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Cooperação em Atividades Inovadoras: Uma revisão da literatura.

João Augusto F. Freire (Aluno do Programa de Pós-Graduação em Economia, UFJF);

Eduardo Gonçalves (Professor Associado, Departamento de Economia, UFJF)

Resumo:
A importância da cooperação como força motriz da inovação é assunto amplamente estudado. Configurações cooperativas constituem potenciais plataformas a transmissão indireta e direta de conhecimento. O objetivo deste artigo é sintetizar as contribuições dos principais trabalhos que tratam da cooperação voltada para a inovação, enfatizando os efeitos de configurações específicas de acordo com suas estruturas de governança, os motivos para cooperar e as caraterísticas de parceiros, o porte das firmas envolvidas, o contexto regional e o estágio de desenvolvimento da economia onde acontece a cooperação. No geral, a cooperação é uma configuração organizacional que almeja compartilhar e difundir conhecimento. A maior parte das evidências analisadas neste trabalho apontam para um efeito positivo da cooperação no desempenho de inovação das firmas. Salvo raras exceções, esta correlação positiva ocorre principalmente em estudos de caso de setores de elevada intensidade tecnológica concentrados em regiões geográficas pequenas.

Palavras-chave:
inovação cooperativa; estrutura de governança; *spillovers*; concorrência; difusão de conhecimento.

Código JEL: L5; L14; O30.

Área Temática: 4.4 Redes de inovação – alianças de P&D, interações universidade-empresa, outras redes.

1. Introduction

Cooperation between economic agents is widely regarded as a setting with a positive influence on innovation performance (Suzumura 2000; Döring and Schnellenbach 2006; Powell and Gianella 2010). It has been gaining importance in recent decades, and there are many empirical and theoretical works aimed at assessing the effect of cooperation on a region's innovative output. The importance of this subject lies in the fact that innovation – or technical progress, its earliest nomenclature – has been widely accepted as the driving force of the economy for many years.

On that note, cooperative settings can be indirect as well as direct knowledge transmission platforms. This is because of the spillover effects inherent to knowledge production (Feldman and Kogler 2010). There is also evidence that cooperation can boost spillover effects even at a longer distance. Therefore, it is arguable that the limitations of regional externalities can be overcome by setting cooperative agreements over great distances (Ponds, Oort and Frenken 2010; Tojeiro-Rivero and Moreno 2019).

Nevertheless, there is no study that aims to pool together these contributions in a literature survey. Therefore, this paper aims to perform a literature survey on cooperation and analyze the results regarding the effect of cooperative agreements on innovation performance. In addition to the effect of cooperation, the specific governance arrangement, the effect of cooperation versus competition, the type of agents involved, and the regional scope will also be covered.

Most of the papers reviewed evaluate the performance of cooperative agreements as their primary objective. Nevertheless, they might present different scopes, such as exploratory case studies, papers assessing the governance of cooperative agreements, the traits of firms that cooperate, the reasons for cooperating, the type of agents involved, and the regional scope of the agreements.

This paper is structured as follows. Section two presents a brief literature review on the matter of knowledge spillovers, how they relate to geography, and how cooperation and networks relate to these two themes. Then, the literature survey is carried out in section three. Finally, section four presents our main conclusions and possible limitations.

2. Cooperation, Spillovers, and Geography[1]

For over a century innovation has been considered the process that drives economic development. Technology is so important to economic development in part because it generates positive externalities that benefit a number of agents, especially those in close proximity to the innovator. Marshall (1890) was the one of the first authors to work with this concept and he developed a theory of industrial localization - namely, the Marshallian industrial district - in which the region's natural resources and costs associated with transportation resulted in a concentration of economic activity. Nonetheless, that concentration resulted in a process of hereditary transmission of aptitude, which meant that knowledge and technology diffusion related to a specific sector would occur in a localized manner, as the famous phrase "the secret of the industry is in the air" suggests. Therefore, positive externalities, or spillovers, would be geographically localized.

R&D activities are the principal means for the generation of new knowledge and technology, especially for firms. In fact, there is wide evidence in some studies on the matter of the return to R&D and its spillovers, so that the elasticity of external R&D is consistently significant, and that the social return to R&D (its spillovers, in other words) is greater than the private return. In terms of spillover channels of transmission, while it is widely accepted that it occurs mainly through face-to-face contact and labor mobility (Hall *et al.* 2010), recent studies are considering the effect of cooperation, in its many forms, on knowledge spillovers and its transmission.

Firms tend to invest in R&D in order to create knowledge and apply it to inventions aimed at producing technological advancements and appropriating financial benefit. This knowledge can be applied directly inside the production process, but can also be interpreted as a boost in the firm's knowledge pool, knowledge stock, or even absorptive capacity. In fact, knowledge, human capital, and externalities are the cornerstone of the mainstream macroeconomic models of economic development (Lucas 1988; Romer 1990; 1994; Krugman 1991; Cassiman and Veugelers 2002), indicating the importance of the matter.

Depending on the industry, the type of knowledge used for the development of new products or processes varies, being either scientific (codified) knowledge or tacit knowledge, sometimes referred to as "applied" knowledge. It is much harder to pass on tacit knowledge, and it is agreed in the literature that it

[1] This section is purposefully brief and aims to deal with the importance of the regional context alongside cooperation. For a deeper analysis of spillovers and geography, see Döring and Schnellenbach (2006): *What do we know about geographical knowledge spillovers*, Beaudry and Schiffauerova, 2006: *Who's right, Marshall or Jacobs? The localization versus urbanization debate*, or Feldman and Kogler (2010): *Stylized facts in the geography of innovation.*

is only passed on via social relations, amongst which the most commonly cited are face-to-face contact and labor mobility (Döring and Schnellenbach 2006). Codified knowledge, on the other hand, is much more easily passed on and learned by other individuals. Given the difficulty of passing on tacit knowledge, spillovers are commonly more relevant for industries that are more dependent on this type of knowledge.

