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Beyond the organizational context: knowledge networks and firms' performance

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Abstract

Although the role of research and development (R&D) is seen as one of the main sources of innovation, it is also clear that this is not the only contributory factor. The innovation process is also the result of specific combinations of knowledge that firms obtain by accessing both the internal and the external environments. In this context, one way for businesses to promote innovation it is through knowledge networks. It is the relevance of these networks in the innovation process that is the focus of this paper. There are three main objectives: firstly, we identify the most important interaction channels used by firms and analyze the mechanisms that underlie these channels with regard to their formal and informal nature. Secondly, we study the relationship between networking intensity and the innovation process. Finally, we analyze the relationship between knowledge networks, the innovation process and firm performance. Our results show that firms that engage more intensively in knowledge networks increase the likelihood of obtaining higher levels of innovation output and better economics performance. The key finding shows the importance of informal interaction mechanisms in the firms´ innovation process.

Keywords: *innovation process, knowledge networks, firm performance, interaction channels, formal and informal interaction mechanisms, Portugal.*

Introduction

The innovation process is the result of specific combinations of knowledge that firms obtain by accessing both the internal and the external contexts (Karlsson and Olsson, 1998; Antonelli and Ferrão, 2001; Antonelli 2005a; Ruten and Boekema, 2004). In this context a way for businesses to promote innovation it is through knowledge networks (Powell and Grodal, 2005; Fisher, 2006). In general, it is recognized that networks facilitate access to and exchange of information and strategic knowledge whilst promoting inter-organizational collective learning. That is, networks are the organizational support that enables economic actors to pursue innovation and explore new business opportunities through joint efforts, resources and competences. By doing so they not only manage the scarcity of resources to the innovation process, they also as reduce the risks associated with uncertainty. Last but not least, networks are an instrument of coordination of interaction between multiple actors involved in the innovation process, whose dynamics contributes to the strengthening of trust between partners, a critical dimension of the innovation process.

These interactions occur through mechanisms of formal, but also of an informal nature (Birley, 1986; Fuller-Love, 2009). Formal networks are structured and governed by legal-formal mechanisms while informal networks result from interaction processes without legal support, such as the interactions associated with non-contracted labour market, the social and professional relationships, personal relationships or simply to social networks. Both formal as informal networks are key factors in the innovation process, complementing and mutually reinforcing. The formal mechanisms promote stability within a relationship, promoting cognitive proximity and the efficiency to transfer specialized codified knowledge. In turn, informal mechanisms provide greater network flexibility in the transfer of tacit knowledge. But perhaps his greatest contribution to the innovation process is to provide knowledge networks with an essential feature to its effectiveness: trust among actors. The relevance of territorial anchoring of innovation networks arises precisely from the fact that the trust achieves greater efficiency through processes of socialization territorially enrolled.

This paper is based on the assumption that knowledge networks play a key role in the innovation process, and aims to contribute to a deeper understanding of the dynamics of networking and its role in business innovation. Specifically, we have three main objectives: first we identify the most important interaction channels used by firms and analyze the mechanisms that underlie these channels with regard to their formal and informal nature. Secondly, we study the relationship between networking intensity and the innovation process. Finally, we analyze the relation between knowledge networks and firm economic performance.

The paper is organized as follows: in section 1 we present the main concepts and the conceptual background, with regard to the importance of knowledge networks to the innovation process. In section 2 we identify the most important network channels and mechanisms of interaction and link them to the innovation process. Then we analyze the relationships between network intensity and the innovation process. Finally we turn to another important issue, the relationship between firms´ economic performance and innovative performance, integrating this relationship with the previous results of the section. To do so we estimate four different econometric models. For each model we present our hypotheses, variables and associated specifications. In the last section we sum up our main results about the importance of knowledge networks to the innovation process and the performance of firms. Then, we finish with some reflections about the policy implications that derive from our conclusions.

1. Innovation, Networking and Firm's Performance

1.1. Why do firms innovate?

The innovation process has become a central theme in the economic literature of recent years. Imposes itself therefore that we start to question: why firms struggle to innovate? Briefly, companies innovate to improve their economic performance, thereby ensuring its competitiveness. Since Schumpeter (1934) introduced the issue, the contribution of innovation to economic growth has been well documented. Despite the importance of innovation, it is the implementation that often leads to success. Innovation allows firms to gain a competitive advantage which will be eroded over time therefore it needs to be a continuous process. There is a general understanding that innovation is the primary source of economic growth, industrial change and provides competitive advantages. These innovations can take the form of new and improved products or services to attract new customers and retain existing ones as well as innovative approaches to the organisation's systems. By innovating, businesses hope to respond to changing consumer requirements and improve their performance. The improvement of is performance can come from two theoretical arguments. The first is that innovation provides a first mover advantage that leads to better performance. The second approach is that when an organisation is constantly trying to improve the quality of its products and services, then this can create a competitive advantage which leads to improved performance in terms of both sales and profits. Damanpour *et al.* (2009) found that innovation led to higher levels of performance, especially when there were different approaches to innovation and that a diverse approach to networks was more likely to create a competitive advantage. Innovation can enhance the dynamic capability of an organisation and enable it to adapt to changes in the competitive environment.

