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Knowledge and Cooperation Determinants of Innovation Networks: A Mixed-Methods Approach to the Case of Portugal

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Abstract

Systemic perspectives of innovation integrate complex interrelations among enterprise, science and technology, and governance spheres. Innovation networks are crucial within innovation systems and refer to the linkages of a variety of actors with the purpose of innovation. In this article, the determinants of innovation networks are analyzed using a qualitative original database of online information about 623 organizations in Portugal. A binary econometric regression for all types of entities is estimated. The model underlines that actors using external technologies and promoting knowledge are more likely to innovate. In parallel, actors that are involved in managing and supporting entrepreneurship have a smaller probability to do it. Advanced firms and universities are the actors more willing to dynamically innovate. Specific models for firms and universities create a direct comparison between the determinants in both collectives. While promoting knowledge and specific orientation towards innovation is essential for firms it is not relevant for universities. Managing knowledge is the crucial catalyst for the innovation practices in universities. External technological linkages are essential for both types of actors in the creation of innovation networks. The article concludes with policy implications regarding the support of cooperation activities to instigate innovation.

Keywords: innovation; innovation networks; innovation system; content analysis; logistic regression.

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Introduction

Innovation encompasses a variety of cooperative activities centered in the development of new products and processes and in the increase of competitiveness. As a relational process, innovation involves a diversified group of actors connected by linkages with different degrees of intensity (Fløysand and Jakobsen, 2010). Largely influenced by Nelson and Winter (1982), evolutionary and institutional perspectives of innovation unveil a multifaceted and multi-stakeholder process, characterized by different types of relationships at various levels, such as social, historical, cultural, beyond a narrow economic approach. An essential feature of the knowledge economy is the high degree of innovation, with a very rapid rate at which skills become obsolete and new competencies are developed (Lundvall, 1996). Processes underlying relations linked to innovation, knowledge creation and transfer, relate to interactive learning (Kirat and Lung, 1999). Knowledge is a process itself, not only coming from R&D, since there are many ways of learning, through learning by doing, learning by using, learning by interacting (Lundvall, 1992), the so-called DUI mode of learning. The existence of these evolutionary processes of learning and knowledge are rooted in the territory.

It is essential the attitude of the community toward the promotion of interactive learning, requiring an intention of actors in developing innovation processes and creating synergies (Capello, 1999; Camagni and Capello, 2009). The territory is seen as a relational space (Capello and Nijkamp, 2009), understood as the area for collective action, interpersonal synergies, informal cooperation that empowers and guide actors' behavior (Bramanti and Riggi, 2009). Geographical proximity increases the transfer of tacit knowledge based on face-to-face interactions. The territory becomes the environment where the process of knowledge creation happens, which depends on the competitiveness of regions and existing companies. Geographical proximity is important, but other types of proximity are also relevant (Boschma, 2005). Territorial dynamics of innovation is defined in a systemic way based on a complex environment and how this complexity defines the innovative capacity. Current innovative dynamics is a consequence of evolution, resulting in a sequence of trigger decisions along the pathway. Innovation is therefore not static but dynamic, evolves over time and is path-dependent.

This article assumes implicitly three basic elements that provide a territorial framework to the knowledge creation process: institutions, routines and cumulative knowledge. Institutions are the foundations for the innovation process, creating stability in uncertainty. They refer to habits, rules, traditions of a given society that are embedded within history, culture and the specific developmental trajectories, humanly devised constraints that structure political, economic and social interactions (North, 1991). Routines are created and followed by actors, conferring more predictability to performance. Routines reflect embedded knowledge in organizations, which were created through experience. According to Nelson and Winter (1982), routines shape the behavior of firms in order to enable the ability to have a decision before the problems emerge. Knowledge is cumulative as current knowledge depends on previous accumulated knowledge, defining future developments regarding the direction of innovative enterprises and path dependencies from which territories can hardly escape (McCann and Van Oort, 2009). Relationships that emerge within a given territory define the technological trajectories that may be more or less favorable to innovation (Storper, 1997). In contrast, territories do not have the same record of accomplishment of innovation because these three elements function as stabilizers, are disparate among regions, as well as the interaction within each territory is distinct. From the systemic perspective of Edquist and Hommen (1999), these differences are recognized and considered fundamental to understanding the complexity of innovation in the territory.

The systemic perspective of innovation is particularly relevant as it integrates complex interrelations among enterprise, science and technology, and governance spheres, infrastructure, and institutions (Chaminade and Edquist, 2006). Even if initiated with a focus in nation-states performances, the attention to sub-national scales gave prominence to territorialized visions of the innovation dynamics. One example is the term 'regional system of innovation' (RIS) that came into use in the early 1990s, informed by in-depth research on a number of European industrial regions (Uyarra and Flannagan, 2013). The variety of concepts of 'innovation system' commonly underline the relevance of innovation networks and institutions that are geographically defined, administratively supported, that interact regularly and strongly to enhance the innovative outputs of firms (Cooke and Schienstock, 2000). Innovation is of critical relevance for the evolution of industries where networks are considered one key element (Malerba, 2006). Innovation networks are, in essence, the sets of relationships, ties or links between nodes that represent the existent innovation actors, persons, firms, organizations, interacting in the generation, use and dissemination of new knowledge (Fischer, 2006a), allowing learning and innovation (Lundvall, 1992; Capello, 1999; Asheim, 2007). There are distinct configurations, origins and implications for networks. The concept of network is a major focus of analysis of the economics of innovation but remains unclear the explanations about internal features and the identification of cooperation dynamics with the goal of creating and consolidating innovation networks.