In fact spillovers are non-intentional effects that are not directly reflected in prices (only partially through pecuniary spillovers) because firms are not able to take full ownership of the knowledge they create. This is because of the characteristics of knowledge itself, i.e. it is a non-exclusive good, which generates appropriability problems. Additionally, there is a consensus in the literature that dates to the concepts of externalities and Marshall's industrial district, that knowledge spillovers are geographically localized. This has greatly influenced the theories of regional growth and development.

In spite of the consensus in the literature regarding spillovers and their transmission mechanisms, Beaudry and Schiffauerova (2006, pp. 320) stress that "it seems that the exact spillover mechanism is not yet fully understood and documented. In fact, there is no direct proof of the existence of knowledge spillovers and there probably will never be." Nevertheless, after carrying out a literature review about the types of spillovers and their effects, they conclude that spillovers have positive effects on growth, productivity and innovation.

Nevertheless, during the innovation process firms might encounter limitations on their knowledge sets or internal resources. Innovation cooperation is a possible solution to that problem, since it is mainly regarded as a beneficial setting for innovation performance, in both theoretical and empirical works. There are several possible types of cooperation, such as the outsourcing or sharing of labor, agreements between firms and universities or joint research projects between firms (Döring and Schnellenbach 2006).

In theoretical terms, the institutional theory base supports the fact that cooperation is a beneficial setting for innovation, with social capital and social relations taking a leading role while the Marshallian industrial district is a kind of starting point for those relations. In other words, a set of informal institutions, defined as rules, norms and customs, can boost trust within a certain community or location and, in turn, make cooperation easier, resulting in economic development and agglomeration in the region (Coleman, 1988).

Following that train of thought, Saxenian (1994) argues that the mere agglomeration of agents is not sufficient for economic development, as the type of interaction, especially more flexible relations supported by a set of informal social relations and institutions, provide better results.

Considering the technological paradigm initiated in the 1980s, smaller firms and cooperation networks are becoming increasingly important for the innovation process. What is argued in this paper is that, just as geography provides a platform to organize economic activity (Feldman and Kogler 2010), cooperation acts as a platform to organize relations and induce knowledge spillovers.

Following that trend, collective invention and open innovation have become very common terms in recent years. This is because the importance of cooperation has steadily been increasing given a new technological paradigm that requires a more diverse set of knowledge and capabilities. It is also because of the approximation to the technological frontier, which makes innovation harder for single firms with a specialized set of knowledge. Therefore, open innovation is a concept created to illustrate this new setting, in which industrial secrecy and internal research are losing relevance in the shade of more collaborative and open settings, aimed at the sharing and diffusion of knowledge (Chesbrough 2003). Collective invention, on the other hand, can be described as a cooperative setting in which certain agents freely share knowledge and information, and each individual agent carries out their innovation efforts, improving their knowledge base and, in turn sharing the new knowledge (Cowan and Jonard 2003).

Despite an apparent conflict of interests in terms of appropriability of an invention, firms engage in collective invention settings as a result of a more intensely specialized labor division, which makes it harder to predict where complementary knowledge will arise, driving agents to share knowledge in order to stay updated – therefore, agents would be open to share information and knowledge. In other words, cooperation would be a means of overcoming information problems and acquiring access to different sources of knowledge (Powell and Gianella 2010).

It is important to note that cooperation was being used more often as an organizational setting in the mid 1980s because there was a major shift in the economy, from what some call the managed economy to the entrepreneurial economy. In this new organizational setting, the introduction of ITC technologies reduced transaction costs, causing a movement to a more technology-intensive economy and reducing the importance of scale economies. As a result, there was more room for innovation, and average firm size dropped (Thurik, Stam and Audretsch 2013). Therefore, cooperation was a solution to problems of resource limitation, asset complementarity and cost savings; downsizing and outsourcing became very common, and cooperation, again, favored the pooling of resources and human capital. In addition to that and as a result of a more technology-intensive paradigm, as research costs increased, the incentive to utilize

external knowledge increased as well (Georghiou 1998; Tether 2002; Becker and Dietz 2003; Rycroft 2007; Sánchez-González, González-Álvarez and Nieto 2009). Also, shorter product cycles increase the urgency to innovate, driving firms to cooperate and obtain access to denser knowledge flows (Faria, Lima and Santos, 2010).

In terms of empirical evidence, even in the early 2000s, many studies already showed the positive and significant relationship between cooperation and innovation (Becker and Dietz 2003). As a matter of fact, at the end of the 1990s an increase in the number and range of cooperative agreements in Europe can be observed, especially in the big science sectors. This is because these are the sectors that benefit the most from cooperation and cost sharing, and as a response from industry players who realize how science can generate a competitive advantage. European firms were overshadowed by American and Japanese firms who turned to cooperation as a method of accelerating the catch-up process (Georghiou 1998). This was because through the 1980s and 1990s antitrust agencies in the EU and the USA had been approving more and more research joint-ventures in which the parts would combine their resources to produce innovation. Spillovers would be partially internalized, aligning social and private returns (Kaiser and Kuhn 2012).