Innovation can provide distinctive differentiating characteristics in the product or service which can provide a sustainable competitive advantage over time. The relationship between innovation and business performance has been studied deeply and there are several studies on the establishment and the rationale for this relationship (see, for example, Kleinknecht and Mohnen, 2002; Kemp *et al.*, 2003; Cefis and Ciccarelli, 2005; Cainelli *et al.*, 2006; Koellinger, 2008; Morone and Testa, 2008; Fagerberg *et al.*, 2009; Cappellin and Wink, 2009; Hall, 2011). In general, these studies have found a positive effect of innovation on a firm's performance, expressed in both productivity and growth in sales. In section 2, based on our sample, we test the relationship between sales growth and the involvement of firms in innovation networks.

1.2. How do firms innovate?

Although the dominant orientation of innovation policy will continue to favour the incentive to R&D, the truth is that this is not the only way for firms to innovate. Multiple studies have shown that firms do not innovate in the same way (see, for example, Nunes & Lopes, 2015; Fitjar and Rodriguez-Pose, 2013; Gokhberg, Kuznetsova and Roud, 2012; Parrilli, González and Peña, 2012; Marlon and Lambert, 2009; Žížalová, 2009; Jensen *et al.*, 2007; Lundvall, 2007; Tödtling, Lehner and Kaufmann, 2006; Lorenz and Lundvall, 2006). Particularly, Lundvall (1985) drew our attention to the fact that innovation result of an interactive and collective learning process. In turn, Antonelli and Ferrão (2001) show that the scope of this learning process is not confined to the inside of the firm, before it materializes on a complex variety of relationships between the firm and its external environment. Through these relational dynamic firms accessing to tacit and codified knowledge that combine to materialize innovation.

More recently, Jensen *et al.*, (2007) showed us that there are two modes of innovation that firms frequently combine with each other. The mode based on the production and use of codified scientific and technological knowledge – Science, Technology and Innovation (STI), and the mode based on learning from experience and supported by interactive learning processes – Doing, Using and Interacting (DUI).

In short, the knowledge relevant for innovation derives not only from the traditional scientific system, but also from the collective learning processes associated with various contexts and the (formal and informal) interaction of the various actors in them. As Hudson stresses (1999: 62) "*The emphasis now is therefore upon recognizing that innovation is an interactive process that involves the synthesis of different types of knowledge rather than privileging the formal scientific knowledge of the R&D laboratory over other forms of knowledge*" and "*creating dense horizontal flows of knowledge and information within, and vertical flows of knowledge and information between, the various functional divisions of the company, while opening the ears of those involved within the company to voices from outside its boundaries".*

In order for firms to develop the innovation process, it is important to look at the different instruments and mechanisms of interaction that allow firms to combine both internal and external knowledge. According to Karlsson and Olsson (1998:31), '*product innovation does not take place in isolation and requires communication and innovation networks play an important role in the process*'. The profitability of a firm depends, to a certain extent, on innovation and developing new products and services. The acquisition of new knowledge, therefore, from various sources, is a key factor in the innovation process. Acquiring external knowledge is recognized as essential in the innovation process as it has been identified as the additional factor which makes the difference to progress (Lopes, 2001; Acs *et al.*, 2012; Nunes and Lopes, 2012). According to Antonelli (2005a:10), tacit knowledge acquired through the learning process is '*articulated both internally and externally by means of network relations*'. In this way, networks allow to firms to innovate more quickly and develop new useful knowledge that´s beyond their individual competences. The overall framework of the current competitive business environment characterized by high uncertainty and increasing complexity of knowledge bases for innovation, means that even large firms need to interact with the exterior to develop innovative activities. Even large firms do not have all the knowledge required to develop new products and services (Nunes, 2012). They need external knowledge i.e. knowledge that is beyond their hierarchical control' in the innovation process (Ruten and Boekema, 2004).

From this perspective, networks are tools to support interactions between different agents, which allow the transmission and acquisition of knowledge which can be used in the activities of firms. The different relevant knowledge bases to the innovation process are increasingly specialized and fragmented, and tend to increase the dispersion, either spatially or in respect to the actors holding it. Thus, universities, firms, individuals, research laboratories and institutional actors engage, increasingly, in cooperative activities and networking. Since learning processes are developing both internally and externally to organizations, the dynamics of interaction are inevitable and networks are formed to support and coordinate the whole process of innovation (Oerlemans, Meeus and Boekema, 1998; 2001; Powell and Grodal, 2005; Fischer, 2006). In general, we can say that a network results from the articulation between different actors with a view of obtaining further knowledge for the innovation process.

Thus the knowledge networks are the instruments through which the various firms participate in the management of external knowledge. These networks connect agents with different knowledge bases, turning into knowledge networks, which work as environments to support interactive and collective learning.

1.3. The role of networks in the innovation process

Karlsson and Olsson (1998: 35) define innovation networks as a set of linkages with preferential partners where the resources flow from supply to demand nodes e.g. technology and across different activities e.g. transformation. According to Karlsson *et al*. (2005) members of a network may develop joint knowledge and product specific language over time which helps to reinforce the relationships. These linkages therefore provide a structure to the organisation of these firms. The dynamics of these network links therefore have an important impact on the innovation processes in an economy.

Networks can take many different forms and may be formal or informal. Parker (2008) describes formal networks as ones where entrepreneurs come together to share information and experience for 'mutual advantage' and therefore improve their competitiveness. Participation in these networks can lead to benefits in the innovation process. Fuller-Love and Thomas (2004) found that formal business networks provided economies of scale and a cost-effective way to improve performance, sharing information and resources and undertaking joint projects.

