logistics, delivery, design, and research), databases, employees, and managers. Further sources include scientific and trade publications, conferences, trade fairs and exhibitions, business websites, searchable repositories or databases, and commercial and trade standards.

One recent exercise using this type of classification, conducted by Demircioglu et al. (2019) and summarized in Table 2, shows how different types of knowledge sources are associated with particular types of innovation, although they rely mainly on the Schumpeterian view of innovation.

Universities are fundamental sources of knowledge for all types of innovation in firms, together with workers and customers. Suppliers are only significant for product innovation, while other organizations in the industry are especially relevant for marketing and process innovations. It was also found that, on average, younger firms, firms with more employees, and firms located in urban areas exhibit a greater degree of innovation activity for different types of innovations, and the propensity to innovate in different economic activities varies significantly.

Empirical research based on extensive international data shows how the sources of knowledge available to firms are diversified and context dependent. Several international studies based on similar sources confirm that simplistic views of innovation are not based on evidence, while also revealing significant limitations, mainly the difficulties in linking existing data to different types of knowledge and a broader view of innovation, and in observing specific processes in different kinds of firms, including SMEs, in diverse productive contexts (Arundel and Smith 2013).

The following section explores a dynamic view of sources of knowledge and their role in innovation processes, based on accumulated knowledge in both management

Table 2 Impact of sources of knowledge on innovation in firms

Variable	Type of Innovation			
	Product	Process	Marketing	All
Source 1: Suppliers	++	+	+	+
Source 2: Customers	++++	++++	++++	++++
Source 3: Others in industry	–	++	+++	+
Source 4: Workers	++++	++++	++++	++++
Source 5: Universities	+++++	+++++	+++++	++++
Establishment years	++++	++++	++++	++++
Number of employees	++++	++++	++++	++++
Rurality index (Beale13)	–	–	–	–
Industry classification (NAICS2) Base: 21: mining				
31: Food manufacturing	++++	+++	+	++
32: Wood, paper manufacturing	++++	+	+	++
33: Metal, machinery, electronic, hardware	++++	++++	++	++++
42: Wholesale trade	++++	++	++	++++
48: Transportation	+	–	+	–
51: Information	++++	++++	++++	++++
52: Finance and insurance	++++	+	++++	++++
54: Professional	++++	+	++	+++
55: Management of companies	+	+	+	+
71: Arts, entertainment	++++	++	++	++++

Key: + not significant, ++ significant at 0.05, +++ significant at 0.01, ++++ significant at 0.001, +++++ significant source with highest coefficient.

Source: Based on Demircioglu et al. (2019)

and innovation studies. It focuses on of the sources of knowledge from the perspective of the firm. It highlights the main factors identified with management frameworks. A common feature is that the essential unit of analysis is the firm. Their research problems are driven by the implications for managers and the organization at large. Many of them used to focus on internal aspects of the firm, as these are important sources of knowledge and innovation, although most approaches have gradually balanced the weighting of internal and external aspects.

Sources of knowledge and innovation from the perspective of the firm

The importance of absorptive capacity

The concept of absorptive capacity refers to "the capabilities to recognize the value of new knowledge, to assimilate it, and to apply it to commercial ends" (Todorova and Durisin 2007: p. 774). Ultimately, the goal is for the absorptive capacity to be developed on an organizational rather than an individual level, so that it is not solely dependent on individual learning capacities. Internally, the absorptive capacity allows organizations to make use of knowledge that comes from outside sources and this is dependent on several factors, such as research and development (which enhances the firm's capacity to use externally available information), manufacturing operations (which allow for better recognition and usage of relevant knowledge to enhance productive activity) and/or cognitive structures (prior knowledge to improve learning capacity on an individual level) (Cohen and Levinthal 1990).

Even though research and development is directed towards generating commercial value, sometimes, the outputs do not directly translate into material gains, but rather contributions towards other organizational and production aspects, which consequently improve productivity and ultimately lead to better economic performance. Research and development is more common in large firms that can afford departments dedicated to this task. SMEs, nonetheless, also make use of research in a less formal manner, given their less intensive workforce and reliance on tacit knowledge instead of codified knowledge, as it happens in larger research intensive firms (Fernández-Esquinas et al. 2017).

Innovation is the goal of research, but while the amount invested has an impact on results, there are other relevant dimensions. Research departments, even in larger firms, tend to present low levels of formalization, which can be attributed to the nature of the research and the heavy emphasis on creativity, requiring considerable freedom from the constraints and bureaucratic procedures that hinder research activities.

Current research has addressed the importance of absorptive capacity capabilities to the creation of valuable knowledge, especially (but not exclusively) in SMEs. This is the case of using business intelligence and analytics (Bozic and Dimovski 2019). SMEs have also shown interest in collaborating, both formally and informally, with cultural and creative industries, in an attempt to acquire and combine heterogeneous sources of knowledge and transforming it into increased performance (Santoro

et al. 2020). And how important absorptive capacity can be for fostering innovation through learning intent (Khan et al. 2019; Limaj and Bernroider 2019).