Bellini, Piroli and Pennachio (2018, pp. 2) describe some of the most important incentives to cooperate in the current economic setting: "Companies mainly collaborate because of the fast pace of technological change, strong markets and high levels of competition, the complexity and uncertainty of the innovation process, the short lifespan of many products, and the high costs of R&D. These factors are especially relevant for small and medium-sized enterprises (SMEs) operating in science-based industries". The factors above are more relevant for smaller firms because they generally have fewer resources and a less diverse set of knowledge. This is especially relevant because there is, assumedly, a tendency of sectors to become less concentrated in this new economic paradigm, given the relevance of startups and smaller firms as disruptive players. Firms and universities possess complementary resources, entailing potential synergies, and this cooperation setting is especially important for SMEs, especially in Europe.

Nonetheless, the process of diffusion for spillovers is weaker the greater the geographical distance, it also takes time and is often incomplete (Döring and Schnellenbach 2006). Maybe cooperation could provide a platform to improve spillover transmission. More recent literature has explored this path, with Ponds, Oort and Frenken (2010) stating that, depending on the technological intensity of a sector, the relevance of geographical distance for the intensity of spillovers declines as cognitive distance (the proximity of industries according to the knowledge utilized in their production process) takes a leading role, allowing for a greater effect of spillovers over a longer distance.

In addition to that, there are more complex mechanisms than just face-to-face informal contact, such as the creation of spinoff firms, specialized labor mobility – as presented by Saxenian (1994) – and the transfer of human capital between firms, EDI and the trade or transfer of goods that are embedded with knowledge (Ponds, Oort and Frenken 2010; Döring and Schnellenbach 2006). Also, it is worth noting that a region's or firm's absorptive capacity, usually measured in terms of its internal R&D spending and human capital assets, is quite important for the diffusion process.

Tying spillovers to our focus on cooperative settings, formal networks of cooperation build solid relationships regardless of distance, which in turn generates more spillovers over a greater distance (Döring and Schnellenbach 2006). As stated previously, cooperation can shorten the distance between two regions, in terms of the range of knowledge spillovers. This is because cooperation strengthens the informal institutions upon which the innovation process and spillovers mechanisms are dependent, as it drives new relationships between agents and increases the frequency of relations and builds a routine of sharing knowledge beyond the firm's boundaries: "Innovative networks are therefore characterized not only by stable routines to share knowledge internally, but also by routines of receiving and handling incoming knowledge spillovers." (Döring and Schnellenbach 2006, pp. 380). On the other hand, firms that do not cooperate tend to work to protect their knowledge, weakening the spillover diffusion process.

Therefore, what we propose here is that, while cooperation networks are definitely a *direct* transmission mechanism of spillovers as it constitutes a platform for interaction and boosts other mechanisms, it may also be an *indirect* transmission mechanism (or a governance setting that boosts the transmission of spillovers), and an especially important one for knowledge diffusion over great distances. It can also be argued that these types of agreements offset the importance of face-to-face contact – for great distance agreements especially – which is considered the main transmission mechanism for spillovers. In addition to that, knowledge that was not initially intended to be passed on can, in fact, be diffused to partners, constituting another way of unintentional knowledge diffusion.

There is also an argument in the literature in favor of cooperation especially for technology intensive sectors that are close to their respective technological frontiers. Innovation on these sectors usually requires a greater diversity of knowledge and resources, and cooperation facilitates cross-fertilization and cost-sharing (Tojeiro-Rivero and Moreno 2019; Ponds, Oort and Frenken 2010).

On another note, some papers read for this article regard the matter of cooperation versus competition in terms of economic and innovation performance. Baker (2007) and Shapiro (2011) deal with this matter more extensively, providing principles that aid in the analysis of whether cooperation or competition would be a better fit in a specific case. In general, it is argued that cooperation is potentially more beneficial, since the synergies principle (related to asset and knowledge complementarity) is usually quite relevant and surpasses appropriability and contestability concerns.[2]

Considering the arguments presented above, now we move to the literature survey, aiming to collect results and see how our proposition stands when tested against theoretical and empirical works on the subject.

3. Literature Survey

The literature survey made use of 59 papers concerning cooperation. This section is divided into four subsections. The first deals with general cooperation performance, pooling contributions that focus on measuring the effect of cooperation on innovation performance with no particular focus on governance. The second subsection aims at discussing papers that treat the effect of cooperation on innovation performance through the scope of antitrust policy, providing insight into how the cooperative setting affects competition dynamics in an industry. Subsection three analyzes cooperation performance through the regional economics vantage point, assessing the spillovers and innovation performance of cooperative agreements. Finally, subsection four gathers papers assessing how the characteristics of firms impact cooperative agreements, examining partner selection, performance of different governance settings, university-industry relations, public involvement, and cooperation in developing countries. Additional insight is provided regarding other themes, such as international cooperation, cooperation performance according to knowledge type, and cooperation performance according to firm size, which are areas that many papers touch but are not often at the center of the analysis.