Birley (1986) distinguishes formal and informal networks providing support for businesses as either being professional or non-professional sources. Formal networks are described as banks, accountants, solicitors, government support agencies etc. whereas informal sources of help include family and friends and other business and non-business contacts. The informal networks include family, friends, previous colleagues or employers. These informal contacts, although they may be less informed than the formal sources are more likely to listen and give advice. However, formal and informal networks can also be defined as those that are formally organized with a structure and those that are not (Fuller-Love, 2009). For the purposes of this paper, formal networks are those that are formalized by different firms and/or institutions through formal mechanisms and informal networks are the result of personal interaction and socialization processes, which may materialize in different contexts: social networks, labour market, associations, etc. Both networks are essential to obtaining additional knowledge for the innovation process of firms. Schoonjans *et al*. (2013) looked at the impact of formal business networking on small firm growth and found that it was significantly positively associated with net asset and added value growth. On the other hand, Parker (2008) found that formal networks enhance the performance of entrepreneurial firms and also promote social welfare and efficiency in the wider economy. Aalbers *et al.* (2006) found that formal networks played an important role in the transfer of knowledge within a firm and that they were often more conducive to knowledge transfer than informal ones. With specialised knowledge, it is often tacit and requires personal contact to disseminate. However, Parker *et al.* (2002) found that informal networks may be best for non-routine knowledge transfer because formal networks may include structures and rules and regulations. Information may also be transferred more quickly in an informal network and they may be more flexible. Both can only take place when trust has been established.

In fact, a competitive environment where innovations depend on multiple dynamics of interaction, networks playing a key role in supporting the links between different actors and promoting access and transmission of economically useful knowledge. There is evidence that external linkages improve innovation development in firms through both formal and informal networks. These linkages can include universities, customers, suppliers as well as competitors. The central theoretical approach is that access to critical resources lie outside the firm. These external linkages provide opportunities to access new ideas (Johannisson *et al.*, 2002). Therefore the greater number of linkages, innovation becomes more likely. According to Hervas-Oliver and Albors-Garrigos (2009), the firms operating in clusters often perform better because they are able to develop and maintain relationships. One of the key issues is that firms exploit relationships in different ways, enabling some of them to access better information and become more innovative.

Several studies point to the positive correlation between research efforts and technological sophistication and the number and intensity of strategic alliances (Freeman 1991; Hagedoorn, 1995; Powell and Grodal, 2005). The importance of networks in the innovation process has been successively recognized by a wide diversity of authors. Networks, create conditions that facilitate the connection and coordination between the different knowledge bases, enabling the coordination and participation of different actors (see e. g., Oerlemans, Meeus and Boekema, 1998, 2000, 2001; Tödtling, Lehner and Trippl, 2004; Rutten and Boekema, 2004; Lambooy, 2005; Caravaca *et al.* 2005; Fischer, 2006). They facilitate exchange and sharing of information and specialized resources, collective and inter-organizational learning, joint development of skills and knowledge and make it possible to develop new opportunities and experiences (Powell and Grodal, 2005; Caravaca, *et al.* 2005). Networks also enable small and large firms to overcome many problems arising from uncertainty and limited resources connected to the innovation process, and the risks associated with the complexity of innovation activities (Tödtling and Kauffman, 2001).

Although innovation networks fulfil different functions, one of the main aims of networking relationships is to create or add value to the products or services and increase sales and profitability. Often the benefit does not come from the direct links but from the weaker links which are opened up by participating in different networks (Granovetter, 1975). These weaker links can provide new information which can lead to opening up new opportunities. Another recognised benefit of networking is in terms of lower transaction costs (Williamson, 1975). By developing relationships with network members, firms can reduce transaction costs and this will, ultimately, have an impact on the economic performance of the firm. According to Coase (1937, 1992), if a contract with a firm is made for a longer period, the costs of making new contracts will be avoided. The game theory approach has also been used to explain the benefit to participants (Cowan *et al.,* 2007). In the Nash equilibrium there is a payoff for cooperation i.e. each participant benefits. Network participants may develop strategic alliances within the network in order to exchange information.

According to Witt (2004) entrepreneurs with larger and more diverse networks are likely to be more successful than those with smaller networks. Witt (2004) found that networking in some industries e.g. biotechnology was more important than in others because of the levels of implicit and tacit knowledge required to maintain competitive advantage. Firms that pursue innovative strategies may need more networking as they rely more on co-operative strategies with other firms. Sammarra and Biggario (2008) looked at the exchange of technical, market and managerial knowledge in the aerospace industrial cluster in Rome. They found that network participants exchange technological, marketing and managerial information because of the complex nature of the innovation process which requires diverse information. Fritsch and Kauffeld-Monz (2010) looked at the transfer of knowledge and information in regional innovation networks in Germany. They found that embeddedness within an innovation network was positively correlated with the inter-organisational exchange of information and knowledge. Hite and Hesterley (2001) found that firms in the early stages can derive more benefits from a cohesive network whereas they can exploit weaker ties when in the later stages of development. Spithoven *et al.* (2013) found that open innovation practices were more important for SMEs than for large firms. Open innovation practice is considered more than sourcing external knowledge, research collaboration etc. They found that small businesses were more dependent on open innovation practices than the larger firms. Although the larger enterprises were more active in open innovation activities, the SMEs had more intense open innovation activities when employment was taken into account. Faems *et al.* (2005) also found that the more firms engage in networks, the more likely they are to create new or improved products that are commercially successful.