Technological intensity

The relevance of sector conditions to the competitiveness and innovativeness of firms also stresses the importance of technological intensity, which plays a major role in how firms acquire, assimilate and apply innovation to their activity to obtain commercial gains (Wu 2012). Technological intensity is understood as "the level of knowledge incorporated in companies' products in every industrial sector (…) measured by dividing the average R&D spending by the firm's revenue" (Zawislak et al. 2018: pp. 189–190).

Pavitt (1984) introduced this term, along with five categories of industries classified according to their technological innovativeness. While influential, it did not take long for other authors to identify weaknesses in this taxonomy, since there can be quite significant variations in firms from the same industry as Pavitt acknowledged in his article. Of relevance is also the dynamic nature of innovation, which stands in contrast with the static and permanent character of taxonomies (Archibugi 2001). The understanding that high-technology-intensive firms tend to be more innovative (even if there are discrepancies in this trend), whereas low-technology-intensive firms tend to be less innovative is by no means consensual (cf. Zawislak et al. 2018).

Ultimately, the ways in which firms make use of knowledge and foster innovation will depend on internal factors. The organizational culture and structure of the firm play as great a role as external and environmental variables, if not greater. Amongst all internal factors, size is often a key variable that may be overlooked: larger firms, for instance, are more likely to develop networks outside their region, while smaller firms are more reliant on local networks, as the social capital of their elements is more dependent on friends and relatives (Huggins and Johnston 2010). Either way, collaborative networks have played a major role in boosting product performance through both product and process innovation, while also affecting on firm's absorptive capacity (Najafi-Tavani, Najafi-Tavani et al. 2018).

Technological intensity also influences how firms organize and manage themselves, thus being a subject of interest in employment relations and human resources research (cf. Harsh and Prasad 2021). Higher technological intensity equates to more qualified employees and higher levels of training, skill development and compensations, which reflects itself in more demanding managerial responsibilities linked to the management and handling of human resources. This is particularly relevant in western countries that have gone through deindustrialization processes, downsizing their manufacturing sectors, and witnessing a growth of technological intensive firms (Sarra et al. 2019).

Higher technological intensity often translates into higher adaptability, due to the necessity of accounting for the uncertainty generated by the increased variability of transformation and production processes. Such emphasis put on customization and responsiveness to customer requirements also means that unique employee contributions are more important as in low technological intensity settings (cf. Lepak et al.

2003). In turn, these particularities put added pressure on management, as to ensure the continuity of responsiveness and unique employee contributions.

Dynamic capabilities

The firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments is referred to as dynamic capabilities. Introduced by Teece et al. (1997), this type of capabilities determines the ability of a firm to adapt its business model to achieve better performance, involving sensing (the environment), seizing (opportunities), and shaping (new capabilities) (Teece 2014). The idea behind the dynamic capabilities of firms is to sense opportunities and make use of those opportunities to introduce changes to the business model, which prompt transformations in the structure and culture of the firm, ultimately leading to better opportunities and improved performance (Fainshmidt et al. 2016). Dynamic capabilities are therefore believed to be more important than size (Naldi et al. 2014).

It is argued that the stronger the dynamic capabilities of a firm are, the faster and easier the alignment between the firm's resources and business model will be (Teece 2017). For firms to consistently be in a favourable position, they must make constant changes to their organization and its culture to avoid threats and take advantage of opportunities.

Knowledge plays a major role in the dynamic capabilities approach, with knowledge-based resources acknowledged as highly important in achieving strong dynamic capabilities (McInerney 2002). This relationship is not surprising, given that knowledge stocks are closely related to the firm's ability to learn and adapt, with human capital and employee knowledge being important dimensions (Nieves and Haller 2014).

It has also been shown that greater knowledge-based dynamic capabilities contribute significantly to the innovation performance of firms by making use of three sub-capabilities: knowledge acquisition capabilities (how employees are capable of acquiring new and externally generated knowledge), knowledge generation capabilities (how the firm can generate new knowledge from within the firm) and knowledge combination capabilities (how firms can integrate and apply internal and external knowledge) (Cheng et al. 2016; Kim and Lee 2010; Qandah et al. 2021; Zheng et al. 2011). For a review and research agenda on dynamic capabilities see Wang and Ahmed (2007).

Stickiness, exploration, exploitation and the knowledge exchange

It is commonly accepted that all forms of knowledge transfer require some degree of effort or commitment, regardless of the source of knowledge or the ultimate goal in mind. It is also agreed, however, that some forms of knowledge are more difficult to transfer than others (Perkmann et al. 2013). The previous observations on tacit knowledge and the difficulty in codifying it can also apply to sticky knowledge.