The present article is focused in the cooperation determinants of innovation networks. It is particularly important to understand how innovation relates with different patterns of collaborative activities regarding knowledge production, exchange and transfer. In parallel, the study is interested in understanding the different behaviors of innovation actors and their likelihood to engage innovation. Using a novel approach, that mixes the selection of qualitative data based in content analysis of organizational websites with standard econometric tools, the study defines types of knowledge cooperation and links these with the specific actors' behavior and the emergence of innovation networks. For these goals, the article is organized as follows. A first section reviews evolutionary and institutional perspectives on innovation networks, clearly separating this notion from other interconnected, knowledge network. A second section presents methodological notes about the empirical analysis and the main interrogations that this study is trying to address. A third section presents an econometric exercise that provides insights for the determinants of innovation networks. The article concludes with policy implications.

From knowledge flows to innovation networks

Innovation systems as the context for networks

An innovation system is a set of actors that interact with the aim of creation and diffusion of knowledge, involving a number of different agents promoting new knowledge and its economically useful application. The commitment between actors may be or not formal, as different types of interactions occur within the innovation system (Edquist and Hommen, 1999; Capello, 2009b). Essentially, there is a focus on cooperation to foster knowledge flows. It is assumed that the greater the interaction, commitment and cooperation between the actors involved, the larger the innovation promoted within the system. The innovation system is based on the possibility that flows do not follow a route defined a priori. This is only possible by assuming that knowledge derives not only from scientific knowledge but also from the combination of different synthetic, analytical and symbolic forms of knowledge (Cooke and Leydesdorff, 2006; Asheim, 2007).

Innovation system approach can focus different scales and perspectives, from National Systems of Innovation (Lundvall, 1992), Sectoral Innovation Systems (Malerba, 1999) to Regional Innovation Systems (Cooke, 1998; Cooke and Leydesdorff, 2006; Asheim, 2007). The National Innovation Systems (NIS) have their main contributions in Lundvall (1992), Freeman (1995) and Nelson (1993), whose basic argument is that innovation comes from a socially embedded process of learning which can only be understood if framed in the institutional architecture, historical context and culture of a particular nation-state. According to this view, the dynamics of innovation regards to the fact that all individuals belong to a nation, defined by common culture, language and ethics, obtained in a single geographical space under one central State authority. The concept of RIS is inspired by the concept of NIS and coincides in several dimensions with other territorial models of innovation such as clusters or industrial districts (Asheim, 2007). The similarities with the NIS are notorious in the sense that it also emphasizes that innovation dynamics depends on elements embedded in territory and society. However, the importance is given to the regional level rather than national. This focus is justified by the existence of cultural and institutional differences between regions, different types of interactions that are developed specifically within each region (Cooke, 1998). RIS combines a focus on regions with a systemic approach (Cooke and Leydesdorff, 2006). Moreover, regions would be more prone to the establishment of systemic relations between actors (Asheim, 2007), through the strengthening of relations of trust (Cooke, 1998) that exists at the regional level, given the geographical and cognitive closer relation.

Companies expand and enhance innovative performance by strengthening internal and external interaction. Impacts at the firm level reflect an increased awareness and capacity of individual knowledge, which in turn will lead to an improved ability of the firm to leverage the individual capabilities and increasing capacity to absorb knowledge at the aggregate level. Absorptive Capacity is the capacity to explore, evaluate and use external knowledge. This ability depends on prior knowledge that can be derived from the basic knowledge, as a common language, to the latest technological knowledge (Cohen and Levinthal, 1990).

Innovation is the result of an interaction between local actors, government and research institutions. These interactions enable companies to overcome internal needs through relationships established in the territory (Fratesi and Senn, 2009). This dynamic tends to be self-reinforcing, since the companies tend to seek external knowledge. As knowledge becomes more complex, the knowledge produced internally is no longer sufficient.

Starting from a basic assumption that geographical proximity effectively promotes the exchange of tacit knowledge through face-to-face contact, there is nevertheless a broader perspective on how this dynamic develops. Tacit knowledge is essential for creating competitiveness through innovation, by its own intrinsic characteristics: it is hardly codified, takes extensive periods to be acquired, is obtained primarily through experience, is extremely expensive and sensitive to the social context (Maggioni and Uberti, 2008). Therefore, tacit knowledge is hardly imitable or transferable to other regions and may be a source of competitiveness. Consequently, geographical proximity is one of the key-enablers of the transfer of tacit knowledge. However, physical proximity is not sufficient to ensure knowledge flows are transformed in stabilized networks. It takes intrinsic aspects of the territory, connected with the social capital (Putman, 1995) referring to the characteristics of a given society that facilitate coordinated action and function as the glue facilitating cooperation and learning (Cappellin and Steiner, 2002). Social capital is a complex phenomenon that involves the relationship and value of a particular group of players that can be activated to produce benefits to those that possess it (Field, 2003). It relates directly to the notion of embeddedness (Granovetter, 1985), suggesting that the actors do not work outside a social context, but are not limited to fulfilling a pre-determined role in accordance with the socio-cultural categories that occupy in a particular moment. Even if the exact role of social capital as an antecedent of innovation remains unclear (Barrutia and Echebarria, 2010), it is crucial as impacts both the performance of businesses and regions (Cooke et al. 2005). Economic, social, cultural and historical fields have a certain social capital, which in turn defines the cognitive models and learning in each region in each moment. It is worth noting that social capital is a spatial phenomenon. The first reason relates to the spatial distribution of actors that possess social capital. But other reasons are also relevant. A dense network of relationships is easier to maintain with proximity. This is even more true for weak links that need to be consistently lubricated, and are seen as crucial to the innovative dynamics (Rutten et al., 2010).