In turn, the literature of territorial approach points out the crucial importance of networks (formal and informal one) to the innovation process (see, for example, Antonelli and Ferrão (2001); Storper and Venables (2004); Gellynck and Vermeire

(2009); Huggins *et al.* (2012); Martin (2013)). In general, as Martin (2013: 1431) did, these studies conclude that "*Embeddedness into networks can have positive effects on innovation outcomes as they facilitate the flow of information and knowledge and provide access to tacit forms of knowledge which are not available elsewhere*".

In summary, our belief is that, irrespective of the innovation in research and development laboratories, networks, in their different forms, have a fundamental importance in the innovation process. Involvement in knowledge networks is not only relevant to enhance the innovative performance of the company, but also to improve its economic performance. In general, we can conclude that knowledge networks provides advantages in the innovation process in the context of sharing costs, reducing risks, gaining additional strategic knowledge and developing international markets. More, several authors point out a positive relationship between networks embeddedness and firms' performance, as we will test empirically in section 2. In the next section we will show that knowledge networks result from coordination between different channels (market, institutional and personal) and mechanisms (formal and informal) of interaction between agents. These interactions between individuals and/or organizations have become more common and increasingly important (see, for example, Breschi and Malerba, 2007).

2. Networking intensity and innovation process: empirical evidences

2.1. Data and methodological options

The database used in this paper is made up of a representative sample drawn from a universe of 981 firms that simultaneously satisfy the following criteria: had a turnover of over € 1 million in 2008 and an increase in turnover of at least 5% between 2007 and 2008[1]. Our intention was to identify a group of more dynamic 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

[1] The universe was obtained from COFACE SERVICES PORTUGAL, SA. See, please, www.coface.pt.

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). This variable seeks to capture 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. This produced a database containing 397 observations, representative of the population on which the statistical and econometric work of this paper is based.

The descriptive statistics of the variables used are reported in Appendix in Table A1 and A2 and the key survey questions for the variables used in this paper are reported in the same appendix in Table A3.

2.2. Network channels, mechanisms of interaction and networking intensity

In accordance with the survey done, we identify in Table 1 the possible interaction channels that firms could use to access external knowledge. In the business survey we asked firms to identify first the channels they normally used and secondly, the importance they attached to each channel using a Likert scale 1-5. These channels were classified as market, institutional or personal channels. For the purposes of this study, for each channel we also asked firms to identify and classify (in the same way as previously) the nature of the interaction mechanism, whether they were formal or informal mechanisms.

[INSERT TABLE 1]

Our first results are presented in Table 2. The "total networking" is the mean of relationships established through the various channels used by firms, which can be formal or informal interactions. Most of these networks are operationalized through formal and informal mechanisms, but in this case, the informal mechanisms are slightly higher (51.4 % vs. 48.6%).

[INSERT TABLE 2]

If we take into account the control variables, the general trend continued to be the same: informal mechanisms are slightly more frequent than the formal ones. These results suggest that the dynamics of interaction of an informal nature are important to the process of firms' innovation.

The third part of Table 2 includes the network intensity, i. e., the relative importance that firms attach to each channel used. This is the variable synthesis that results from the following transformation: in the numerator we have the sum of the classification attributed by the firms to each channel and the denominator is the maximum that can be assigned. This variable ranges from 0.2 – if firms acknowledge the importance of each channel to a minimum (Likert=1) – and 1 – if such recognition is the maximum (Likert=5). The greater the intensity of networking will be the more the variable approaches unity. The difference between the number of channels and the importance of channels allows us to understand that the same channel can be used with different intensity by different firms. We are assuming here that if the firm attaches more importance to a channel it means that the firm uses it more intensely. Consequently, more intensity means more utility to firms compared to a channel which the firm recognizes as having less importance.

Table 3 presents the top five most important network channels, in accordance with to the answers given by firms to the survey.

[INSERT TABLE 3]

Table 3 shows the most important channels of interaction that firms recognize in their dynamics of networking. Overall, the market channels, or of interaction between clients, suppliers and competitors, or access to specific knowledge associated with the labour market are the most valued. From the perspective of the mechanisms utilized, the three most important channels associated with formal mechanisms are the channels of the market – customers, suppliers and competitors – followed by the institutional and labour markets. In informal terms, the main difference is the substitution of market channels (customers and suppliers) for institutional channels normally associated with specific external knowledge. Note that these are usually the main channels mentioned in the literature with regard to key actors in knowledge networks that influence the process of innovation.

Having identified the channels used by firms and the importance/intensity of interaction mechanisms, it is now important to analyze the relationship between the number of channels used and the intensity of networking. We considered the following hypothesis:

Hypothesis 1 - The intensity of networking depends on the number of interaction channels utilized, using either formal or informal mechanisms.

The complexity of the innovation process requires that firms use multiple channels of interaction and networking activities' intensity, in order to obtain the necessary knowledge for their innovation process that is not available within their organizational context.

In order to test this hypothesis, we estimate Model A (all the dependent and independent variables can be seen in Table 4). Model A uses as dependent variable the *Networking Intensity* (constructed as explained before), and as independent variable the *Number of Network Channels.* This variable is the sum of the different relationships referred in Table 1, who means that the total network channels are the sum of formal and informal network interactions.