As Szulanski (2003) states, sticky knowledge transfers are difficult to accomplish due to three major factors: low absorptive capacity, causal ambiguity, the uncertainty

caused by incomplete understanding of knowledge (McIver and Lengnick-Hall 2017), and the relationship between source and recipient (i.e., how amicable and fluid the relationship is and how fruitful the cooperation is likely to be, based on these terms). These factors combine to create *stickiness*, either at the source or the recipient, which hinders the process of knowledge transfer. Unproven knowledge can also account for stickiness, as can the motivation of the source and recipient, as well as their retentive capacity (Elwyn et al. 2007).

Another subject of interest concerning knowledge in firms is the difference between exploration and exploitation of knowledge. These two terms represent different and contrasting models (although they are not mutually exclusive). Exploitation refers to the use and development of existing knowledge, while exploration represents the search for new knowledge (Liu 2006). Exploration is associated with risk-taking, creativity, and innovation, and is thus labelled knowledge development, while exploitation seeks to build on what is already there, and hence is described as knowledge use (Pinto et al. 2019).

Although exploration and exploitation represent opposite views, firms are expected to use a combination both. No firm can rely solely on exploration without sacrificing present performance, nor can it be successful in the long run without investing in exploration. Therefore, the goal is to explore and make use of current capabilities while seeking new competencies (March 1991). And even though for years these two approaches were presented as a trade-off relationship, in the last decade and a half, the organizational ambidexterity approach has broken away from this assumption, presenting arguments in favour of how organizations can (and should) simultaneously balance exploration and exploitation to achieve a sustained economic performance (Raisch et al. 2009).

Introduced less than two decades ago, the concept of organizational ambidexterity is still maturing, both theoretically and conceptually. Empirical evidence for the success of organizational ambidexterity has also been polarized, with studies finding either positive or negative relationships, but rarely mixed positions, although some of these studies have been criticized on the basis of their methodological design and the need to consider contextual factors (Junni et al. 2013). As the concept is recent, researchers are still figuring out the best approaches to measure ambidexterity, and even if the idea of a balance is acknowledged by most, translating that into research has proven difficult so far (Simsek 2009).

Open innovation

One important concept related to innovation that has surfaced in the last years is that of open innovation (Bigliardi et al. 2020). Historically, knowledge in industry and firms, especially in sectors with high levels of research and development, has been viewed as a competitive edge to be protected. Those in possession of hidden knowledge had an advantage over their competitors, and, to this day, there are examples of corporate property being kept secret for commercial reasons. From secret ingredients in fast-food chains, to chemical processes in beverages, manufacturing techniques in musical instruments… the examples are countless.

What has changed, then? To begin with, while patents and trade secrets remain very much alive, the way in which knowledge is viewed by firms and organizations has changed a great deal. Whereas decades ago, research and development was something only major corporations and industries could afford, with the democratization of knowledge (Tushman et al. 2012) the threshold has lowered significantly, as knowledge sharing and access to information have shifted research away from a process that occurs solely within the firm to one that receives inputs from external sources as well. This transition has been referred to as a paradigm shift from closed to open innovation (Chesbrough 2004).

Open innovation became one of the most widely discussed subjects in organizations, management, innovation studies, and several other fields, with thousands of publications addressing or presenting research on the subject (Chesbrough and Bogers 2014). The idea behind open innovation is that firms "can and should use external ideas as well as internal ideas, and internal as well as external paths to market, as they look to advance their innovations" (Bogers et al. 2018: p. 6).

The fundamental argument is that openness promotes growth: sharing knowledge benefits society as a whole and advances technology faster than the former closed innovation approach. But to say that openness alone can lead to increased performance might be questioned, as research is still divided as to how big a role external knowledge plays in fostering innovation. Nonetheless, some studies suggest that it plays a more prominent role in high-technology firms (cf. Flor et al. 2017).

Culture of the firm

Culture can be both a conditioning factor regarding access to knowledge and a knowledge resource as well. Culture consists of "the symbolic elements of social life that are crucial for human interaction, mutual understanding and order", with cultural elements being "values, norms, cognitive repertoires, roles and institutions" (Fernández-Esquinas et al. 2017: p. 1900), and manifests itself within organizational contexts as routines, narratives, symbols, languages, ideologies, power structures and control systems rituals (Kayworth and Leidner 2003).

This analytical definition is rooted in classic sociological thought which attributed considerable relevance to differentiating between social structure and culture, with the former derived from individuals playing a role in the status hierarchy, while the latter is concerned with the symbolic elements crucial for social life (Portes 2010). It is also consistent with the prevailing definition of knowledge as high-value information, dependent on context, linked to meaningful behaviours and embodied in people's capacity to act.

In the context of organizations, innovation depends on "a set of actors that interact with the aim of creating and diffusing knowledge, involving a number of different agents promoting new knowledge and its economically useful application" (Pinto et al. 2015a, b: p. 85). The combination of both concepts allows organizations to be viewed as actors on a larger stage, seeking to innovate in order to gain advantages over their competitors, while their culture is what sets them apart from one another. As such, innovation culture refers to an organizational environment and infrastructures that encourage workers to come up with novel and creative ideas

(West and Richter 2009), as well as aligning employees' attitudes towards innovative ideas (Botelho 2020).