Furthermore, in the innovation system perspective the linear model is replaced by chain-linked versions (based in Kline and Rosenberg, 1986), admitting multiple interactions in many different ways, loopbacks and feedbacks among actors as an essential source of innovation and self-reinforcing processes (Edquist and Hommen, 1999). Innovation systems are not tangible or restricted, are internally "alive" and relate primarily with networks of complex relationships, which allow knowledge flows to reproduce continuously. For this continuity to occur, innovation systems have to be opened, linking with other systems of innovation (Bramanti and Fratesi, 2009; Bramanti and Riggi, 2009), giving relevance to the role of networks and connections of territorial actors with other external networks (Fratesi and Senn, 2009; Uyarra, 2010). Each system has its own channels that enable and allow its existence. Relationships between actors, when being continually enhanced, promote the stabilization of networks (Chaminade and Edquist, 2006).

The Emergence of innovation networks

Networks may have different origins and be constructed in different ways. Knowledge sharing gives a special feature to the dynamics of innovation systems. Shared knowledge usually results in the increasing of the reservoir of knowledge, contrasting with other economic inputs and factors of production that seem to diminish when shared (Sveiby, 2001). This situation created a growing emphasis on networks as a fundamental strategy for competitiveness. In the words of Storper (1997), if mass production was the recommended strategy three decades ago, currently the best strategy is the participation in networks. Networks in the context of knowledge economy imply the need for two key elements: cooperation and intentionality (Visser, 2009). Cooperation involves necessarily not only companies but other actors such as universities, research institutes, laboratories, public agencies and government. Knowledge networks are strategic processes in the sense that they are intentional, selective and repetitive, albeit temporary, of knowledge exchange between innovation actors. Networks rely on how acquaintance linkages are mobilized (Morone and Tayor, 2012). Knowledge networks depend on the past success, accumulated experience that may help to innovate together and increases the similarity of knowledge stocks. Tensions exist between the facility of engaging with partners that share a relevant proportion of commonalities and partners with different and complementary knowledge. The ways that actors overcome these tensions result in the variety of network structures (Cowan, Jonard and Zimmermann, 2006). Innovation networks are evolving entities that depend in the tacitness of the knowledge base and the irreversibility of the system (Llerena and Ozman, 2013). The evolution of networks also depends on the relations between leaders and followers (Grebel, 2012).

Three aspects derive from the ideas explained above: first the existence of knowledge networks is a prerequisite for the dynamics of innovation in a systemic approach. The second aspect involves the attribute of trust. Networks involve a certain stability of relationships, so there is a central role for trust among the agents involved. Trust is the basis of social capital and for the promotion of knowledge sharing as it allows the reduction of risk and uncertainty (Capello, 1999). Trust is so important in the dynamics of innovation that the breach of trust is fatal to the successful operation of systemic interaction (Cooke, 1998). The third aspect derives from the recognition that for one hand, innovation involving creation and transfer of knowledge is essential for economic competitiveness, on the other, it is assumed that new knowledge does not always necessarily lead to economic gains. This last point raises a question, how to ensure that knowledge flows effectively become economically useful?

The relationship between knowledge production and economic growth is not clear or obvious in evolutionary frameworks. More precisely, knowledge networks alone do not guarantee economic gains, as the generation of knowledge does not imply necessarily economic usefulness (Bramanti and Riggi, 2009). Knowledge generated must be channeled in specific ways for promoting its economic valorization, transforming invention into innovation that is new economically useful knowledge, often connected with new product development. It is necessary that knowledge networks evolve into innovation networks, which require intense and fluid knowledge flows (Camagni and Capello, 2009; Cooke, 1998). In sum, it is argued that innovation networks have three additional features beyond the cooperation and intentionality characteristics of knowledge networks (Nijkamp et al., 2010):

- Endowned with intelligent agents in the sense that they have a purpose, not only to work, but with the ability and intention to search for learning in a broad sense, aimed at the continuous creation, assimilation, use and transfer of knowledge with a logical and useful purpose. Agents do not only receive knowledge passively but are creative, find new solutions, actively contributing to the increasing complexity of knowledge.

- Exchange relations of knowledge are intense. The idea of intensity refers not only to the amount of knowledge exchanged in time. The intensity is related to the proximity of interests and with the opening of mentality, towards an open exchange and spontaneous knowledge. There is a focus towards the quality of relations and a real commitment to knowledge sharing and interactive learning.