[INSERT TABLE 4]

Model A was estimated twice by using a beta distribution, according to the nature of the dependent variable. The dependent variable is a ratio that is bounded between 0 and 1 (more precisely between 0.2 and 1, although never assumes the value of 1), so the effect of explanatory variables tends to be non-linear, and the variance tends to decrease when the mean gets closer to one of the boundaries. This means that linear regression isn´t appropriate (Buis, 2006)[2]. We assume that the proportion follows a beta distribution that is bounded between 0 and 1 (but does not include either 0 or 1). The beta distribution

[2] We could use others ways to model the dependent variable (fractional logit or zero one inflated beta) but since we don't have 0 and 1 beta distribution is more appropriated for our objective.

models heteroscedasticity in such a way that the variance is largest when the average proportion is near 0.5 (Buis, 2007).

Firstly, we computed “network intensity” against the “total number of channels” and the second regression used “innovation intensity” against the “number of channels” according to its mechanisms of interaction (formal and informal). Controls for level of technological intensity, region and size were included. Both estimation results can be analyzed in Table 5.

[INSERT TABLE 5]

The results of Table 5 allow us to confirm our hypothesis; the intensity of networking depends positively on the number of interaction channels used by firms, using either formal or informal mechanisms. In terms of the level of technological intensity, there are only slight differences in the intensity of networking practiced by firms, although the results suggest that the intensity of networking slightly increases as the level of technology intensity increases. The most significant differences relate to the size of firms. The group of micro firms shows a higher networking intensity face to SMEs and large firms. These results support an important point in that network intensity is a collective and interacting process of knowledge accumulation by means of formal and informal learning processes.

2.3. Innovation process and network intensity

Assuming the role of knowledge networks and the intensity of networking as an essential dynamics of the innovation process, it is important to find empirical evidence of such relationships including the effects of the “network intensity” on the “innovation process”. In order to do so, we tested the following hypothesis:

Hypothesis 2 – The network intensity has a positive effect on innovative performance

We used two econometric models to capture different perspectives of the innovation process: Model B and the Model C.

First we estimated Model B (see Table 4) measuring innovative performance with two variables: we ask firms if they had introduced "product innovations" or/and "process innovations" in the market in the last five years. These are two binary variables that we introduced as dependent variables. As an independent variable we used "network intensity", as we define it in the last section.

Model B was estimated using logistic regression, according to the nature of the dependent variable. First we computed separately product and process innovations against total network intensity, and then we computed separately product and process innovations against formal and informal network intensity. We integrated all the estimation results in Table 6.

[INSERT TABLE 6]

For our sample, the odds ratio estimate shows that the increase of network intensity has a (large) positive effect on increasing the likelihood of firms introducing product and process innovations. However, the most substantial impact occurs with the introduction of process innovations (see column 1 and 2). Columns 3 and 4 indicate very interesting results. A higher network intensity supported by formal and informal mechanisms of interaction has a (very large) positive effect on increasing the likelihood of firms introducing product and process innovations. For product innovations formal mechanisms have a major positive impact while for informal mechanism are more relevant for increasing the process innovations.

Innovative performance is a multidimensional phenomenon. In Model C we use an aggregate measure of innovative performance, in order to incorporate some of that diversity. Based on the business survey data, we construct a new variable – "Innovation Intensity". We take four types of innovation outputs: product, process, organizational and patent introduction. We asked firms which type of innovation they had introduced in markets in the last five years. We then had an ordinal variable that ranged from "zero types of innovation" – if the firm didn´t introduce any type of innovation – to "four types of innovation" – if firms simultaneously introduced all types of innovation. We used this variable as the dependent variable and "Network Intensity" as the independent variable (table 4).

The Model C was estimated by using ordered logistic regression, according to the nature of the dependent variable. The results can be seen in table 7.

[INSERT TABLE 7]

The odds ratio estimate shows that increasing the network intensity raises the probability more than 2.6 times higher of having increased levels of innovation intensity (compared to having lower levels). The marginal effects show these results in a more detail. In other words, firms that engage more intensively in knowledge networks increase the likelihood of obtaining higher levels of innovation output. The results showed in column 2 confirmed the same results consistently, with the relevance of the informal networks.

Given the set of results achieved in this section, we confirm hypothesis 2. We can empirically support the argument that knowledge networks had a positive impact in the firms´ innovation performance. This remains consistent whether we analyze the performance through one-dimensional innovative measures or through aggregate measures of innovation output, even if different contexts of innovation are considered.

2.4. Knowledge networks and firm's economic performance

In this section we will test the relationship between the innovation process (where we use the knowledge networks) and the firm´s economic performance. Our third hypothesis of study is:

Hypothesis 3 – the innovation process has a positive impact on firm´s economic performance

In order to analyze this hypothesis we estimated the following Model D. This model attempts to capture the economic performance of firms through the growth of firms' turnover between 2007 and 2008, classifying firms into 6 levels (see table 4 and table

A2 in the Appendix). We obtained this variable from a different database regarding to our sample[3].

On the right side of our model we looked at three key dimensions of the innovation process, namely the innovation output, the innovation context and the knowledge networks. As dependent variable we used the level of turnover and as independent variables we used "network intensity", the "innovation context" and the innovation product and process as previously defined in the former sections.

Model D was estimated by using ordered logistic regression, according to the nature of the dependent variable. The context of 'in-house' innovation was used as a benchmark for the purpose of interpreting the results of innovation contexts. The results are shown in Table 8.

[INSERT TABLE 8]

The variable "innovation product" was not statistically significant. The other results show us that firms that introduce process innovation in markets increase the probability of having higher levels of growth of turnover (compared to be in lower levels).