Although the link between culture and sources of knowledge seems obvious, culture has since long been a complex concept to explain or apply in research, which makes the understanding of innovation culture in firms more difficult. This, perhaps, explains why the concept of culture is rarely discussed in articles on innovation culture. Several disciplines related to management, particularly sociology, anthropology, and organizational sciences, have invested in developing conceptual tools and empirical evidence on the links between culture and knowledge of the firm (Giorgi et al. 2015).

A first group of studies point to the distribution of the organizational values and cognition. They have provided useful empirical observations about the influence of values in the capacity to innovate. It has been showed that elements of the organizational culture shape access to internal and external knowledge, and are at the root of learning, knowledge sharing, transfer, and utilization (Hofstede et al. 2010; Schein 1985; Tung and Stahl 2018).

Cultural elements can function as both assets and barriers. For instance, the values shared among managers and workers may influence what kind knowledge is considered important. They also influence if knowledge is seen as a personal possession or as an asset of the firm. The conceptualization of knowledge is relevant when deciding if the knowledge available is used and adequately stored in a form that is cumulative for the firm. In addition, the cultural homogeneity or heterogeneity of a firm determines knowledge sharing among workers, and among workers and managers (De Long and Fahey 2000; Gonzalez-Loureiro et al. 2017).

An important issue in most recent research is the configurational nature of culture. In contrast to older visions that tended to study culture as a set of independent dimensions, culture is now viewed as an integrated, complex set of interrelated and potentially interactive patterns and characteristics of a group of people. Therefore, in addition to examining the role of values shared by the members of a group, modern approaches pay attention to schemas, narratives and discourses, and to the capacity of people to manipulate cultural elements (Kraatz et al. 2021).

A second group of studies is based on the assumption that the organizational culture can be considered a knowledge resource and facilitates other management activities. Grounded on the above empirical observations, much of the literature proposes strategies to foster cultural elements in order to become a learning organization. This is accomplished by identifying the appropriate cultural style depending on the internal and external company factors. As Kayworth and Leidner (2003) argue, the proper culture management can promote knowledge creation (through social and collaborative processes, individual reflection, foster knowledge storage (by focusing on developing the organizational memory, namely written documentation, electronic databases, codified human knowledge, procedures, and know-how), invest in knowledge transfer (between individuals and groups, within or outside firms), or focus on knowledge application (i.e., how individuals pursue knowledge and how that pursuit can be nurtured and rewarded).

The idea is that knowledge management should be built having in mind that entrenched cultures are difficult to change, and that new values and practices are

seldom imported and introduced by fiat. Cultural elements, and social relations based on culture, are embedded in any organization (Weber and Dacin 2011). This means that management will often have to manage subcultures and adequate their strategy depending on contextual factors that may hinder of facilitate the specific approaches to culture management as pointed by Kayworth and Leidner (2003).

Human capital and skills

When it comes to innovation and economic performance of firms, human capital and skills are a second major underlying factor of success. Innovation does not take place in a vacuum, nor is it the result of abstract osmosis: it happens through the individuals that constitute organizations, whether employees or managers. Not surprisingly, higher levels of employee skills often translate into higher productivity, especially when business owners are highly skilled themselves (Chinomona 2013), ultimately contributing to an innovative culture in the firm.

Human capital comprises the knowledge, skills, and experience of the workforce (Lepak et al. 2011). Higher human capital levels translate into higher quality performances, hence why it is regarded as a key resource for productivity (Kramar et al. 2011; Pennings et al. 1998). It can be developed through education (general human capital) and professional experience and skills (specific human capital) (Almeida et al. 2014). Human capital has also been shown to play a major role in firm's capacity for innovation, as well as being important for high technological intensity firms or cutting-edge industries.

Notwithstanding, possessing a high degree of human capital does not ensure higher productivity, albeit it can greatly contribute to it. No matter how skilled a workforce is, the proper leadership and adequate management approach is required to make the most out of the employees' skills, especially in highly technological economic activities or creative settings (Coff 2011).

In the context of organizations, skills are often divided into hard and soft skills. Hard skills (also referred to as cognitive skills) are related to technical elements, such as processes, procedures, tools, and techniques, which usually have a practical application. They are primarily learnt through formal education in schools and universities, as well as through internships and in-service training, and can be quantified and measured (Gale et al. 2017). For these reasons, hard skills tend to be closely related to codified forms of knowledge, as they are usually taught and transferred.