- Thirdly, innovation networks have a dynamic synergy. This aspect comes from the cognitive environment that involves innovation networks, ensures the strengthening of networks and the continuity of evolutionary dynamics of the innovation system. It fosters innovation and provides the economic purpose of the network.

Altogether, innovation networks originate robust innovation systems, having an internal renewal capacity, making flows complex, as they create and distribute knowledge (Smith, 2002). In the case of clusters, its essence is the concentration of similar businesses in the territory, where there are vertical and horizontal relationships, therefore networks of economic activity (Porter, 1998). In the innovation system perspective, the assumption of the existence of knowledge networks, whose evolutionary process in the region will lead to innovation networks. These will be equipped with intelligent actors, intense relationships and dynamic synergies that, as Cooke (1998) points out, are committed to interactive learning. Specialization is important but diversity and complementarities of related actors and sectors is critical to the creation of Jacobs' spillovers within the system. An innovation system is a framework that will encompass the internal innovation networks but also external connectedness. In short, it is very important to emphasize that networks have an essential role on the systemic approach. Innovation systems consist of relationships and networks are the channels that enable these relationships.

Preliminary Aspects for the Empirical Analysis

Having presented the interest in studying innovation networks, as they are central for innovative dynamics and to structure robust innovation systems, in the following empirical section we will develop a confirmatory study about the types of cooperation flows that are prominent in innovation networks using a mixed methods approach – qualitative and quantitative data and techniques.

We depart from the notion that innovation networks to exist require the focus in the economic usefulness. This is the distinctive character of innovation when compared with invention. The analysis gives emphasis for new product development, one of the types of innovation (OECD, 2005) that more clearly relates to direct economic benefit.

The literature underlined that innovation networks are explained by different patterns of cooperation channels and agglomeration. This study provides evidence of the likelihood of innovation actors participating in innovation networks given the behavioral constraints and the different types of entity. To this purposes it was necessary to gather data that provided information about the type of actors in the system, their spatial location, and the innovation-related cooperation activities.

The data collection was performed with a careful observation and content analysis of 820 internet websites of innovation actors. The data collected refers to the Portuguese innovation system and reveals not only the actual activities developed but also the strategic options of communication. Details on the recent evolution of the Portuguese NIS can be found in Guerreiro and Pinto (2012). The database collection and sample are specified in detail in Galindo et al. (2011). The clean database comprised 623 organizations: 18 governmental agencies, 297 private organizations, 70 associations, 20 technological parks and centers, 58 R&D organizations, 48 entrepreneurship support entities, 12 technological schools, 80 universities and university interfaces, and 14 other entities.

The content analysis of the qualitative data on the websites facilitated the creation of 12 binary variables related with the cooperation flows (table 1). Content analysis is a set of techniques to understand communication, using systematic procedures and objectives to describe the explicit and latent content of the message (Bardin 2006). The content analysis followed three phases. The first stage was the pre-analysis, with the organization of the collected data with the aim of making it operational, streamlining the initial ideas and main goal. The second phase was the exploration of the material, which consisted in the examination of the material with the definition of categories and identifying units of meaning and context within data. The third phase of the content analysis was the treatment of the results, inference and interpretation, with the condensation and the highlight of the relevant information to the overall analysis, culminating in inferential interpretations. This is a moment of intuition, reflective and critical analysis. Descriptive statistics for all variables are presented in annex.

Variables	Explanation	Number of 1s
CENTRAL_CITY	A dummy variable 1 if organization is located in the capital city (Lisbon)	181
FIRM	1 if the actor is a firm	297
UNIV	1 if actor is a university or other public research organization	128
ORI	1 if specific orientation towards innovation	262
COOP	1 if promoting partnership and cooperation	299
AET	1 if using external technologies	139
PRD	1 if promoting R&D	139
MG	1 if managing technology and knowledge	242
PK	1 if promoting scientific knowledge	314
SP	1 if studying productive processes	147
SE	1 if supporting entrepreneurship	81
KT	1 if transferring knowledge to external actors	273

Table 1: Selected Explicative Variables

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This set of explicative variables facilitates the comprehension of the different aspects illustrated in Figure 1:

- Even if all the cooperation channels are theoretically relevant some may be critical to innovation networks;
- The localization in the capital city[1] where agglomeration economies tend to be more intense may be of different relative importance for different types of innovation actors;
- The types of actors that are more engaged in the creation of innovation networks through new product development - the firms are an almost obvious actor but other actors, such as universities and other public research organizations, are also engaged in this specific matter?
- Channels of cooperation activities that influence innovation networks vary regarding the type of innovation actor.

