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Knowledge Diversity, Innovation and Firms Economic Performance

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The innovation process is the result of specific combinations of knowledge that firms obtain by articulating two types of contexts: the organizational context and external contexts. This paper has three main objectives: first it examine whether it is possible to find empirical evidence that firms recognize the need of external knowledge for their innovation process. Second it will analyze the relationship between "contexts of innovation" and the "intensity/complexity of the innovation process". Finally it will test the importance of the "innovations contexts" on the firm's performance. The main conclusions allow us to stress some results: first, most firms developed their innovation activities in the "context of cooperation". Second, empirical evidences was found that the "context of cooperation" is a critical factor for the firms' innovation performance´. Finally, it was possible show the importance of external knowledge, materialized in cooperation, to innovative and economic firms´ performance.

Keywords: innovation process**,** external knowledge, cooperation context, in-house context, firm performance, Portugal

JEL: D21; D8; R12; O31

1. Introduction

Our approach take innovation as a systemic process, supported by interactive and collective dynamics of learning that contribute to the articulation of different forms of knowledge, the principal resource of innovation process. The innovation process is the result of specific combinations of knowledge that firms obtain by articulating, in various degrees, two types of contexts: the internal or organizational context and the external contexts (with different spatial scales). The literature usually deducts the need of firms' external knowledge (and their materialization in cooperation) for its innovation process, from the nature of the innovation process itself. This paper has three main objectives: first it examine whether it is possible to find empirical evidence that firms recognize the need of external knowledge for their innovation process. Second it will analyze the relationship between "contexts of innovation" (context "*in-house*" vs. context of "*cooperation with external organizations*") and the "intensity/complexity of the innovation process". Finally it will test the importance of the "innovations contexts" on firms´ performance.

The remainder of the paper includes three main sections: in section 2 will be presented the main concepts and the conceptual background, with regards to the innovation process, the importance of knowledge diversity and some approaches that allow one to understand the importance of external knowledge to the development of innovation activities. Section three describes the hypotheses, variables, data and methodological options. This section allows highlighting some insights about the firms´ need for external knowledge and will be analyzed the relation between innovation contexts and the intensity/complexity of the innovation process. Finally in section 4 the analysis turns to another important issue, the relation between firms´ economic performance and innovative performance, integrating this relation with the results of previous sections. The conclusion sum up our main results about the importance of external knowledge and cooperation's to the innovation process and the performance of firms.

2. Concepts and conceptual background

2.1.The innovation process

Following Pavitt (2005: 88), the innovation process "*involve the exploration and exploitation of opportunities for new or improved products, processes or services, based either in advance in technical practice ("know-how"), or a change in market demand, or a combination of the two*". This process is naturally uncertain, involving several risks of conception, design, implementation and commercialization. In this framework the learning process is a critical success factor of knowledge accumulation, the main source of innovation. Some of this learning is specific to organizations and their internal dynamic of interactions, although an important part clearly outweighs this scope, being projected to external contexts that strongly condition the innovation processes of firms. As

Antonelli (2003: 53) emphasizes, actually innovations are seen as "*the result of complex alliances and compromises among heterogeneous group of agents. Agents are diverse because of the variety of competences and localized knowledge they built upon*". In this paper innovation should be understood as the "*successful commercial exploitation of new technologies, ideas or methods by introducing new products or processes, or by improving on existing ones. Innovation is the result of a collective learning process that involves several internal and external actors to firms*" (European Commission, 1996: 54). The definition of innovation adopted is underpinned by the explicit recognition of innovation as a process. In this sense, it is important to discuss the nature of this process. Fischer (2006:1) argues that "*the concept of innovation has changed dramatically in recent years as the focus of attention has shifted from the single-act philosophy of innovation to the complex mechanisms that underline the production of new products and new production processes*". Since the seminal work of Kline & Rosenberg (1986), innovation is seen as nonlinear and highly interactive between enterprises, infrastructures of knowledge production, consumers, producers, suppliers and other institutional actors (Dosi, 1988; Lundvall, 1992a, 1992b; Malecki, 1997a, 1997b; Morgan, 1997; Ulijn & Brown, 2004; Lambooy, 2005; Fagerberg, 2005; Fischer, 2006). This nature, interactive and collective, leads to the development of support structures and mechanisms of coordination and governance, to ensure the necessary interactions between the several actors involved, reducing the costs of interaction and minimizing uncertainty associated with the natural process of innovation. According to Pavitt (2005), this generic innovation process should be divided into sub-processes, partially overlapping, consistent with the two explicit features of innovation: its procedural nature and the intrinsic uncertainty that is inherent in the development of this process.