Soft skills, on the other hand, encompass communication skills and the ability to work with others to solve problems and conflicts, and are thus quite difficult to measure, quantify or even identify, as they are only revealed through social interaction. Whereas recruiters rely on CVs to determine whether a candidate possesses the appropriate hard skills for a position, the same cannot be said for soft skills, hence the use of interviews, which may provide a better indication of a candidate's soft skills (Sakamoto et al. 2010). They are closely related to tacit knowledge, as aspects such as the cultural environment and how employees *fit in* to the firm are difficult to express in words, and both can be seen as implicit dimensions.

Leadership

Leadership is equally important for the way in which a firm promotes innovation and develops an innovative culture (Cabello-Medina et al. 2011). The word leadership has had many meanings in history and much has been written about the ability to lead and set examples for others to follow. Yet, how can someone be a leader when it comes to innovation?

Leadership has been theorized as something that people possess (traits theory), behaviours individuals have (behaviourist theories), and reactions to environmental and situational elements (situational and contingency theories) (Sorenson and Goethals 2004). Transactional leadership has also been distinguished from transformational leadership, with the former occurring when leaders approach others in order to exchange or trade something of value, while the latter occurs when leaders and followers promote each other and attain higher levels of motivation and morality (Burns 1978).

More recent theoretical developments also see leadership as a dynamic process that requires taking followers into consideration as an active part of the leading process, rather than a passive element (Hollander 1992). Constructivist theories of leadership have emerged, focusing on cognitive structures and how leadership arises from sharing relatable stories and manifesting one's own identity through these stories (Sorenson and Goethals 2004).

Even if nothing resembling a universal definition of leadership exists, there are some common elements in the most popular definitions. Leaders engage, motivate, inspire, guide, and coordinate their followers to accomplish common goals. Leadership is a process rather than a single person or situation that arises in specific contexts, and requires the ability to identify problems and surpass them by making use of the available human and non-human resources (Toor and Ofori 2008).

With regard to innovation, leadership requires a great deal of creativity and inventiveness not only to look beyond the horizon, but to drive innovation forward and make this approach resonate with employees and other stakeholders, thus promoting an innovative culture (Kremer et al. 2019). Leadership is essential for firms to establish an appropriate climate to foster innovation and creativity, and align the organization towards innovation processes (Auernhammer and Hall 2014; Botelho 2020).

Leadership is fundamental to some of the cases discussed so far, such as aligning and motivating the work force and make most of the firm's human capital, it is instrumental in technological intensive settings that require a higher intervention from management and just as important to foster open innovation and develop a culture of innovation (NG, Tan and Ang 2011; Teece 2011).

Contextual factors for knowledge in the firm

Knowledge environments for innovation and the firm

This section reviews the group of studies that focus on the role of the wider environment in the firm's sources of knowledge and their implications for innovation.

The perspectives presented here contrasts with those which focus on the organization or the micro level. They mainly emphasize the dynamics of the wider environment, on the assumption that firms are not isolated. Their main premise is that environments are not merely a collection of external actors but include systemic and dynamic issues that influence sources of knowledge. Environments also determine the sources of knowledge that firms can draw on and incorporate.

The way in which firms and other organizations make use of knowledge from their environment has become an extremely important matter, especially in cutting-edge technological areas. Tokyo-Yokohama, Shenzhen-Hong Kong-Guangzhou, Seoul, Beijing or Silicon Valley, for example, are locations which are considered innovation hubs and occupy top spots in the Global Innovation Index ranking for innovative regions (Dutta 2020). But what makes these regions or cities so effective at innovating? The answer is complex, but it can be said that it is in no small part due to the knowledge that exists there and is transformed into innovation.

The gist of the argument is that organizations are not islands, and their environment can be an invaluable source of knowledge, provided that organizations can learn from it, thus explaining why innovation often has geographical distribution patterns (Cooke 2001).

In recent decades, a great deal of emphasis has been placed on the firm's external environment as a key aspect for generating and absorbing knowledge and innovating. This stemmed from the emergence of a branch of studies that focused explicitly on territorial innovation models (TIMs) during the post-Second World War period, which highlighted the importance of the structural transformation of regions as a means of overcoming the limitations created by stagnation in many areas highly dependent on traditional manufacturing industries (Moulaert and Sekia 2003).

Inspired by the consolidation of regional science as a new research field (Isard 1956), TIMs emphasized the location and the cumulative nature of productive and learning processes as suitable for enabling specific territories to compete in the global economy through innovation (Lagendijk 2006). The forces for endogenous development, systems theory, evolution, and learning, as well as network organization and governance, are the building blocks for these models (Moulaert and Sekia 2003).

One of the most important notions for TIMs is *agglomeration economies*, particularly relevant in the vision of Alfred Marshall (1920), to explain how firms specialize through the creation of an industrial *atmosphere*, the presence of specialist input suppliers, a local pool of specialist labour skills and specialist knowledge associated with the secrets of the respective trade. It is also essential to explain, according to Jacobs (1969) that there are benefits for local firms of a diversified economy, boosted by agglomeration and critical mass, given that this can generate a new way of thinking, new ideas and greater innovation.