The correlation analysis (table 2) also shows some interesting

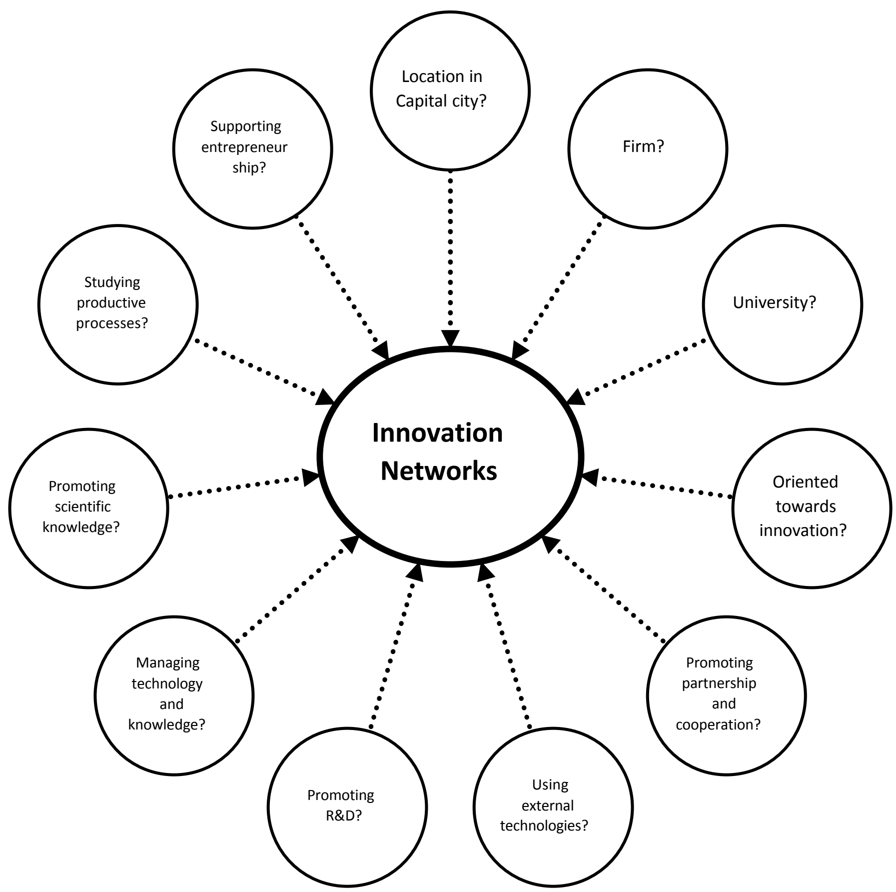

Figure 1: Innovation Networks and Potential Determinants

[1]It is relevant to underline that Portugal is often seen as a centralized country. The European Regional Innovation Scoreboard 2012 is relevant to illustrate the relative discrepancies of Lisbon region to other Portuguese regions.

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preliminary aspects. New product development (NPD) correlates positively with all the cooperation variables but more intensively with using external technologies (AET), promoting scientific knowledge (PK), and transferring knowledge to external actors (KT). Location in the central city is positively correlated with the presence of universities but negatively with the presence of firms, showing that the agglomeration of academic actors is more intense than the private ones. In general, cooperation activities are not correlated with this variable. The pattern of correlation between cooperation activities also shows that there are different degrees of association among these variables. There exist two groups of variables that seem more connected, on the one hand, external technologies (AET), orientation towards innovation (ORI), knowledge management activities (MG), and on the other hand, cooperation and partnership (COOP), studying processes (SP), supporting entrepreneurship (SE) and promotion R&D (PRD). Activities for knowledge promotion (PK) and knowledge transfer (KT) seem to relate to both groups of variables.

	CENTRAL_ CITY	AET	COOP	FIRM	ORI	NPD	PRD	MG	PK	SP	SE	KT	UNIV
CENTRAL_ CITY	1												
AET	-0.035	1											
COOP	0.115	0.402	1										
FIRM	-0.214	0.336	-0.244	1									
ORI	-0.009	0.501	0.681	-0.102	1								
NPD	0.014	0.725	0.461	0.218	0.492	1							
PRD	0.115	0.234	0.528	-0.179	0.301	0.314	1						
MG	0.091	0.487	0.707	-0.094	0.588	0.476	0.546	1					
PK	0.091	0.453	0.773	-0.161	0.743	0.529	0.464	0.668	1				
SP	0.079	0.398	0.410	0.050	0.373	0.467	0.513	0.437	0.535	1			
SE	-0.017	0.023	0.356	-0.187	0.376	0.002	0.068	0.142	0.365	0.022	1		
KT	0.132	0.432	0.786	-0.149	0.591	0.502	0.552	0.783	0.710	0.481	0.158	1	
UNIV	0.173	-0.176	0.149	-0.485	-0.112	-0.041	0.376	0.238	0.044	0.140	-0.067	0.207	1

Table 2: Correlation

Econometric results

The econometric approach is inspired by a set of empirical contributions that focus the cooperation determinants on university-industry relations. Recent examples can be found in Gulbrandsen, Mowery and Feldman (2011) or Pinto and Esquinas (2013). A recent review of this type of analysis was presented in Perkmann et al. (2013).

The dependent variable of this analysis, considered the proxy for the participation in innovation networks, is the new product development (NPD), connected with the economic usefulness of knowledge, that we directly associate with the existence of an innovation (table 3). The nature of this dependent variable, a binary variable, taking a value from 1 or 0, denoting the existence or absence of new product development, causes that a linear probability approach is inaccurate (Gujarati and Porter 2010). Since the NPD is binary, the error term in the estimated model will also be binary and follow a binomial distribution. The alternative method commonly used is a logistic regression with a maximum likelihood estimator, the LOGIT model. This method facilitates the understanding of the change in the probability of the occurrence of an event with the modification of the explanatory variables under evaluation.