In terms of firms´ innovation, the concern must focus on three sub-processes: knowledge production – from the industrial revolution that the trend has been for the scientific and technological knowledge becomes increasingly specialized by discipline, by function and institution; the transformation of knowledge into products and services – despite the explosion of scientific knowledge in recent years, the theory continues to be an insufficient guide to practical technology. This reflects a trend towards the increasing complexity of these goods and services and the bases behind them; and, thirdly, the placement of products in the markets – this aspect involves an ongoing process of articulation and integration between the needs (real or perceived) of users of these devices and the characteristics (real or latent) of the goods and services produced (Pavitt, 2005).

2.2.The importance of knowledge diversity

The definition of innovation has implied the relevance of different types of knowledge in the innovation process. If one consider the current knowledge base that the various firms, industries and sectors need to develop their competitive process, it becomes clear that this has increased considerably its complexity. There is an increasing variety of knowledge sources, inputs used by various organizations and that emphasizes a greater division of labour and interdependence between actors: individuals, firms and other organizations also quite different in nature and spatial localization (Asheim & Gertler, 2005). This tendency is reflected in the increased diversity and interdependence of the creation, production and use of knowledge processes. According to several authors (Pavitt, 1984; Fagerberg, 2005; von Tunzelmann & Acha, 2005), firm´s innovation processes depend on their specific knowledge base, which tends to vary substantially across sectors of activity. Several authors have shown that firms can develop quite different innovative processes and that different types of innovation (or innovation modes) need different types of knowledge and specific learning interactions (Tödtling & Trippl, 2004; Tödtling, Lehner & Kaufmann, 2006; Lorenz & Lundvall, 2006; Lundvall *et al*., 2007; Lundvall 2007; Nunes, 2012; Nunes & Lopes, 2015).

Knowledge in its different forms is an abundant resource in the economies. The real difficulty lies in demonstrating the capacity to mobilize the competences which can transform them into economic value. Therefore, efforts to codify knowledge and make it explicit and articulable are important ways of increasing the sharing of knowledge in the society as a whole. However, the codification of knowledge does not make it necessarily more accessible to third parties, be it individuals, firms or other organizations. The implicit knowledge is always necessary to be able to make knowledge economically useful. This implies that the codified knowledge cannot, by itself, provide any economic benefit, always needing to articulate competencies and skills embodied in economic agents. It is through the articulation between tacit and codified elements of knowledge that it is possible to operationalize their use (Lundvall & Ernst, 1997; Lundvall 2007; Howells, 2002). There is a symbiotic relationship between these two expressions of knowledge. Knowledge only becomes useful when the tacit dimension gives it a particular meaning in the broader process that is a part of it. It is the tacit dimension of an agent and its contextual dimension that highlights the value of knowledge as an economic resource that can be used in innovation activities. On the other hand, the skills and experience needed for the introduction of new knowledge and new products are largely acquired through learning processes resulting from the multiple interactions between consumers, producers, suppliers and competitors (Antonelli, 2003). Table 1 tries to synthetize the most important characteristics related to knowledge and the learning processes that produce and transform it.

Table 1 – *Types, attributes and learning processes associated with knowledge*

TYPES	ATTRIBUTES	LEARNING TYPES	NATURE
Know-what	Codifiable and easily transferable as information	Access and transfer of data and information	Public Good 
Know-why	Codifiable and easily transferable as information	Access and transfer of data and information	
Know-how	Tacit, difficult the codify and transfer	Training and experience associated with cumulative processes (by doing, by using and by interacting) – collective learning	
Know-who	Tacit, embedded in social contexts; mechanisms of interaction mostly informal	Social interaction (by interacting) – "selective" collective learning	Localized and collective good

Source: Authors' own compilation based on Lundvall (1996); Lundvall and Ernst (1994); and Lundvall and Björn (1997)

2.3.The firm and beyond the frontiers of organizational knowledge

Traditionally, it has been suggested that the firm is the main actor determinant of the process of business innovation. However, the firm and its role in the innovation process has changed significantly from the representative firm (processing information), through the heterogeneous firm and producer of interactive knowledge to the potentially innovative firm.

Neoclassical theory considers the behavior of the firm as the result of optimal responses to signals from the markets that it detects, allowing to instant adjustments. In a world where all agents share the same economic model, communications are easy to perform and the information is obtained without costs, the firm's objective is the maximization of profits subject to a given set of technological constraints (Cohendet & Llerena, 1998). In these approaches, the cognitive capacities are taken and there is no learning process that can be able to modify them.