3.1 General Cooperation Performance

Perhaps more important to the work in hand is the empirical evidence that supports the theoretical base and conjectures posed above. It is interesting to note that, despite most of the evidence pointing to a positive effect of cooperation on innovation performance, there are negative and inconclusive results as well. These results may vary because of the database used, the technology intensity of the region analyzed, and many other factors. Also, a significant number of the papers use the knowledge production function (KPF) approach, as introduced by Jaffe (1989), or some method that assumes the existence of a KPF and accounts for productivity, while many others mainly use patent data to measure spillovers.[3]

The evidence that R&D cooperation is a way of benefiting from the complementarity of resources between two (or more) firms is ample. In fact, complementarity of resources is a major reason to cooperate, and this cooperation is especially important for small firms (Najib and Kiminami 2011). Also, it is argued that the number of partners has a positive effect on R&D commitment by firms, although it might depend on the complexity of knowledge and on the objectives of the firms involved (Becker and Dietz 2003; Teece 1992). The positive side of the argument could relate to something discussed previously: if a firm has more partners in a cooperation setting, it is likely that the partners are more heterogeneous, with diverse knowledge sets, which boosts synergies and improves research productivity. On that note, the positive effect of cooperation on innovation and productivity based on asset complementarity is greater than the appropriation problems it may cause (Foray 1991).

Empirical evidence demonstrates that, in the case of fragmented industries, complex forms of cooperation, such as interfirm agreements and alliances, are beneficial for innovation and for the competitive environment of the industry.

In fact, emphasis is put on the positive effect on innovation from cooperation in complex networks for technology-intensive sectors: “Cooperation is said to underpin the global reach of these networks and to reduce the time in which complex technologies can be innovated” (Rycroft 2007, pp. 556). This trend was visible as early as the mid 1990s, when the possibilities and range of cooperative agreements in Europe were widened, as there were attempts to catch-up with more developed technologies in the US. Japan emerged as a highly innovative economy based on cooperation and researcher (scientist) mobility, as well as a greater use of scientific knowledge in R&D for commercial use (Georghiou 1998). Later, the European

[2] For further reading on the subject, in addition to Shapiro (2011) and Baker (2007) see Pires-Alves, Gonzalo and Lyra (2019).

[3] See Nagaoka, Motohashi, and Goto (2010) and Hall, Mairesse and Mohnen (2010) for more information on measuring innovation with patent data.

Regional Innovation Survey would provide data to confirm that intensive cooperation networks led to greater innovation, especially for knowledge intensive sectors (Koschatzky and Sternberg 2010).

In the case of Spanish industry, there is evidence to support the fact that cooperation is more important for firms concerned with environmental and green innovation. These are sectors with commonly high technology-intensity and networks with suppliers and universities provide better results in terms of performance (De Marchi 2012).

Nevertheless, there is also evidence contrary to the beneficial effect of cooperation for innovation performance. Some works emphasize that internal resources and capabilities are more influential in innovation performance than external knowledge (Negassi 2004). This is where antitrust concerns might arise, since cooperation might provide a platform for firms to collude, which could bring negative effects not only to innovation performance, but also to society as a whole.

3.2 Cooperation, competition, and antitrust

Regarding the rise in number of cooperative arrangements, from the standpoint of the dynamic of the competitive process, in high value-added sectors, innovation takes a leading role in the competition process, especially in knowledge and technology intensive sectors (Rycroft 2007). At first, one could conclude that, because of that, competition would always be preferred in terms of innovation performance when compared to cooperation. However, that is not the case. We have demonstrated earlier that, in a context of smaller firms and more dynamic markets, cooperation can be beneficial (and in most cases superior to competition) because of asset complementarity and synergies between firms' knowledge sets (Baker 2007; Shapiro 2011).

In fact, while it is true that cooperation is a more efficient organizational setting most of the time, competition policy literature can provide insight regarding in which conditions competition is preferable to cooperation. The diversity principle holds that, since the process of innovation is a process of trial and error and firms have a routine significantly dictated by learning-by-doing, the elimination of a competitor through an acquisition, for example, can be inefficient. The diversity principle puts forward that a more diverse pool of firms and therefore knowledge will explore a more diverse range of possibilities in terms of innovation. This concept connects to our subject by implying that cooperation would be better than the elimination of a player from the market by an acquisition, because the players would be able to benefit from the synergies and complementarities of assets, and this type of agreement would keep the pool of firms diverse (Kerber 2010).

In addition, it is argued that *ex-ante* cooperation arrangements (i.e. joint R&D) provide better results and less anticompetitive concerns than *ex-post* arrangements (i.e. patent licensing). This is because, on the one hand, *ex-ante* arrangements may drive greater investment in R&D, because of the sharing of information and the expectation to internalize spillovers. On the other hand, joint investment in R&D might be smaller than if both firms were pursuing the same goal separately. However, the chances of success are often higher (Katz and Ordover 1990).

In simpler and more direct terms, cooperation mostly brings benefits. Examples are the sharing of risks and costs, asset complementarities, cross-fertilization, etc. without possible anticompetitive effects, such as the elimination of a line of research, a reduction in innovation performance or the abuse of market power (Schilling, 2015). Nevertheless, there is the possibility of abuse of market power, especially under certain market conditions, such as high barriers to entry or when the collaboration agreement encompasses a substantially high share of the market. This might result in discrimination or opportunistic behavior, which would undermine innovation efforts and, therefore, social benefit (Brodley, 1990; Katz and Ordover, 1990; Helm and Kloyer, 2004).

3.3 Cooperation, spillovers, and the regional factor

Turning to the relationship between the regional context, spillovers and cooperation, the idea that cooperative relationships work as a vehicle for knowledge spillovers has been tested, and the results are rather ambiguous. In part, this might be a consequence of the very "elusive" nature of spillover measurement, as highlighted by the regional economics literature itself. There are positive and negative results, and some results are positive but not significant. While the R&D productivity differential between two regions might be explained by greater efforts by some agents in a particular region and the spillover effects that they cause in that region. Early evidence suggests that R&D cooperation is not only not important as a spillover transmission mechanism, but also does not translate into technological success.