Value	Count	Percent	Cumulative Count	Percent
0	439	70.47	439	70.47
1	184	29.53	623	100.00

Table 3: Number of Zeros of Dependent Variable (NPD)

The estimation of a general model, including all sample cases underlines the relevance of several variables for new product development[2]. In annex, the complete tables for the different logistic regressions are presented. Linear probability models were also estimated for all regressions as confirmatory process of signals.

The general model shows that the most relevant cooperation channels for new product development are, in this order:

- AET – using external technologies
- PK – promoting scientific knowledge
- KT – transferring knowledge to external actors
- ORI – specific orientation towards innovation

Entities that directly address managing technology and knowledge (MG) and the support of entrepreneurship (SE) have smaller probability to engage directly in innovation as both variables have negative signals. The other variables are not statistically significant. Additionally, being a firm is more relevant for the likelihood to new product development than being a university although both situations are positive and statistically significant. The location in the central city is not a critical factor for NPD.

[2]As there is no measure of goodness of fit in LOGIT, like R-squared is to OLS estimation (Dougherty 2011), commonly used measures of the quality of the model are a pseudo R-squared (McFadden measure) or the predictive capacity (table in annex). These measures validate the quality of the estimated models.

Using the same principles, we estimated additionally three models for sub-samples. The goal was to understand the relative importance of the cooperation channels in the probability of generating innovation given the different types of entity. For the purpose it was created three groups of innovation actors, the first constituted by the 297 firms, the second groups of 128 universities and other public research organizations, and finally a third group of 198 other innovation actors. The results of these models are summarized in the table 4.

Variable	TOTAL SAMPLE	FIRMS	UNIVERSITIES	OTHERS
C – Intercept	----	----	----	----
Organization is located in the capital city	+	-	-	+
AET - Using external technologies	++++	++++	++++	++++
KT - Transferring knowledge	++	-	-	+
MG - Managing technology and knowledge	---	-	++++	----
ORI - Specific orientation towards innovation	+++	++	+	+++
PK - Promoting scientific knowledge	++++	++++	+	-
COOP - Promoting partnership and cooperation	+	+	+	+
PRD - Promoting R&D	+	-	-	+
SE - Supporting entrepreneurship	----	+	-	---
SP - Studying productive processes	+	-	+	+

Table 4: Cooperation Determinants of Innovation
[Symbols: - non-significant negative coefficient; -- significant negative coefficient at 0.1; --- significant negative coefficient at 0.05; ---- significant negative coefficient at 0.01; + non-significant positive coefficient; ++ significant positive coefficient at 0.1; +++ significant positive coefficient at 0.05; ++++ significant positive coefficient at 0.01].

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Firms are more likely to innovate with new product development if engaged in cooperation activities of promotion of knowledge (PK) and the utilization of external technologies (AET). Specific orientation for innovation (ORI) also has a relevant impact in the probability to innovate.

Regarding universities, the most relevant aspect is the proactive management of knowledge (MG). Universities and other public research organizations that are proactive in the management of their knowledge reservoir have a higher probability to develop new product developments. Other relevant channel for innovation is the utilization of external technologies (AET).

Other innovation actors are more willing to engage in innovation if they use external technologies (AET) or have a strategic focus to innovation (ORI). Nonetheless, the utilization of two types of cooperation flows are significant but negatively associated with the new product development. Most relevant is management of knowledge (MG). On the opposite situation of the universities, where MG was a critical positive aspect, when this group of actors gives emphasis to the management of knowledge are less likely to develop new products. On the same basis, innovation actors that are worried in the support to entrepreneurship (SE) are themselves less likely to introduce innovations by their own.

Conclusive remarks

The systemic approach brought new understandings to the innovation activities because these phenomena are transformed simultaneously into origins and consequences. Systems function as circuits for multiple reciprocal relationships where the complexity of the innovation dynamics will be unveiled. If on the one hand, linkages among actors create spillovers, the increase of cooperation and knowledge sharing generate more knowledge flows outside of firms leading to spillovers, on the other hand, the existence of spillovers leads to networks because increasingly the flow of external knowledge induces to an increased need for channels that enable shared and cooperative knowledge networks.

Assuming that in a given society social capital encourages interactive learning and knowledge flows, it tends to enhance the knowledge base by making it more complex. The complexity of the knowledge base and commitment to interactive learning, makes environment to embrace knowledge networks to answer to the need for proper channels of knowledge sharing. If there is an internal dynamics that favors the continuation of the process, knowledge flows become more intense having a qualitative effect on the interactions between actors. It creates linkages and growing trust in the creation, exchange and sharing of knowledge as well as an increasing involvement with learning. This is surrounded by a dynamic environment, where the growing complexity of knowledge requires a dynamic synergy between actors creating innovation networks.