The literature on TIMs has expanded, underlining different features of the process within the territory (Crevoisier 2014), but also the crucial role of agglomeration dynamics and different types of proximity in general for the production of knowledge and its transfer to the economic fabric (Boschma 2005). It is considered that regional development is stimulated by innovation and, in particular, by technological innovations that are valued by the market. Nevertheless, perspectives on innovation

are gradually emphasizing its social character and non-technological elements. The importance of cumulative knowledge dynamics that distinguish specific regions, sectors, and firms should be regarded as an endogenous capacity to access external knowledge and anchor it through combinatorial innovation. Several authors are using the term territorial knowledge dynamics (TKDs) to explore these particular socio-economic processes based on the existence of networks (Crespo and Vicente 2016; Crevoisier and Jeannerat 2009; James et al. 2016; Jeannerat and Crevoisier 2016). Table 3 highlights some critical differences between TIMs and TKDs.

TKDs may vary according to their openness/closure and exploration/exploitation (Crespo and Vicente 2016). They may be embedded knowledge networks (with high density outward and inward relations), closed knowledge networks (emphasizing inward relations) or dispersed/random knowledge networks (in which the external focus is dominant). TKDs based on exploration focus on science and engineering, while TKDs focused on exploitation are market-driven, as well as leisure and symbol-driven TKDs.

The State is seen in these models as the governance space that defines the rights and duties of economic agents, playing an active role in the construction and redefinition of the institutional framework for the economy and markets (North 1991) and therefore crucial to instigating innovation through market creation (Mazzucato 2018). The State is often considered a key external source of knowledge for firms. It can provide the stimulus for innovation not only through the public research organizations it directly finances (Pinto et al. 2015a, b), such as universities and research centres, but also through the demand and supply it generates for firms through public procurement (Uyarra et al. 2014), the regulations and standards it promotes (Blind et al. 2017), and the protection granted to intellectual property (Moser 2013).

TIMs, such as development poles, innovative milieux, industrial districts, clusters, and learning regions, are crucial to underlining the relevance of these approaches and are often translated into policymaking. The next subsections specify the main characteristics and implications for firms' sources of knowledge.

Fundamental territorial innovation models for the firm

Poles and innovative milieux

Perroux's *development pole* (Perroux, 1955) emphasized the impact that targeted investment, especially in infrastructures, could bring to the concentration of firms. This agglomeration would serve as the catalyst for a series of effects in the surrounding regional economic fabric. Some years later, the *innovative milieu*, a concept suggested by the Groupe de Recherche Européen sur les Milieux Innovateurs (GREMI) in France, proposed a radical shift. The firm was no longer an isolated agent but was embedded in a larger territorial context (Aydalot 1986). The focus shifted to the relations between firms and their territorial insertion and to their models of territorial organization, identifying different spaces for the activity of the firm: the production, the market and the support space. The way in which firms adapt is

Table 3 From Innovation and proximity to territorial knowledge dynamics (TKDs)

	(Traditional) Territorial innovation models	Territorial knowledge dynamics
Initial question	Explain the success/failure of certain regions in a context of technological change	Explain the territorial consequences of the knowledge society
Mobilization of new knowledge	Specialized/intermittent	Generalized/continuous
Unit of change	Innovation (mainly industrial or technological)	Knowledge dynamics
Market interdependencies	Production and consumption are distinct (traditional goods and services)	Complex production–consumption networks
Local knowledge dynamics	Essentially cumulative trajectories	Mainly combinatorial dynamics
Territorial scales	Local/global	Multi-location networks and multi-scalar processes
Spaces where emergence occurs	Innovative milieux, industrial districts, etc	Multi-location environments
Relation to the global environment	Specialization of activities; differentiation of products	Specification of the project or the business model
Regional policy	Synergies between production and training/research systems	Capacity to participate in multi-location knowledge dynamics and anchor them in the territory

Source: Adapted from Crevoisier and Jeannerat (2009)

understood to be incremented by learning The apprenticeship dynamics and collaborative patterns also lie at the core of this TIM (Maillat 1995).

More recently, Crevoisier (2016) linked different types of innovative milieux to their focus on owned or shared knowledge. This author differentiates between substantive knowledge and substantial knowledge. The former concerns knowledge that can be embodied in products and services and directly commodified, while the latter is especially present in workers, the firm's culture, or local community institutions that help create meaning for action. The *learning region* is an updated version of the notion of innovative milieux. It served as a synthesis of the ongoing debates of the 1990s on regional innovation, inspired by institutional and evolutionary economic geography (Morgan 1997). It is therefore based on the relational vision of innovation and on learning processes on a regional scale.

Districts and industrial spaces

The study of the *industrial district* derives directly from Marshall's classic studies and became famous due to the experience of the Third Italy, where groups of small firms developed in the 1970s and 1980s in the Central and Northeast regions of the country, such as Tuscany, Umbria, Marche, Emilia-Romagna and Veneto. Each region specialized in a range of loosely related products and each firm usually had a limited number of workers, often fewer than ten. This suggested a post-Fordist shift from mass production and economies of scale to flexible specialization and economies of scope (Piore and Sabel 1984).