One conjecture is that higher spillovers would lead to more cooperation, which is not confirmed at a national level. It has also been argued that the relationships that generate spillovers between agents might be below the scope of cooperative relations, in the sense of the high formality of this arrangement (Fritsch and Franke 2004; Negassi 2004). Nevertheless, there is a tendency of spatial agglomeration, not in

technology intensive sectors, but in the cooperation patterns in these sectors, hinting at the importance of spillover effects and of cooperation in that context (Fritsch 2003). Other scholars seem to provide a better picture of the actual effect of cooperation on knowledge spillovers. Indeed, there is evidence that the R&D performance of agreements depend heavily on their spillover potential, especially for vertical agreements, which can additionally affect horizontal arrangements (Atallah 2001).

Panel data estimation for Spanish firms can demonstrate how the regional context affects the efficiency of cooperation networks, seeking a direct spillover transmission mechanism. As usual, a strong agglomeration in denser regions is identified, such as Madrid and Cataluña, as well as a much higher intensity of R&D spending for firms that cooperate, reaching ten times that of firms that do not cooperate. Obviously, that incurs better performance for firms that cooperate. For regions with a technology-intensive base, full-on cooperation appears to be the best organizational setting, as outsourcing shows better results for firms in low technology intensity areas. This seems to be due to two factors: first, high intensity regions possess greater absorptive capacity, and therefore are able to exchange knowledge with greater ease, while low intensity regions present better results from using outside resources, as they are not able to collaborate at such a high level, and are limited by a lower absorptive capacity (Tojeiro-Rivero and Moreno 2019).

From the Netherlands there is conclusive evidence that cooperation networks with universities are important spillover transmission mechanisms for technology intensive sectors. The networks increase spillover range and there are agglomeration effects near specialized research laboratories and universities (Ponds *et al.* 2010).

In Korea, the relationship between "unintended innovation performance" – which could be interpreted as some form of spillover effect – also provides interesting insights regarding the connection between cooperation and spillovers. In the manufacturing industry, R&D cooperation increases the probability of unintentional innovation. In addition to this, the relationship between the sector's technology intensity and its appropriability regime may affect the outcome of cooperation. These findings are in line with the literature presented above in the sense that the synergies principle is strong in both cases and for sectors with weak appropriability regimes[4] the knowledge produced by research institutions, which tends to be codified knowledge, is beneficial for innovation (Seo *et al.* 2017).

3.4 Who Cooperates?

3.4.1 Partner selection/Traits of firms that cooperate

First, it is interesting to note that different governance settings and partner types for cooperation mean that firms acquire information from different sources. Further, one could argue that the traits of partners matter to the innovation process, and that different governance structures might affect outcomes in different forms. This section aims to pool the evidence on these topics.

In fact, the type of partner chosen might shed light on what are the complementary resources and synergies that firms aim to use and achieve. Evidence from Canada suggests that innovating at a high level demands a wider pool of information, in the sense that firms seek complex knowledge in many different locations and organizations. Based on similarity and complementarity, firms might engage in cooperative agreements (Amara and Landry 2005; Arranz and Arroyabe 2008; Foray 1991). In turn, this raises the argument that the more research partners a firm has, the better its innovation performance, and this has been consistently tested in the literature with inconclusive results. In fact, the results of having many cooperation arrangements at the same time depend on firm size, since smaller firms do not have the resources to sustain multiple agreements at the same time – and on the specific strategy of each agreement. The bottom line is that engaging in several different R&D cooperation agreements is not a guarantee of improved performance (Belderbos *et al.* 2006).

The search for complementary technology and knowledge is probably the most important incentive a firm may have to cooperate, followed by gaining access to new markets. Regarding the process of choosing partners, the motives behind a firm's decision to cooperate actually dictate the type of partner that is best suited to cooperate with. Accordingly, firms that seek knowledge usually cooperate vertically – horizontal cooperation happens less often – with local suppliers, consumers and research institutions, while firms that seek market access tend to cooperate internationally (Miotti and Sachwald 2003).

European data mainly supports the argument that firms choose partners according to the synergies they seek, as their cooperation patterns remain local for the locally technology intensive sectors, and as they seek international partners for sectors that are not locally developed (Arranz and Arroyabe 2008). There is also evidence pointing to the fact that more complex innovators usually cooperate more with

[4] For more information on appropriability regimes, see Malerba and Orsenigo (1997): *Technological Regimes and Sectoral Patterns of Innovative Activities,* Industrial and Corporate Change, Volume 6, Issue 1, Pages 83–118

international players (Tether 2002). Evidence from the Campania region in Italy sheds light on matters concerning performance and certain aspects of the organizational setting, in addition to firm's perspective on their partners' characteristics and what they expect of a partner, emphasizing trust and previous cooperative experience (Bellini *et al.* 2018).

In addition to this, vertical arrangements seem to be more effective than horizontal ones, which once again raises concern about cooperation *vs.* competition (Miotti and Sachwald 2003). This becomes clear in terms of a share of cooperation partners. One study points out that 67.3% of firms cooperate with business-oriented service suppliers, 58.2% cooperate in R&D with customers, 45.4% with manufacturing suppliers, 30% with public research institutes and only 25.9% cooperate with other firms (Fritsch 2003). For cooperation with consumers, the degree of transparency of information plays a major role in the decision to cooperate because if information is rigid, firms will need to cooperate with consumers to acquire the information they need (Sánchez *et al.* 2009).