Innovation networks arise from knowledge networks, which reached a level at which knowledge flows are intensively shared. Innovation networks are instigated from knowledge spillovers and the absorptive capacity of firms. Although there are several possible ways of how this dynamics may evolve, after the existence of innovation networks, there will be positive effects on economic performance. It is assumed that if innovation networks do not bring economic benefits, they cease to be useful, leading to its own degeneration and loss of internal dynamics. The economic aspect is part of the raison d'être of innovation networks and therefore the essence of innovation systems. Cooperative activities are connected with social capital, developing the preconditions for the dynamics of innovation occur.

Econometric results were illustrative of the relevance of particular types of cooperation activities for innovation networks exist. Firstly, it is important to underline that agglomeration benefits to new product development were not evident in the estimation, as the location of the innovation actors in the main city was not statistically significant in any model. In this way, the determinants of innovation were more related with specific cooperation activities. The utilization of external technologies is of greater relevance. This is indicative that much of innovation within knowledge networks can derive from absorbing external knowledge and incorporating new technologies in the productive processes. This means that this type of knowledge exchange channel should be taken seriously by policy-making and benefit from direct support for the improvement of the overall innovation system performance.

Other relevant feature regards the relevance of strategic orientation towards innovation. Actors that strategically orientate their activities are more likely to develop new products and thus creating innovation networks. This means that the qualification of strategic processes should also be targeted by policies that could improve the knowledge intelligence capacity.

Innovation actors are quite different in terms of what is determinant for them to innovate. It means that innovation policies that intend to develop networking and knowledge exchange need to address carefully the specificities of each type of actor. Besides the external linkages through technology acquisition, while for companies it is particularly relevant the active promotion of produced knowledge, universities need to develop the management of the existent knowledge reservoir. This implicates that firms should benefit from policies oriented to the promotion of the new knowledge produced in their networks, i.e., mainly an external feature, when, in parallel, universities need to benefit from policies for the upgrade of their internal knowledge management capabilities.

Another interesting result is that the engagement in particular types of activities that are crucial for the innovation, as supporting entrepreneurship, do not grant to these actors a status of innovator. In the fact is the contrary, supporters of innovation are relevant actors but not the innovators themselves. This clarification is extremely helpful for decision and policy makers, at different levels, from governments to university boards, that begin to confuse often the functions of innovation intermediation actors with the role of firms and research entities within innovation networks.

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Annex

	CEN-TRAL_CITY	AET	COOP	FIRM	ORI	NPD	PRD	MG	PK	SP	SE	KT	UNIV
Mean	0.291	0.222	0.479	0.476	0.421	0.294	0.223	0.389	0.503	0.235	0.130	0.439	0.206
Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Minimum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std, Dev,	0.455	0.416	0.500	0.500	0.494	0.456	0.417	0.488	0.500	0.424	0.337	0.497	0.405
Skewness	0.920	1.339	0.084	0.097	0.319	0.903	1.328	0.455	-0.013	1.252	2.197	0.246	1.456
Kurtosis	1.847	2.792	1.007	1.009	1.102	1.816	2.763	1.207	1.000	2.567	5.829	1.061	3.118
Jarque-Bera	122.255	186.926	103.668	103.669	103.935	120.913	184.184	104.778	103.667	167.304	707.957	103.762	219.980
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sum	181.000	138.000	298.000	296.000	262.000	183.000	139.000	242.000	313.000	146.000	81.000	273.000	128.000
Sum Sq, Dev,	128.330	107.383	155.228	155.138	151.640	129.159	107.937	147.846	155.494	111.730	70.452	153.178	101.659

Table A1: Descriptive Statistics for Explanatory Variables (Total Sample)

Variable	**Mean**	**Variable**	**Standard Deviation**				
	NPD=0	**NPD=1**	**All**		**NPD=0**	**NPD=1**	**All**
C	1.000	1.000	1.000	C	0.000	0.000	0.000
CENTRAL_CITY	0.287	0.298	0.291	CENTRAL_CITY	0.452	0.459	0.454
FIRM	0.405	0.646	0.477	FIRM	0.492	0.479	0.500
UNIV	0.216	0.179	0.205	UNIV	0.412	0.385	0.404
ORI	0.264	0.793	0.421	ORI	0.441	0.406	0.494
COOP	0.330	0.837	0.480	COOP	0.471	0.370	0.500
AET	0.027	0.690	0.223	AET	0.163	0.464	0.417
PRD	0.139	0.424	0.223	PRD	0.346	0.496	0.417
MG	0.239	0.745	0.388	MG	0.427	0.437	0.488
PK	0.332	0.913	0.504	PK	0.472	0.283	0.500
SP	0.107	0.543	0.236	SP	0.310	0.499	0.425
SE	0.130	0.130	0.130	SE	0.336	0.338	0.337
KT	0.278	0.821	0.438	KT	0.448	0.385	0.497
Observations	439	184	623	Observations	439	184	623

Table A2: Descriptive statistics for Explanatory Variables (taking into consideration NPD)