Initiated on the work of Penrose (1959) and Alchian (1951) were developed some approaches that consider the firm as a support organization of knowledge, where the coordination mechanisms and cognitive abilities play a central role. Since the 80s of the 20th century, many scholars from the fields of strategic management, organizational economics and industrial organization are tributaries of the work of Penrose (1959), seeking to develop the intellectual foundations of the approach called resource-based theory. In this approach, the firm plays a key active role, while the context of creation and accumulation of technological knowledge and skills and its transformation in technological and organizational innovations. The firm is seen essentially as a repository and a producer of knowledge and skills and, through them, select the actions that enable

them to achieve competitive performance in the markets. The major contribution of this approach to the present discussion results from tackle the role of knowledge, learning and skills, together, in the theory of the firm. This implies, in particular, to eliminating the notion of "representative firm" inherent in the traditional approach. On the other hand, eliminating the "representative firm" requires considering, conceptually and in practice, the heterogeneity between organizations, the various combinations of knowledge and the complementarity of their resources. This complementarity of resources and its consequent interdependence drives firms to form alliances with other organizations in order to reduce uncertainty and to gain access to additional resources (Ozman, 2009). It is based, therefore, on the need for firms to develop networks of inter-organizational collaboration as a way of achieving intermediate objectives by themselves that were reached through two extreme ways: within the organization and in the markets, intermediated by the prices system.

This recognition drives us beyond the frontiers of organizational knowledge. Within this theoretical framework, we fund several theoretical approaches to the conceptualization of the external contexts, especially those which take the territorial context as its privileged space of relations. Although our objectives in this article are only to recognize the importance of external knowledge for the innovation process, we briefly identify the main approaches in the literature.

The knowledge spillovers literature developed in the 90s of the 20th century, takes as its starting point that innovation activities have a high spatial concentration (Feldman 1994, Audretsch & Feldman, 2004; Krugman, 1991a, 1991b). The reading that the approach of knowledge spillovers makes of this phenomenon can be briefly described as follows: the spatial dimension of innovation derives from the fact that innovation activities present high degrees of geographic concentration that generates increasing returns and positive effects on these innovative activities (Capello, 2007).

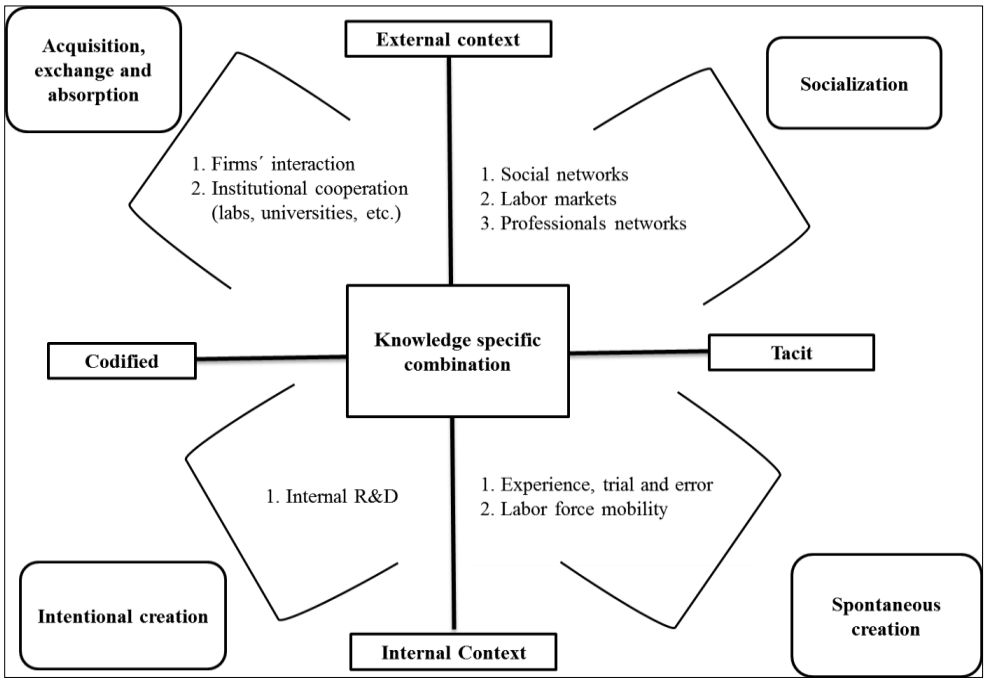
The industrial theory approach "*was the first to conceptualize external economies (of agglomeration) as source of territorial competitiveness. It did so with a model in which the economics aspects of development are reinforced by a socio-cultural system which fuels increasing returns and self-reinforce mechanisms of development*" (Capello, *op. cit.*: 185). This theory was developed originally with the work of Bagnasco (1977), Becattini (1979), Brusco (1982), Garofoli (1983), in order to describe the success of some regions of Italy, started in the late 70s of the 20th century, conceptualized like industrial districts. Adopting a critical approach to some aspects of industrial districts, seeking to extend conceptually the nature of interactions and the factors of economic performance of organizations in the 80s of the 20th century, a group of researchers led by Phillipe Aydalot (GREMI, 1984) decided to give special attention to the following assumption: "*that "something" , localized on the regional level made it possible to understand why certain regions were more dynamic than others*" (Crevoisier, 2004: 368). Briefly, "*these include*

a set of collective and dynamic processes incorporating many actor within a given region that lead to networks of synergy-producing interrelationships" (Simmie, 2005: 793). More important is that this perspective has "*brought space as the generator of dynamic efficiency into the central focus of analysis of territorial development*" (Capello, 2007: 196).