Regarding the cognitive proximity or the technological diversity of partners in cooperation, it is argued that a moderate level of diversity provides the better results in terms of innovation (Sampson 2007). The logic behind that argument is that if cooperating firms are too similar, then *there is no benefit* in sharing knowledge, capabilities and resources. On the other hand, if they are too different, then they *are not able to* benefit from their partner's knowledge and resources, because they are not compatible and do not have the necessary absorptive capacity. Separating diversity into geography and knowledge (or function, routine), these types of diversity act via separate channels: functional diversity leads to a variety of knowledge and synergy effects that are essential for product development and commercialization. In terms of innovation, the benefits of cooperation are a result of the process of exploration of complementarities between firms at different stages of the vertical chain or in different geographical locations. Furthermore, firms that cooperate with external partners have a higher innovation output per worker (which is even higher for incremental innovation). In terms of how firms choose their partners, previous experience, patenting and IT infrastructure are the main factors. In addition to these, functional diversity has a more significant influence on radical innovation, and geographical diversity influences incremental innovation relatively more. Interestingly, bigger firms (in size) tend to cooperate more while multinational groups cooperate less (van Beers and Zand 2014).

It is worth noting that conclusions might vary according to different model specifications. For example, evidence from Korea suggests that a general test of cooperation, which does not differentiate types of governance, shows a negative effect for collaboration variables on product innovation, with only government support positively and significantly influencing innovation. However, when separating types of partners and assessing process innovation, the results showed a positive and significant effect for interfirm collaboration and cooperation with research institutions, although there was no statistically significant effect for agreements with universities (Kim and Park 2008).

Some evidence from Spain on the traits of firms that use mainly cooperation as a means to innovate might seem contradictory at a first glance: smaller firms and firms in lower technology intensity sectors tend to be cooperation-based innovators, while large and R&D intensive firms tend to innovate more alone. Nevertheless, this is not inconsistent with the literature, since smaller firms lack the internal capabilities to innovate, and depend more on other sources of information and resources. Additionally, cooperation-based innovators – small firms – tend to cooperate with fewer agents, mainly providers and national partners, while large firms tend to cooperate with more diverse agents, including international players (Barge-Gil 2010). On the other hand, and more in line with the mainstream, there is also evidence pointing to a greater importance of cooperation for bigger firms in technologically intensive sectors; more specifically for firms with a high absorptive capacity, high levels of investment in innovation, high R&D intensity and high share of R&D employment, and that actively work on incoming spillover management (Fritsch and Lukas 2001; Fritsch 2003; Faria *et al.* 2010).

In fact, firms that consider outside information (incoming spillovers) more important to their innovation process are much more likely to cooperate. Also, firms that are more effective in appropriating the benefits from their innovation process, in other words managing outflowing knowledge (outgoing spillovers), are also more likely to cooperate. Not only that, but firms are able to improve on these skills, becoming better at managing information inflows and outflows (Cassiman and Veugelers 2002).

Although there is evidence suggesting that collaborative experience has no significant effect on innovation performance (Schwartz *et al.* 2012), the majority of the papers analyzed point to a positive effect. Efforts from Italy shed light on the matter of how a firm's experience of cooperation arrangements and the trust they have towards possible partners affect the performance of the arrangement. Their results suggest that trust is the factor with the greatest impact on tangible benefits, while collaborative know-how has the most significant effect on intangible benefits, and collaborative experience has a positive effect on both types of benefits (Bellini *et al.* 2018).

3.4.2 Performance of different governance settings

On the matter of the effects of different governance structures on innovation performance, we must emphasize that the results are potentially very case-specific, varying considerably between industries and governance structures. This is argued in many of the papers studied here, many in technologically intensive sectors, such as pharmaceuticals, biotechnology, telecommunications and semiconductors (Staropoli, 1998; Quintana-García and Benavides-Velasco, 2004; Sampson, 2007; Cassiman *et al.*, 2010).

That said, let us first analyze what some authors call "co-opetition", which is the situation in which firms compete and cooperate in the same horizontal market. It is found that co-opetition strategies are mainly beneficial, and sometimes even more so than cooperation with slightly diversified agents. Notwithstanding, co-opetition with large firms has been found to be the best in terms of innovation performance (Quintana-García and Benavides-Velasco, 2004). There is also evidence showing that the relationship between co-opetition strategies and innovation performance present an inverted U-shape (or bell shape), which is actually softened by strong technological capabilities or by cooperating with universities and research institutes (Wu, 2014).

There is also evidence demonstrating the influence of joint R&D or sourcing agreements. In fact, while sourcing appears to only have a positive effect on innovation if the firm that has contracted the outside resources is in a low technology intensity sector, joint R&D agreements usually have a clear positive effect, especially for technologically intensive sectors. Nonetheless, outsourcing can be beneficial as well because it affects cost variables. Therefore, it is not a matter of "one or the other", but a matter of using these arrangements strategically, for the purpose that suits them best (Adams and Marcu, 2004; Tojeiro-Rivero and Moreno, 2019). Further evidence suggests that contracting *vs.* R&D cooperation depends on the strategic value of the information that firms are developing. They are more reluctant to openly share valuable information. In this case, firms are more likely to employ outsourcing activities instead of formal cooperative agreements, in order to protect their valuable information. On the other hand, basic projects are more likely to be developed through formal cooperation, while if firms need to *develop* new knowledge, they adopt a more open approach. Finally, if a firm's needs are quite outside their capabilities, it is more common for them to outsource from scientific organizations (Cassiman *et al.* 2010).