As a theory, the industrial district gained attention with Bagnasco (1977) and popularity with Becattini (1990). A district is understood as a territorialized productive system, characterized by a dominant activity and anchored to the local division of work between highly specialized firms in defined phases of the production. It is also known for producing high quality products and employing highly skilled, well-paid workers. Firms are therefore design-oriented and multidisciplinary, involving collaboration between entrepreneurs, designers, engineers, and other workers.

The paradigm of industrial districts was later complemented by the Californian School of Geography, with the launch of the notion of new industrial spaces (Storper, and Scott 1988). This involved the promotion of the innovation capability of enterprises through highly flexible systemic aggregations at territorial level, designed to foster greater competitiveness in the existing productive areas, which are export intensive, by revitalizing them through research activities addressing key technologies, thus enabling product and process innovations.

Clusters

One of the most policy-influential TIMs is the *cluster*. Attention to clusters has increased, particularly following the work of Michael E. Porter (Porter 1998), who understood clusters as geographically proximate groups of interconnected companies, suppliers, service providers, and associated institutions, linked by externalities of various types. Another key source is Saxenian (1994), who emphasized the importance of cooperation, a networked economic structure, individual organization

of firms, local context, governance, institutions, and the culture for regional development, while attributing less emphasis to market forces and competition than Porter (1990).

Cluster policy became omnipresent in the world of policymaking at the turn of the millennium (Ebbekink and Lagendijk 2013). As Martin and Sunley (2003) point, clusters have become a world-wide policy fad. Taylor (2010) argues that the great political appeal of the cluster concept lies in its accessibility and the way it passes for expert knowledge.

Policy makers have been attracted to the cluster because of its merits, its marketability, and branding presentation (Palazuelos 2005). The existence of a cluster is based on the fact that actors are located in a geographic context strongly influenced by mainly positive externalities that affect productivity. These positive externalities emerge through knowledge and workforce agglomerations that connect industries, technologies, skills, and purchased inputs.

Innovation systems

Another of the most influential TIMs is based on regional innovation systems. The innovation system approach was originally conceived to explain the economic performance of nation states and their international competitiveness (Asheim et al. 2011). Considering that the nation state is the main territorial level on which institutional architectures are configured and acquire specific characteristics, the first generation of studies using a systemic approach to innovation cantered on national innovation systems (NIS), placing great emphasis on the developed countries' institutional structures, collective learning, and path dependence (Freeman 1995; Lundvall 1992; Nelson 1993). A second generation of innovation system studies was sceptical of the macro-approach of NIS and shifted towards a regionalized perspective.

The term regional innovation system (RIS) came into use in the early 1990s, as a result of in-depth research on a number of European industrial regions (Uyarra and Flannagan 2013). These regions were seen to be operating as innovation systems and were defined as a "geographically defined, administratively supported arrangement of innovative networks and institutions that interact regularly and strongly to enhance the innovative outputs of firms in the region" (Cooke and Schienstock 2000).

The RIS approach stresses that the regional level is the appropriate scale for analysis and for implementing innovation policies, in particular due to the said agglomeration effects and proximity benefits (Asheim et al. 2011; Cooke 2001). An RIS can be understood as an innovation system geographically defined at sub-national level, supported by specific governance entities, institutions, actors, own networks, and regular interaction to strengthen the innovation performance of firms in the region (Cooke and Schienstock 2000). All regions, even those which are peripheral and based on low tech sectors, came to be seen as operating some kind of RIS, although it is not clear whether these systems are, in fact, present in all territories (Uyarra 2010).

The ideas of clusters and RIS are clearly related, but it is important to distinguish the two concepts (Asheim et al. 2011). RIS focusses on knowledge and innovation networks. The RIS paradigm was very important for several generations of innovation policies that aimed to stimulate innovation in the regions. It is important to emphasize that the RIS concept was crucial, in Europe for example, to the definition of regional innovation strategies such as the RIS program (1994–2001), the RITTS – Regional Innovation and Technology Transfer strategies (1994–2001), and the European Regional Development Fund Innovative Actions (2000–2006). More recently, RIS has returned to the spotlight as a crucial theoretical building block in the RIS3 – Research and Innovation Strategies for Smart Specialization (Foray 2016; McCann and Ortega-Argilés, 2016).

The emergence of the ecosystem

The concept of the ecosystem has recently entered the TIM mainstream debate (Feldman et al. 2019). It refers to the entity formed by biotic (living) communities that inhabit and continuously interact in a defined territory, together with the abiotic (non-living) factors that are present in these communities, such as temperature, light, and water. The concept has been widely used in the social sciences to analyse delimited contexts in which actors develop specific activities. It is often linked to ideas stemming from complexity theory, which describes complex adaptive systems exhibiting emergence characteristics, as well as evolution theories, which emphasize change, adaptation, and selection.