Other approaches like the National Innovation Systems, the Regional Innovation Systems, the Learning Regions or the Spatial Innovations Systems they all have in common three central aspects in the innovation process: the importance of knowledge diversity, different learning processes and the dynamic of contextual interactions between a diversity of actors embedded in different spaces.

In short, the definition of innovation adopted not only understands the innovation as a process, but as a process of collective learning that involves actors and resources internal to the firm like external actors, combining codified and tacit knowledge. The next figure summarizes this approach of the innovation process.

Figure 1 – *Innovation process: diversity of knowledge combination*



Source: Authors' adaptation on Antonelli & Ferrão (2001: 39)

3. External knowledge and innovation contexts: the empirical research

The research seeks to find empirical evidence that firms explicit recognize the need for external knowledge to develop their innovation process and then seek to establish cooperation with other institutions in order to overcome this lack of knowledge

underlying their internal organization.

3.1. Hypotheses, variables and methodological options

The database used in this article resulted from a sample who is representative of the 981 Portuguese firms that satisfy the following criteria: turnover of over € 1 million in 2008 and at the same time an increase in turnover of at least 5% between 2007 and 2008. This choice was made with the aim of identifying the more dynamic group of firms from the point of view of their economic performance. It is possible to stratify the universe according to the following variables:

- Levels of technological intensity and knowledge services: high-technology (HT), medium-high technology (MHT), medium-low technology (MLT) and low-technology (LT). We also took knowledge services (KS) firms into account. This typology was chosen because it is the most commonly used in the international literature, mainly by reference entities such as the OECD and the European Union;
- Firms' size – classified into Micro (0-9), SMEs (10-250) and large firms (> 250) by number of employees (2008);
- NUTS III (Greater Lisbon and Setubal Peninsula, Pinhal Litoral and Greater Porto). These 4 NUTS correspond to the Portuguese metropolitan areas (natural habitat of innovation) and Pinhal Litoral, one of the non-metropolitan areas repeatedly referenced as having a strong innovative dynamics. Therefore, this variable seeks to capture the differences in the regional structure under analysis.

As it is not financially possible to carry out an investigation of the entire population, a representative sample was subsequently chosen. This was obtained by stratification and proportional affixation, from telephone interviews conducted by an independent specialized company in late 2010 and early 2011. The survey included key components in line with the theoretical framework developed, covering the following aspects: description of the firm, innovation activities, internal resources and performance, activities involving different modes of innovation, external resources, types of proximity and aspects related to the crisis in the innovation process. This produced a database containing 397 observations, representative of the population on which the statistical and econometric work of this paper is based.
We take two working hypotheses to analyze the firms´ needs for external knowledge:

Hypothesis 1: Firms need external knowledge and establish cooperation with other organizations
This hypothesis will be consistently confirmed if we can find empirical evidence of the following sub-hypotheses:

- Hypothesis 1.1 – Mostly firms recognize the need for external knowledge;

- Hypothesis 1.2 – The recognition of the need for external knowledge is across multiple domains of the innovation process as well as the control variables;
- Hypothesis 1.3 – Mostly firms establish cooperation mostly as a way to develop their innovation activities;
- Hypothesis 1.4 – Establishing cooperation is across multiple domains of the innovation process as well as the control variables.

Hypothesis 2: The need for external knowledge and the context of cooperation is as great as more intense/complex the innovation process proves to be

The hypothesis 2 will be consistently confirmed if we can find empirical evidence of the following sub-hypotheses:

- Hypothesis 2.1 – The need for external knowledge becomes stronger with increasing intensity/complexity of innovation by firms;
- Hypothesis 2.2 – The development of innovation activities in context of cooperation becomes stronger with the increasing intensity/complexity of innovation by firms.