These results also show us that the probability of having higher levels of growth of turnover (compared to lower levels of growth) is almost 1.3 times higher for firms which develop their innovation activities in a 'co-operative context' compared to firms which developed their activities 'in-house'. The magnitude of the marginal effects, support the argument of the importance of the cooperative contexts but not excluding the importance of in-house activities. Finally, when firms increase their involvement in knowledge networks they substantially raise the likelihood of having higher levels of growth of turnover (compared to lower levels of growth), which is an essential aspect of firms' economic performance. The marginal effect shows us a clear pattern of this important dimension of the innovation process. When we introduced the control variables in Model D only the "innovation context" remains statistically significant.

A strong conceptual argument can now be put forward in the following terms. The economic performance of firms depends on their innovation performance and the

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[3] It comes from a database hold by Coface. In our business survey we couldn't get enough information about this dimension, so we have to use the date back to 2007 and 2008. This time lag isn´t problematic since all our survey questions asked in 2011 were concerned with the behavior of firms "in the past five years".

contexts in which they develop their innovation activities, highlighting the positive effect of a co-operative context on firms´ economic performance. Furthermore, knowledge networks, taking into account formal and informal learning processes (such as the interactive, collective, cumulative and systemic learning context), play a key role in the firm's innovation performance and, thereby, in their economic performance.

3. Discussion and main conclusions

Our findings confirm some of the previous studies on this topic. Huggins *et al.*, 2012, for example, conclude that the innovation performance of firms is significantly related to network capital investment. Rogers (2004), points out that innovation is not an internal process. He concluded that in the innovation process, the suppliers, customers and the external environment all have an impact. Our research found that customers, competitors, suppliers and labour market are the most important linkages in the innovation process. In the formal networks the three most important networks were customers, suppliers and competitors. This confirms earlier findings (Johannisson *et al.*, 2002; Gellynck *et al.*, 2009, e.g.) that these linkages play an important role in the innovation process as they provide access to new ideas and information. These links with suppliers and customers can also lead to a reduction in transaction costs (Coase, 1992) as relationships develop over to time and become more established. This can lead to an increase in trust which is necessary for the transfer of knowledge. The transfer of both implicit and tacit knowledge is especially important in the innovative process (Witt, 2004; Antonelli and Ferrão, 2001) and is required for firms to develop and maintain competitive advantage.

Our study also confirms that the labour market has a crucial importance. The labour market appears not only as an important mechanism for formal relationship, but rather as an informal mechanism for access to information and knowledge outside the firm. . The regional environment is an important influence in, as well as skilled labour innovation (Karlsoon and Olssen, 1998). The availability of skilled manpower in an area increases the opportunity for the exchange of knowledge which may have been created either in the region or elsewhere. Because of their size, SMEs will employ fewer qualified staff than larger companies and are more likely to be dependent on the regional network for innovation and product development. Therefore, access to a qualified labour market is an important factor in the innovation process.

Our results also found that the number and type of network linkages confirmed earlier studies. In fact, firms that developed innovation in a co-operative context were more likely to have higher levels of growth and turnover. This confirms Faems *et al.* (2005) who found that increased network linkages led to more successful innovation. This indicates that networks play an important role in the development of successful innovation i.e. new products and services which are likely to lead to increased turnover and profits.

The sample includes mainly small and medium sized firm with a profile of predominantly incremental innovation, which may affect the scope of the conclusions. It is possible that informal mechanisms have greater importance for this type of firms. But that fact does not challenge our main conclusion: knowledge networks play a key role in the innovation process of the firms. Firms need diversified forms of knowledge to their innovation process, and networks are precisely the support mechanism that allows them to access such knowledge. For most SMEs, this is possibly the only way by which they can innovate, and thus ensure their competitiveness. In summary, the development of innovation activities in the context of cooperation substantially increases the innovation performance of firms and hence their economic performance.

However, Freel (2000:263) also noted that '*networking cannot be considered either a necessary, nor less sufficient condition for innovation and that it may be that, within both the academy and the policy, the tendency to overstate the impact of networks persists'*. Osajalo (2008) pointed out that networked co-operation does not guarantee successful innovation as the innovation process is very challenging and requires good networking skills. That is, acknowledging that networks play an important role in innovation, it is important to investigate the factors associated with the success of dynamic governance of knowledge networks. For example, it should be clarified to what extent the effectiveness of dynamic governance of networks depends on the proximity ensured through the channels and mechanisms that structure the network. In particular, further research could be carried out into the different spatial (and non-spatial) contexts related with the knowledge networks analyzed here, stressing the role of the geographical location and the physical proximity to the innovation process. Other research could also look at the weighting of the different types of networks e.g. customers, suppliers, competitors etc. in the innovation process.

There are also some lessons that we can draw from the results already obtained for the guidance of innovation policy, particularly in the context of EU countries. In line with the European 2020 agenda, the EU (2010) approved the document *Regional Policy Contributing to Smart Growth in Europe*, which assumes the goal of adopting a regional policy that promotes "smart specialization" of the economies of the EU. Knowledge and innovation are recognized as strategic factors of smart specialization. On the other side, in ESPON (2012) three typologies of regions are empirically identified: technologically-advanced regions; scientific regions and knowledge networking regions. This means, among other things, that the knowledge economy is expressed in a territorially differentiated way. A knowledge economy region can be identified as a region specialised either in high-tech sectors, or in scientific functions or is capable to obtain knowledge from other economies through cooperation and networking.