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Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.058	0.028	-2.032	0.042
CENTRAL_CITY	0.006	0.026	0.247	0.804
FIRM	0.110	0.031	3.498	0.000
UNIV	0.097	0.038	2.535	0.011
ORI	0.070	0.039	1.760	0.078
COOP	0.059	0.046	1.271	0.204
AET	0.579	0.038	14.959	0.000
PRD	0.002	0.038	0.070	0.944
MG	-0.108	0.042	-2.545	0.011
PK	0.177	0.045	3.889	0.000
SP	0.084	0.036	2.332	0.020
SE	-0.145	0.040	-3.622	0.000
KT	0.099	0.045	2.181	0.029
R-squared	0.613	Mean dependent var	0.295	
Adjusted R-squared	0.606	S.D. dependent var	0.456	
S.E. of regression	0.286	Akaike info criterion	0.358	
Sum squared resid	50.065	Schwarz criterion	0.450	
Log likelihood	-98.643	F-statistic	80.810	
Durbin-Watson stat	1.682	Prob(F-statistic)	0	

Table A3: Linear Probability Model OLS for NPD (total sample n=623)

Dependent Variable: NPD Method: ML - Binary Logit (Quadratic hill climbing) Included observations: 623 Convergence achieved after 6 iterations Covariance matrix computed using second derivatives				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	-4.991	0.526	-9.482	0.000
CENTRAL_CITY	0.0823	0.313	0.262	0.792
FIRM	1.710	0.448	3.816	0.000
UNIV	1.247	0.482	2.587	0.009
ORI	0.835	0.385	2.165	0.030
COOP	0.870	0.537	1.619	0.105
AET	3.166	0.412	7.676	1.630
PRD	0.007	0.409	0.018	0.985
MG	-1.006	0.438	-2.296	0.021
PK	1.874	0.480	3.9046	0.000
SP	0.383	0.354	1.079	0.280
SE	-1.157	0.434	-2.665	0.007
KT	0.890	0.484	1.838	0.066
Mean dependent var	0.295	S.D. dependent var	0.456	
S.E. of regression	0.282	Akaike info criterion	0.568	
Sum squared resid	48.676	Schwarz criterion	0.661	
Log likelihood	-164.080	Hannan-Quinn criter.	0.604	
Restr. log likelihood	-378.079	Avg. log likelihood	-0.263	
LR statistic (12 df)	427.996	McFadden R-squared	0.566	
Probability(LR stat)	0			
Obs with Dep=0	439	Total obs	623	
Obs with Dep=1	184			

Table A4: Logistic regression (total sample)
The model with the substituted coefficients is presented below:
NPD=1-@LOGIT[-(-4.99+0.082*CENTRAL_CITY+1.710*FIRM+1.247*UNIV+0.871*COOP+3.166*AET +0.836*ORI+0.008*PRD-1.006*MG+1.874*PK+0.383*SP-1.158*SE+0.891*KT)]

Prediction Evaluation (success cutoff C = 0.5)						
	Estimated Equation	**Constant Probability**				
	Dep=0	**Dep=1**	**Total**	**Dep=0**	**Dep=1**	**Total**
P(Dep=1)<=C	413	48	461	439	184	623
P(Dep=1)>C	26	136	162	0	0	0
Total	439	184	623	439	184	623
Correct	413	136	549	439	0	439
% Correct	94.077	73.913	88.121	100	0	70.465
% Incorrect	5.923	26.087	11.879	0	100	29.535
Total Gain*	-5.922	73.913	17.656			
Percent Gain**		73.913	59.782			
	Estimated Equation	**Constant Probability**				
	Dep=0	**Dep=1**	**Total**	**Dep=0**	**Dep=1**	**Total**
E(# of Dep=0)	390.498	48.501	438.999	309.343	129.656	439
E(# of Dep=1)	48.501	135.498	184.000	129.656	54.343	184
Total	439	184	623	439	184	623
Correct	390.498	135.498	525.997	309.343	54.343	363.686
% Correct	88.952	73.641	84.430	70.465	29.535	58.377
% Incorrect	11.048	26.359	15.570	29.534	70.465	41.623
Total Gain*	18.486	44.106	26.053			
Percent Gain**	62.592	62.592	62.592			
*Change in "% Correct" from default (constant probability) specification						
**Percent of incorrect (default) prediction corrected by equation						

*Change in "% Correct" from default (constant probability) specification
**Percent of incorrect (default) prediction corrected by equation
Table A5: Predictive capacity of the LOGIT model for NPD

Dependent Variable: NPD Method: ML - Binary Logit (Quadratic hill climbing) Convergence achieved after 6 iterations Covariance matrix computed using second derivatives			
Variable	**Coefficients FIRMS**	**Coefficients UNIVERSITIES**	**Coefficients OTHERS**
C	-4.095***	-41.752***	-3.880***
AET	2.581***	3.101***	3.185***
CENTRAL_CITY	-0.410	-0.986	0.632
KT	-0.823	-0.970	1.579
MG	-0.488	42.249***	-2.825***
ORI	1.918*	0.0757	2.332**
PK	3.087***	0.0887	-0.776
COOP	1.069	0.892	1.237
PRD	-0.129	-1.316	1.247
SE	0.713	-0.684	-2.450**
SP	1.292	0.796	-1.128
McFadden R-squared	0.798	0.395	0.437
Obs with Dep=0	178	95	166
Obs with Dep=1	119	33	32
Total Observations	297	128	198

***significant at 0.01, **significant at 0.05; *significant at 0.1.
Table A6: Model for Firms, Universities and Other Actors

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