To study these hypotheses we take the following variables (please see Table 2):

Table 2 – *Variables and Categories*

V2 – Innovation intensity	V4 – Type of competition
v2.1 – zero type of innovation	v4.1 – geography-price
v2.2 – one type of innovation	v4.2 – quality-innovation
v2.3 – two types of innovation	
v2.4 – three types of innovation	
v2.5 – four types of innovation	
V3 – Innovation radicalness	V5 – Type of innovation activities
v3.1 – improving products/processes	v5.1 – knowledge production
v3.2 – new to the firm	v5.2 – knowledge transformation
v3.3 – new to the market	v5.3 – placing product's on the market

Source: Authors' own compilation

Need for external knowledge – Variable 1: was asked to firms about the "number of problems faced in the innovation process in the last five years", "the number of technologies needed to solve it" and "how many of these technologies the firms have in their organizational context". By confronting their answers we can identify which firms don't have all the technologies for development of their innovation process and so they need external knowledge.

Innovation intensity – Variable 2: the survey take four types of innovation outputs: product, process, organizational and patent introduction (in the last five years). It is an ordinal variable that ranges from "zero types of innovation" – if the firm did not produce

any type of innovation – to "four types of innovation" – if firms simultaneously produced all types of innovation.

Innovation radicalness – Variable 3: was asked to firms to attribute a level of importance (Likert scale 1-5) to three degrees of innovation radicalness: improving products and processes, new to the firm and new to the market. With that information we range firms from incremental to radical innovation.

Firms´ type of competition – Variable 4: was asked to firms to attribute a level of importance (Likert scale 1-5) to five items: price, innovation, quality, geographical diversification and product diversification. With that information we classify the firms regarding the type of competition that they give priority to: competition based on innovation-quality and competition based on geography-price.

Firms´ type of innovation activities – Variable 5: was asked to firms to attribute a level of importance (Likert scale 1-5) to twelve sub-types of innovation activities that we classify in three types of innovation activities: knowledge production (basic research, applied research, acquisition of knowledge, combination of knowledge, reverse engineering and technology adoption), knowledge transformation (development, design and prototypes) and placing products on the market (marketing, market implementation and commercialization).

Innovation contexts – Variable 6: was asked to firms to attribute a level of importance (Likert scale 1-5) to the context where they mostly develop their innovation activities. Based on their answers we classified the firms in two innovation contexts: "In-house" and "Cooperation with other organizations".

In this paper the term "intensity/complexity" of the innovation process must be taken by the following: based on variables 2, 3, 4 and 5, more and diverse knowledge that firms need to develop their activities of innovation mean more "intensity/complexity" of the innovation process.

3.2. To innovate firms need external knowledge and need to establish cooperation

The analysis of the empirical data allows studying the hypothesis presented.

Hypothesis 1.1 – Firms recognize the need of external knowledge

According to the sample 64% of the firms recognize the need of external knowledge to develop their innovation activities, as we can see in table 3.

Hypothesis 1.2 – The recognition of the need for external knowledge is across multiple domains of the innovation process as well as the control variables

Taking into consideration the control variables, it can be verified that for all the

technological levels the proportion of firms that recognize the need for external knowledge is higher than the ones that do not recognize that need. This result still holds for all sizes of firms (Large>SME>Micro) and for all regions NUTS III (GL/PS>GP>PL). As it can be confirm in Table 3, it is possible to find a similar pattern across all the domains of the innovation process considered here.

Table 3 – *Need for external knowledge (%) vs. innovation process*

V_2 – Intensity of innovation - types						
Zero	One	Two	Three	Four	Total	
33.3	57.1	63.9	67.1	68.2	64.0	Yes
66.7	42.9	36.1	32.9	31.8	36.0	No
V_3 – Radicalness of innovation						
Improvement product/process	New to firm	New to market			Total	
63.2	64.8	63			64.0	Yes
36.8	35.2	37			36.0	No
V_4 – Type of competition						
Geography-price	Quality-innovation				Total	
57.8	66.3				64.0	Yes
42.2	33.7				36.0	No
V_5 – Type of innovation activities						
Market	Transformation	Production			Total	
67.7	55.4	57.6			64.0	Yes
32.3	44.6	42.4			36.0	No
CONTROL VARIABLES						
Level of Technological Intensity						
LT	LMT	MHT	HT	KS	Total	
62.1	63.7	61.4	61.3	70	64.0	Yes
37.9	36.3	38.6	38.4	30	36.0	No
Firm Size						
Micro	SME	Large			Total	
60.7	63.7	67.3			64.0	Yes
39.3	36.3	32.7			36.0	No
NUTS III Regions						
Greater Lisbon and Setúbal	Greater Porto	Pinhal Litoral			Total	
65.8	65.3	55.9			64.0	Yes
34.2	34.7	44.1			36.0	No

Source: Authors' own compilation based on survey

From the analysis of the former table we can confirm hypothesis 1.1 that states firms to recognize the importance of the need for external knowledge and hypothesis 1.2 as well. However, the variable "need for external knowledge" that was being analyzed should really be interpreted as the perception that firms have the need for external knowledge to continue their process of innovation. The V_6 variable provides us with more precise information about the innovation contexts (in-house vs. cooperation) where firms develop their innovation activities. It is therefore important to understand to what extent the use of this new variable allows you to keep (or not) the information that had been determined using a variable that represents the perception of a need. The perception of the need for external knowledge should be associated with external cooperation, since without additional knowledge firms lose effectiveness in the pursuit of their innovation activities. Therefore we will undertake a similar analysis for the variable "innovation contexts" testing this association.