If R&D is not the only way in which the knowledge economy is expressed in, then this cannot be the only approach to innovation policy. Promoting networking should be a central dimension of innovation policy, especially in countries such as Portugal, where the business community is overwhelmingly composed of SMEs and where the potential for innovation is mostly incremental. Innovation policy should therefore be designed specifically for SMEs with incremental innovation as one of its main concerns. "*The challenge for regional policymakers is to develop a more targeted approach to particular subgroups with respect to their behaviour in networking and their innovation capacity…*" (Gellynck *et al.* 2009: 732). This should be a primary concern not for reasons of size but by the specificity of the relationship of this type of firms with the knowledge networks and their role in the articulation of the medium and low-tech sectors with medium and high-tech sector in the EU.

This paper shows the importance knowledge networks on the innovation process, especially on innovative performance. Previous studies have found the effect of the role of knowledge in the innovation process. Nunes and Lopes (2012b) showed that firms need external knowledge to develop their innovation activities and establish co-operation with other organisations to obtain that extra knowledge. In this paper, we also show that firms operationalise co-operation through different channels supported by different interaction mechanisms. The dynamics inherent to those channels and mechanisms became networks that firms use with different intensity. Finally, we found empirical evidence that those networks had a positive effect on firms' innovative performance.

Considering the results obtained, we can now conclude that the participation in knowledge networks is an alternative pathway for firms to pursue innovation. Knowledge networks play a key role in the innovation performance of firms and, by such means, in its economic performance. In fact, our results show that firms that engage more intensively in knowledge networks increase their levels of innovation output. We obtained empirical evidence too, that when firms increase their involvement in knowledge networks they substantially raise the likelihood of having a better economic performance, measured by higher levels of growth of turnover. Finally, we also highlighted the importance of informal mechanisms of interaction inherent to the dynamics of governance of knowledge networks.

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Appendix

Table A1 – Sample used on empirical analysis

		Micro		SME		Large		Total	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Greater Lisbon and the Setúbal Península	LT	1	5.6	34	19.8	11	28.9	**46**	**20.2**
	MLT	5	27.8	37	21.5	6	15.8	**48**	**21.1**
	MT	2	11.1	33	19.2	5	13.2	**40**	**17.5**
	HT	2	11.1	19	11.0	7	18.4	**28**	**12.3**
	KS	8	44.4	49	28.5	9	23.7	**66**	**28.9**
	Total	**18**	**100.0**	**172**	**100.0**	**38**	**100.0**	**228**	**100.0**
Greater Porto	LT	2	40.0	33	39.8	3	23.1	**38**	**37.6**
	MLT	1	20.0	22	26.5	2	15.4	**25**	**24.8**
	MT	1	20.0	17	20.5	4	30.8	**22**	**21.8**
	HT	0	0.0	2	2.4	1	7.7	**3**	**3.0**
	KS	1	20.0	9	10.8	3	23.1	**13**	**12.9**
	Total	**5**	**100.0**	**83**	**100.0**	**13**	**100.0**	**101**	**100.0**
Pinhal Litoral	LT	3	60.0	15	24.2	1	100.0	**19**	**27.9**
	MLT	2	40.0	38	61.3	0	0.0	**40**	**58.8**
	MT	0	0.0	8	12.9	0	0.0	**8**	**11.8**
	HT	0	0.0	0	0.0	0	0.0	**0**	**0.0**
	KS	0	0.0	1	1.6	0	0.0	**1**	**1.5**
	Total	**5**	**100.0**	**62**	**100.0**	**1**	**100.0**	**68**	**100.0**
Total	**LT**	**6**	**21.4**	**82**	**25.9**	**15**	**28.8**	**103**	**25.9**
	MLT	**8**	**28.6**	**97**	**30.6**	**8**	**15.4**	**113**	**28.5**
	MT	**3**	**10.7**	**58**	**18.3**	**9**	**17.3**	**70**	**17.6**
	HT	**2**	**7.1**	**21**	**6.6**	**8**	**15.4**	**31**	**7.8**
	KS	**9**	**32.1**	**59**	**18.6**	**12**	**23.1**	**80**	**20.2**
	Total	**28**	**100.0**	**317**	**100.0**	**52**	**100.0**	**397**	**100.0**

Table A2 – Descriptive Statistics

	N	*%*	*Min.*	*Max.*	*S.D.*	*Mean*
Network channels	397		0	38	5.896	23.38
Formal network channels	397		0	20	3.584	11.37
Informal network channels	397		0	34	3.808	12.01
Network intensity	397		0.200	0,640	0.071	0.419
Formal network intensity	397		0.200	0.650	0.075	0.412
Informal network intensity	397		0.200	0.730	0.080	0.427
Product innovation	**397**					
• No	91	22.92				
• Yes	306	77.08				
Process innovation	**397**					
• No	232	58.44				
• Yes	165	41.56				
Innovation Intensity (output)	**397**					
• Zero type of innovation	3	0.76				
• One type of innovation	70	17.63				
• Two types of innovation	147	37.03				
• Three types of innovation	155	39.04				
• Four types of innovation	22	5.54				
Level turnover 07-08	**397**					
• 05-10	104	26,20				
• 11-15	66	16.60				
• 16-20	58	14.60				
• 21-30	64	16.01				
• 30-50	45	11.30				
• >50	60	15.10				
Context of cooperation	**397**					
• In-house	170	42.82				
• Cooperation	227	57.18				