Many of the papers examined here analyze joint ventures. In fact, evidence supports the fact that joint ventures are quite relevant when it comes to the development of cooperation skills by firms, in addition to, of course, providing a platform for knowledge sharing (Anderson *et al.*, 2011). There is evidence linking the performance of different joint venture structures directly to the spillovers that are expected from each of them. The main conclusions are that horizontal cooperation does not necessarily hinder R&D spillovers if horizontal spillovers are low, since vertical spillovers might compensate them if the firms are cooperating vertically as well, and both those governance structures are combined. That is because a positive causality between vertical spillovers and horizontal spillovers is found to exist. Nonetheless, there is no clear "winner" between no cooperation, horizontal cooperation, vertical cooperation, and combined horizontal and vertical cooperation. Each structure is best fitted to a specific case, industry, and spillover pattern (Atallah 2001). Indeed, the regional context cannot be underestimated. Spatial proximity seems to be important especially for partnerships with business-oriented services, public research institutes and other firms in technologically intensive sectors (Fritsch 2003). The regional factor is also particularly relevant when dealing with tacit knowledge.

The debate around firm size and innovation performance is not new and can be traced back to Schumpeter's first contributions at the beginning of the 20th century. In terms of cooperation, it has been shown that there is a consolidated idea that small firms benefit more from cooperation because they lack resources and capabilities, while bigger firms tend to be more independent innovators, and firm size commonly appears in models with a negative sign pointing to the greater importance of cooperation for smaller firms (Najib and Kiminami 2011; Bellini *et al.* 2018). Even though some of the papers examined so far have covered the matter in part, now we examine the papers that test firm size as a central factor influencing cooperation and innovation performance.

It is interesting to note that there is evidence portraying small firms as being more productive than bigger firms, because they might have a higher patent to sales ratio. Nevertheless, the two kinds of firms can be seen as mutually dependent as smaller firms very often cooperate more than bigger firms, and mostly with bigger firms in order to innovate (Shan *et al.* 1994; Arranz and Arroyabe 2008; Belderbos *et al.* 2006; Barge-Gil 2010; Okamuro 2007; Okamuro *et al.* 2011; Koschatzky and Sternberg 2010).

Interestingly, bigger firms (in size) tend to cooperate more while multinational groups cooperate less – the reason for this would be that multinationals have more resources (van Beers and Zand, 2014). Small firms, on the other hand, have the necessity to cooperate with different agents in order to build an open innovation environment and acquire knowledge from different sources (Zeng *et al.* 2010).

On the other hand, there is also evidence suggesting that small firms are not more or less cooperative than others (Negassi 2004; van Beers and Zand 2012). In fact, some argue that, in a modern economy, firm boundaries are ill-defined and internal resources and capabilities do not matter as much, since cooperation is such a disseminated practice (Teece 1992).

3.4.3 University-Industry relations

Turning our attention to agreements involving universities, evidence shows that these institutions tend to have more collaborative connections and to cooperate more with small firms than the average firm does. In fact, universities are of much greater importance to small firms than otherwise, because they can provide knowledge and skilled individuals. There is no basis to support the argument that either (universities or firms) have more localized relations than the other (Roper and Hewitt-Dundas 2012). On the other hand, collaborating with universities might be one way that firms have to escape not only competition, but the "co-opetition" process as well, as they can engage with a partner (university) they are not in competition with (Wu 2014).

In the Netherlands, university-industry (UI) the effects of cooperation on innovation performance and spillovers are analyzed. Results point to the conclusion that channels through which academic research affect regional innovation are geographical proximity and networks. This is due to the fact that in technology-intensive sectors firms that invest heavily in R&D are usually closely related to universities and research institutions. Knowledge spillovers are localized to the extent that the channels through which they impact innovation are localized. The innovation output of a region depends on the R&D spending of universities and firms in the region and on R&D spending of firms in adjacent locations. 'Internal' spending is their direct investment, which increases the region's absorptive capacity. R&D spending of adjacent regions spills over to the first region. One very interesting finding is that formal UI networks of cooperation are important mechanisms for spillover transmission. In addition to that and according to the literature, it is found that spillovers of academic knowledge have greater reach, or wider range, than spillovers of applied knowledge (Ponds *et al.* 2010).

Once again, a study from Italy provides a useful insight on the positive roles that trust and previous cooperative experience play on the success of University-Industry arrangements, since these factors provide tangible as well as intangible benefits (Bellini *et al.* 2018). One interesting piece of evidence suggests that individual contracts with academics, rather than agreements with universities, provide better value for inventions, since the individual might have a greater incentive to share his knowledge (Fassio *et al.* 2018).

3.4.4 Public involvement

Now we turn to the performance of agreements with government institutions or organizations that have some sort of government support. We begin with evidence regarding how the agreements between firms and research centers contribute to open innovation. The establishment of publicly-funded research centers (PRCs) is a way that public policy can drive innovation and cooperation in an open innovation setting. The findings suggest that academic centers form more connections than industrial centers, but there is no evidence suggesting that industrial cooperation is more localized than academic cooperation. Also, the research carried out in universities must be appliable in firms, especially smaller ones (which are the ones that benefit more from cooperation) in order to boost performance and benefit open innovation (Roper and Hewitt-Dundas 2012).