Hypothesis 1.3 – Mostly firms establish cooperation as a way to develop their innovation activities

In the previous analysis, it was found that 64% of firms recognize that they needed external knowledge. Assuming that this need would lead firms to establish external cooperation, the analysis of our sample allows us to observe in table 4 that 57.2% of firms develop their innovation activities in the context of cooperation, while 42.8% conduct their activities in-house. It means that most firms develop their innovation activities in the context of cooperation stressing in this way (even with a lower share than previously found – 64.0%) the importance of external knowledge.

Table 4 – *Innovation Contexts (%) vs. innovation process*

V_2 – Intensity of innovation - types						
Zero	One	Two	Three	Four	Total	
100	52.9	55.8	58.1	68.2	57.2	Cooperation
0.0	47.1	44.2	41.9	31.8	42.8	In-House
V_3 – Radicalness of innovation						
Improvement product/process	New to firm	New to market			Total	
53.9	56.8	69.6			57.2	Cooperation
46.1	43.2	30.4			42.8	In-House
V_4 – Type of competition						
Geography-price	Quality-innovation				Total	
55.0	58.0				57.2	Cooperation
45.0	42.0				42.8	In-House
V_5 – Type of innovation activities						
Market	Transformation	Production			Total	
55.3	58.5	63.6			57.2	Cooperation
44.7	41.5	36.4			42.8	In-House
CONTROL VARIABLES						
Level of Technological Intensity						
LT	LMT	MHT	HT	KS	Total	
65	58.4	44.3	48.4	60	57.2	Cooperation
35	41.6	55.7	51.6	40	42.8	In-House
Firm Size						
Micro	SME	Large			Total	
67.9	57.7	48.1			57.2	Cooperation
32.1	42.3	51.9			42.8	In-House
NUT III Regions						
Greater Lisboa and Setúbal	Greater Porto	Pinhal Litoral			Total	
57.9	55.4	57.4			57.2	Cooperation
42.1	44.6	42.6			42.8	In-House

Source: Authors' own compilation based on survey

Hypothesis 1.4 – Establishing cooperation is across multiple domains of the innovation process as well as the control variables

The data analysis gives consistency to the pattern; it embodies the fact that most firms develop their innovation activities in the context of cooperation. This trend is common – with some exceptions highlighted in bold in Table 4 – at the level of technological intensity, firm size and the NUTS III regions in question (control variables). As we can confirm in table 4, the tendency that we have been making explicit – most firms develop their innovation activities in the context of cooperation, because they need external knowledge – remain valid for all the activities of the innovation process. We confirm thereby our hypotheses 1.3 and 1.4.

The consistency found in the analysis of these hypotheses, allows us to give coherence to the first hypothesis: H1: Firms recognize the need for external knowledge to take effect the process of innovation and, therefore, establish cooperation with other organizations.

Innovation contexts and the intensity/complexity of the innovation process

One way to try to qualify the evidence explicit in the previous hypotheses, involves understanding the behavior of this tendency when faced with the increasing intensity/complexity of the activities inherent in the innovation process. In the case of finding a clear relation between both of them – the need for knowledge/development activities in the context of cooperation and the level of intensity/complexity of the activities inherent of the innovation process – we cannot fail to recognize the importance of external knowledge and the contexts of cooperation (that allows us to obtain it) in the development of innovation activities. The second hypothesis seeks more information on this matter.

Hypothesis 2: The need for external knowledge and the context of cooperation is as great as more intense/complex the innovation process proves to be

Indeed, this relation was already visible in Tables 3 and 4. However, given its conceptual importance in this article, it was decided to empower this result in its own section. In order to proceed with the analysis of this relationship, the hypothesis 2 was divided into two sub-hypotheses. The first (sub-hypothesis 2.1) analyzes this relationship in terms of recognition of the need for external knowledge by firms to develop their activities inherent in the innovation process. The second sub-hypothesis (2.2) analyses the level of contexts (“cooperation” and “in-house”), where firms have developed their innovation activities.