The subject of ecosystems gained considerable popularity in recent years (Thomas and Autio 2020), particularly related to the topic of innovation, as innovation is most likely to occur within an entrepreneurial ecosystem (Feldman et al. 2019). An innovation ecosystem is defined as the evolving set of actors, activities, and artefacts, together with institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors. In this definition, artefacts include products and services, tangible and intangible resources, technological and non-technological resources, and other types of system inputs and outputs associated with innovation.

Entrepreneurial ecosystems, on the other hand, are distinguished in terms of institutional, geographic, economic, or industrial environments with different levels of aggregation (e.g., firms, industries, universities, regions, and nations). The concept of entrepreneurial ecosystems suggests a dynamic set of relationships, services, and interdependencies that boost the creation, renewal and growth of firms. In the opinion of several authors, the gains from adding *eco-* to the treatment of national and regional innovation systems are limited, as the ecosystem is not a clearly defined concept in the literature, and contains pitfalls, notably concerning its overemphasis on market forces (e.g., Oh et al. 2016), thus requiring more research before a meaningful analogy can be established with natural ecosystems (Ritala and Almpanopoulou 2017).

In fact, the concept of the ecosystem has faced a great deal of criticism from many social scientists because it is based on biology and neglects important social elements that have been studied for decades, such as those related to social structure,

including power, class and inequalities, and others related to culture, such as values. Nonetheless, the conceptual differences between entrepreneurial ecosystems and other TIMs are, in our view, relevant, particularly in emphasizing two aspects: the exploitation of the digital as a key enabling technology, and the focus on evolutionary features as a complex adaptive system.

Apart from its analytical and political nature, an innovation (eco)system can also be viewed as a knowledge network. The existence of knowledge networks is a prerequisite for the dynamics of innovation. Networks presume a certain stability in relationships, meaning that there is a central role for trust and reciprocity among actors, which reduces risk and uncertainty (Capello 1999).

Conclusion

Knowledge is crucial not only for production aspects, but also for the value creation in firms. Hence why so much attention has been paid to organizations and institutions that create knowledge in recent decades, with the advent of the knowledge economy. To understand the role knowledge plays in firms, it is necessary to consider the characteristics of the environment in which the firm is established, the economic sector under analysis, and the type of firm considered. Sources of knowledge can be internal or external: the innovative capacity of the firm depends on its production and absorption of knowledge. Thus, understanding the factors that influence success of the firm means understanding the factors that condition the generation and application of knowledge.

Knowledge within the firm is a very broad topic that is difficult to summarize in a single article. Many relevant contributions deal with this topic, which has been steadily expanding in recent decades, and there are dozens of different frameworks, many barely compatible with each other. Some approaches deal with corporations, some with larger firms, and others with SMEs. Others focus on research or on innovation. Some are inspired by high-tech environments, while others reflect on the possibilities for peripheral environments, either in the developed world or in developing countries. Some are purely managerial and micro-level; others are grounded in evolutionary or socioeconomic frameworks and focus on meso- and macro-levels. The only common aspect is the shared understanding that firms capture, process, and incorporate knowledge into their activities.

This article acknowledges this diversity and tries to overcome the fragmentation in the literature, with the prevailing separation of managerial and territorial perspectives, and the distinction between studies that use the micro-, meso- and macro-levels. It is heavily inspired by contributions on innovation systems which link micro (and more managerial) insights to macro (and more institutional) understandings.

Another issue is the operational difficulties in giving attention to different dimensions simultaneously, to (empirically and analytically) delineate the role of different factors as sources of knowledge. Certain topics are mentioned but not explored as fully as they could be, since an in-depth discussion would be beyond the scope of this work. But these brief mentions might prove helpful in at least providing a basic understanding of some related factors and subjects.

The article considers research on sources of knowledge as a *constellation* of strategically selected topics, compiled in a narrative which aims to provide meaning through a systematic conceptual structure to better grasp the complex multidisciplinary and pluriparadigmatic subject of knowledge.

There are challenges and promising avenues for research on the sources of knowledge. The first challenge is the division of the research areas in terms of meta-theoretical assumptions and the need for an overview of the issues pertaining to conceptual development on the nature of knowledge and innovation. One important line of research is the cross-fertilization of approaches in Science, Technology and Innovation studies, and the different conceptions of knowledge. A second challenge concerns the relationship between the micro levels of study (firms, groups and individuals, from the perspective of the firm), and the meso- and macro-levels (organizational fields, networks, systems, sectors and territories). Although the former is essentially a theoretical problem, it is also an empirical problem due to the difficulties in finding data that can link the different levels. Finally, the fact that several disciplines and areas conduct research on knowledge, while originating plentiful important contributions, also fragments the research field. Interdisciplinary dialogue is not always as fruitful as one could hope, but there is much to gain and learn by combining contributions from the several traditions and disciplines.

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