Evidence from Argentina suggests that a firm's collaborative experience is important when cooperating with public research organizations, although the knowledge base of the firm does not seem to matter. Nevertheless, firms that do cooperate with public research organizations tend to invest more in innovative activities and are more likely to patent (Arza and López 2011). In fact, evidence from Germany and France shows that firms that cooperate with public research institutions show better results in terms of product innovation, although in terms of process innovation, the performance depends on the firm's level of openness. Innovation benefits much more from these agreements in Germany than in France, since German innovation policy is much more centralized and engineers have more scientific training and experience, facilitating the integration (Robin and Schubert, 2013). Further evidence from government supported projects in Germany suggests that large firms produce more patent applications but do not increase the number of scientific publications. On the other hand, university involvement increases the number of publications but not the number of patents filed (Schwartz *et al.* 2012).

For Danish firms, the effects of government subsidized joint ventures have been estimated and a positive effect was found on the number of patents filed by firms and on employment. Interestingly, the

policy appears to have little effect on large firms and it is suggested that it be focused on smaller firms (Kaiser and Kuhn 2012).

3.4.5 Developing Countries

Cooperation can also be seen as an indispensable tool of industrial policy, as demonstrated by evidence from Germany and countries that have developed their economies in the recent past, such as Japan, Korea and China. Now we examine what the literature has to say regarding international cooperation and cooperation in developing economies. Indeed, innovation is probably the best way through which an economy can insert itself into high positions of the global value chain. One study from China shows that firms in developing countries must seek structural holes in the value chain and use information to their advantage. They must also build international joint venture portfolios according to the knowledge they need in order to enter that position (Sun and Lee 2013), especially because international cooperation agreements seem to be even more focused on accessing and acquiring new knowledge in order to innovate (Arvanitis and Bolli 2013).

Firms and institutions in developing economies must be able to select partners according to their own needs and the partner's possible contribution, then determine the best strategy and cooperation setting. Considering an open innovation setting, governments should aim to provide a platform for networking and encourage firms to collaborate with international agents (Lee *et al.* 2020). In fact, SMEs in developing economies are especially dependent on innovation cooperation, since they benefit greatly from cooperation with several kinds of agents and from clusters of innovation (Zeng *et al.* 2010; Najib and Kiminami 2011).

Evidence drawn on international joint-ventures in Taiwan point to the importance of these agreements for developing countries. The economic value of these agreements lies in the need to acquire external knowledge (Mahmood and Zheng 2009). There is also evidence highlighting the institutional factors of a location that favor the results of international joint ventures in China, measured by R&D spending of that joint venture as proxy. It is argued that regions with better infrastructure, a developed banking system, technical services, universities and research institutions have a positive effect on innovation (Ma *et al.* 2014).

4. Conclusions

This paper has performed a literature review on the matter of cooperation, especially cooperation on innovation activities. The 59 papers analyzed here provide a good picture as to the evolution of the subject, providing evidence on the general effect of cooperative agreements, as well as performance differences between certain governance structures. Additionally, we deal with the matter of how firms choose their partners and what traits make firms more likely to cooperate. Finally, more peripheral themes are examined, such as UI relations, the effect of the public presence in cooperation agreements, how firm size might affect cooperation and innovation performance, the matter of cooperation in developing countries, how cooperation intertwines with externalities and the regional context, and antitrust concerns regarding cooperative agreements.

Most of the evidence on the effects of cooperation points towards a positive effect on innovation performance. There are certain differences depending on the industry and the subjacent type of knowledge, but the positive effects of cooperation are consistent throughout the literature. The possible limitations of the literature presented are that papers mainly test the effect of cooperation on very small regions, such as Bellini, Piroli and Penacchio (2018) Ponds, Oort and Frenken (2010), and Cassiman and Veugelers (2002), although there are exceptions, such as De Marchi (2012), or a much broader scope, analyzing at the international level. Furthermore, working with aggregated data might provide poor conclusions regarding a more localized scope. One possible way to further this topic would be to merge these two approaches, by analyzing many countries together, in a larger scope, but with disaggregated data.

It is also interesting to note that, regarding the proposition we put forward in section two, that cooperation may constitute a platform that boosts spillover transmission mechanisms, some papers provide evidence to confirm this, such as Tojeiro-Rivero and Moreno (2019), Ponds, Oort and Frenken (2010) and Bellini, Piroli and Penacchio (2018). It is widely accepted that spillovers happen with face-to-face contact, but cooperation drives knowledge sharing and diffusion in an organizational setting and in an environment explicitly for this purpose.

Cooperation in Innovative Efforts: A survey of the literature

Abstract

The importance of cooperation as a mechanism leading to innovation has been widely examined. Cooperative settings are potential platforms for indirect as well as direct transmission of knowledge. The aim of this article is to synthesize the contributions of the main papers dealing with innovation cooperation, while emphasizing the effects of cooperative settings according to their different governance structures, the reasons to cooperate and partner's characteristics, firm size, the regional context, and the stage of development of a country's economy. In general, cooperation is an organizational setting that determines the sharing of knowledge and its diffusion. Great part of the empirical evidence analyzed here points to a positive effect of cooperation on innovation performance. However, although there are exceptions, this positive correlation is found most often in case studies of technology-intensive sectors in small regions.

Key Words: cooperative innovation; governance structure; spillovers; competition; knowledge diffusion.

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