Hypothesis 2.1 – The need for external knowledge becomes stronger with increasing intensity/complexity of innovation by firms

The analysis of tables 3 and 4 identifies an interesting pattern of firms' behavior, is dealing with the increased intensity/complexity of their innovation activities. This pattern shows that as firms are associated with more intense levels of innovation need as well, with greater intensity, more external knowledge. This is a conclusion which stems from the fact that the proportion of firms that need external knowledge in all the considered classes is higher than the proportion of firms referred that do not require external knowledge (already seen on the sub-hypothesis 1.2) and the increasing trend of this pattern to the group acknowledged that need external knowledge, concomitantly with the decreasing trend for the other group, as it covers the entire typology of innovation involved (see please table 4).

Hypothesis 2.2 – The development of innovation activities in context of cooperation becomes stronger with the increasing intensity/complexity of innovation by firms

As the example of the trend observed for the variable "need for external knowledge" and "intensity/complexity of innovation", in this case there is a similar pattern, i.e., higher proportions of firms in contexts of cooperation in the face of proportion of those which perform in-house, are associated with the greatest intensity of innovation. In general, this means that firms that have produced more and different types of innovation (higher intensity/complexity) are proportionally more concentrated in contexts of cooperation connected to the context in-house. An identical pattern can also be found also in the analysis of the degree of radicalness of innovation faced with the contexts in which firms have developed their innovation activities (see please table 4).

The analysis performed, as well as the results obtained, provide consistency to the two sub-hypotheses (2.1 and 2.2) and state that, together, give coherence to the second hypothesis. It is confirmed therefore that the need for external knowledge and the development of innovation activities in the context of cooperation becomes stronger with increasing firms' involvement in activities of higher innovation intensity/complexity.

4. Economic performance, innovative performance and innovation contexts

The relationship between innovation and firm performance has been deeply studied and there is abundant literature on this issue (see, for example, Kemp *et al.*, 2003; Kleinknecht & Mohnen, 2002; Cefis & Ciccarelli, 2005; Jefferson *et al*., 2006; Morone & Testa, 2008; Koellinger, 2008; Fagerberg *et al*., 2009; Cappellin & Wink, 2009; Hall, 2011). Now, will be related the above results with firm performance: firms recognize the need for external knowledge to develop their innovations' activities, they establish cooperation to obtain

that extra knowledge and there is an association of that result with higher innovative performance and, consequently, higher economic performance. We will test this last argument taking the following third hypothesis:

Hypothesis 3 – the economic performance of firms is positively related both with their innovative performance and with the innovation context

Model A: Economic performance, innovative performance and innovation contexts

Model A attempts to capture the economic performance of firms through the firms growth of turnover between 2007 and 2008, classifying firms into 6 levels. We measure innovative performance using, respectively, two variables concerning innovation output: if firms have brought to market product innovations and if firms have brought to market process innovations in the last five years. For the innovation context we use the variable 6 already defined in section 2.1. (See table 5 for all the variables and categories used in Model A and B).

Table 5 – *Variables used in Model A and B*

	Dependent variable	Independent variable
Model A	Growth of Turnover (six levels of %) 1 – 05-10 2 – 11-15 3 – 16-20 4 – 21-30 5 – 31-50 6 – > 50	Innovation Product 0 – No 1 – Yes Innovation Process 0 – No 1 – Yes Innovation contexts 0 – In-house 1 – Cooperation
Model B	Aggregated Economic Performance 1 – Zero type 2 – One type 3 – Two types 4 – Three types 5 – Four types	Aggregated Innovation Performance 1 – Zero type 2 – One type 3 – Two types 4 – Three types 5 – Four types

Source: Authors' own compilation

Model A was estimated by using ordered logistic regression, according to the nature of the dependent variable. The context of innovation "in-house" was used as a benchmark for the purpose of interpreting the results. All the results are shown in Table 6 and 7 (here we can see the marginal effects of both models).

Table 6 – *Model A and B: Estimation results*

	Growth Turnover	**Aggregated Economic Performance**	
	Model A	**Model B**	
	Coefficients (odds ratios)		
		Cooperation	**In-House**
In-House – reference			
Cooperation	1.413*		
	(0.0540)		
Innovation Product	0.966*		
	(0.0759)		
Innovation Process	1.094**		
	(0.0430)		
Zero type – reference			
One Type of innovation		10.96**	0.303**
		(0.0322)	(0.0183)
Two types of innovation		7.065*	0.709
		(0.0686)	(0.429)
Three types of innovation		6.917*	0.657
		(0.0732)	(0.329)
Four types of innovation		19.18**	
		(0.0181)	
Technological Intensity	*YES*	*YES*	*NO*
Firm Size	*YES*	*YES*	*NO*
LR chi2 (3)	*10.93*	*8.72*	*6.43*
Prob > chi2	*0.01*	*0.06*	*0.09*
Log pseudolikelihood	*-691.9*	*-335.9*	*-255.1*
Observations	397	227	170

Source: Authors' own compilation based on survey *Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Table 7 – *Model A and B: marginal effects (Df/dx)*

	Model A			
Dependent	*marginal effects Df/dx*			
	Cooperation	Product	Process	
05-10	-6.6	0.6	-1.7	
11-15	-1.7	0.1	-0.4	
16-20	0.0	0.0	0.0	
21-30	1.8	-0.1	0.4	
31-50	2.3	-0.2	0.6	
>50	4.2	-0.4	1.1	
	Model B			
Dependent (cooperation)	*marginal effects Df/dx*			
	One	Two	Three	Four
Zero type – reference	-6.9	-8.7	-9.1	-6.0
One Type of innovation	-23.2	-24.1	-24.5	-22.2
Two types of innovation	-20.1	-12.3	-11.2	-24.4
Three types of innovation	4.2	15.1	16.2	-8.1
Four types of innovation	46.0	30.1	28.6	60.9

Source: Authors' own compilation based on survey

The odds ratio estimate shows that the probability of being in higher levels of turnover growth (compared to be in lower levels) is more than 1.4 higher for firms which develop their innovations activities in a "cooperation context", compared to firms who carry out their activities in the context "in-house". We estimate a change in the probability of 2.3% to the level of (31-50%) and 4.2% to the higher level (>50%).

We can say, therefore, that the variable "contexts of innovation" has a positive impact on the probability of firms being in higher levels of the growth of their turnover, i.e., an important component of the economic performance of firms. Concerning the innovation outputs, the results show that as firms introduce product innovations in markets the probability of being in higher levels of turnover growth (compared of being in lower levels) slightly decreases. Moreover, firms that introduce process innovations in markets increase the probability of being in higher levels of turnover growth (compared of being in lower levels). We estimate the Model A with control variables and the results remain consistent.

Model B – Firm performance and innovation contexts: aggregate measures

As the literature states clearly, both performance indicators (economic and innovative) are multidimensional phenomena. Model B take aggregate measures of both variables,

trying to incorporate some of that diversity. For the dependent variable was constructed an aggregate measure of economic performance. It was asked to firms if, in the last five years, they have increased turnover, share of export, share of employment and share of orders. This variable ranges from “zero type” – not increasing none of them – to “four types” – if firms increase all of them. The independent variable – here named aggregate innovative performance – is our V_2, already defined in section 2.1.

Model B was estimated by using ordered logistic regression, according to the nature of the dependent variable. We performed two estimations, one for firms that develop their innovation activities in a cooperation contexts and another for those which do it in-house. The level “zero type of innovation” was used as a benchmark for the purpose of interpreting the results. All the results can be seen in table 6 and 7.

The estimation results of Model B suggest that the relationship between aggregate economic performance and aggregate innovation performance still remains, but with one significant difference: this relation has a greater magnitude and statistical consistency for firms that develop their innovation activities mainly on cooperation context, in relation to those developed in the context "in-house". The marginal effects help us to confirm these results as we can see in table 7 that as firms increase different types of innovation output they get better results concerning their diversity of economic output. These results give consistency to our third hypothesis.

5. Conclusions

It can be synthetized the main conclusions in the following points. Most firms clearly recognize the importance and the need to access external knowledge in order to develop their innovation activities. The analysis allows us to find evidence that most of the firms developed their innovation activities in the context of cooperation. Both facts (1 and 2) are true across the control variables and the different components of the innovation process, namely: type of innovation activities, innovation intensity, radicalness of innovation and type of competition. It is further noted, emphasizing that it was possible to give consistency to the pattern that indicates that the higher the intensity/complexity of innovation activities that firms are engaged in the greater the need of external knowledge and the development of cooperation. The cooperation context is a critical factor for the innovative performance of firms and its importance is greater as the more intense/complex the innovation process proves to be. The development of innovation activities in the context of cooperation substantially increases the innovation performance of firms and hence their economic performance, whether it is measured by the change of its turnover or its aggregate economic performance. Finally, one last note. The fact that we highlight the contribution of the context of cooperation to the innovation process of firms doesn´t mean that they don´t innovate in the “in-house” context. Our sample confirms that firms can innovate in both contexts. What we clearly confirmed by enough

empirical evidence is the fact that as firms are engaged in activities that are more demanding and a more complex process of innovation, the context of cooperation seems to play an increasingly critical success factor. It can then be stated with some consistency and coherence, that cooperation is a predominant condition of innovation activity, and appears even decisive (we could almost say a "necessary condition") as the complexity of the business process innovation increases. Once we establish the relation between economic performance and innovative performance, we link directly the importance of this “necessary condition” to the firms’ economic performance.

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