Table A3 – Variables and business survey questions

Variables used	***Business survey questions***	
Network Channels	we listed five market (suppliers, customers, consulting services, labour market and competitors), six institutional (universities, polytechnics, research laboratories, regional innovation centres, professional associations and public institutes) and one personal (personal relations) channels of interaction and ask the importance given to each one (Likert 1-5)	
Learning and interaction mechanisms	Formal	we listed the 12 channels and ask the firms the importance given to formal and informal mechanisms of interaction with each one (Likert 1-5)
	Informal	
Innovation Product	Binary (0-no; 1-yes)	if firms have brought to market product innovations in the last five years
Innovation Process	Binary (0-no; 1-yes)	if firms have brought to market process innovations in the last five years
Innovation Contexts	Binary (0-in-house; 1-cooperation)	Which context was mostly used to developed their innovation activities
Innovation Intensity	Zero type of innovation One type of innovation Two types of innovation Three types of innovation Four types of innovation	if firms have brought to market each one of these types of innovations in the last five years: product, process, organizational or patents
Growth of Turnover	Growth of Turnover between 2007 and 2008 (information obtained directly though COFACE)	

Table 1 – Channels of interaction: typology and nature

Typology	Nature
Suppliers	Market
Customers	Market
Consulting Services	Market
Labour Market	Market
Competitors	Market
Universities	Institutional
Polytechnics	Institutional
Research Laboratories	Institutional
Regional Innovation Center	Institutional
Professionals Associations	Institutional
Public Institutes	Institutional
Personal Relations	Personal

Table 2 – Networking channels, Network intensity and control variables

		Level of technological intensity					*NUT III region*			*Firm size*		
	TOTAL	**LT**	**MLT**	**MHT**	**HT**	**KS**	**GL/PS**	**GP**	**PL**	**Micro**	**SME**	**Large**
Networking channels (mean)	**23.38**	**22.67**	**23.83**	**22.76**	**23.91**	**23.98**	**23.50**	**22.55**	**24.18**	**24.18**	**23.48**	**22.31**
Formal Networking channels (mean)	11.37	10.95	11.44	11.47	11.94	11.49	11.51	10.87	11.62	12.04	11.41	10.73
Informal Networking channels (mean)	12.01	11.72	12.39	11.29	11.97	12.49	11.99	11.68	12.56	12.14	12.07	11.58
Networking channels (%)	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Formal Networking channels **(%)**	48.6%	48.3%	48.0%	50.4%	49.9%	47.9%	49.0%	48.2%	48.1%	49.8%	48.6%	48.1%
Informal Networking channels **(%)**	51.4%	51.7%	52.0%	49.6%	50.1%	52.1%	51.0%	51.8%	51.9%	50.2%	51.4%	51.9%
Networking intensity	**0.420**	**0.404**	**0.425**	**0.416**	**0.433**	**0.432**	**0.421**	**0.419**	**0.419**	**0.502**	**0.416**	**0.402**
Formal Networking intensity	0.413	0.396	0.414	0.415	0.431	0.423	0.414	0.413	0.409	0.497	0.408	0.393
Informal Networking intensity	0.428	0.412	0.436	0.417	0.437	0.441	0.427	0.426	0.431	0.505	0.423	0.412

Table 3 – Most important network channels used by firms (top five)

Total	Formal	Informal
Competitors	Customers	Labour Market
Customers	Suppliers	Competitors
Labour Market	Competitors	Consulting Services
Suppliers	Public Institutions	Research Laboratories
Consulting Services	Labour Market	Polytechnics

Table 4 – Dependent and independent variables

	Dependent variable	***Independent variable(s)***
Model A	**Network intensity**	**Total network channels** **Formal network channels** **Informal network channels**
Model B	**Product innovations** 0 – No 1 – Yes **Process innovations** 0 – No 1 – Yes	**Total Network Intensity** **Formal Network Intensity** **Informal network Intensity**
Model C	**Innovation Intensity** 0 – Zero type of innovation 1 – One type of innovation 2 – Two types of innovation 3 – Three types of innovation 4 – Four types of innovation	**Total Network Intensity** **Formal Network Intensity** **Informal network Intensity**
Model D	**Growth of Turnover** 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 **Network Intensity** **Innovation contexts** 0 – In-house 1 – Cooperation

Table 5 – Model A: estimation Results[4]

Dependent Variable	*Coefficients – Odds ratio*				*Discrete Change*	
Network Intensity	mu	ln_phi	mu	ln_phi	***Min to Max***	***Min to Max***
Network channels	1.038*** (0)				32.5	
Formal Network channels			1.037*** (0)			17.3
Informal Network channels			1.040*** (0)			31.7
Low Technology – reference						
Medium-Low Technology	1.050** (0.0427)		1.050** (0.0436)		1.1	1.1
Medium-High Technology	1.053* (0.0522)		1.055** (0.0477)		1.2	1.3
High-Technology	1.087** (0.0221)		1.088** (0.0210)		2.0	2.0
Knowledge Services	1.058** (0.0365)		1.057** (0.0380)		1.3	1.3
Greater Lisbon and SP – reference						
Greater Porto	1.052** (0.0172)		1.052** (0.0184)		1.2	1.2
Pinhal Litoral	0.979 (0.409)		0.978 (0.398)		-0.5	-0.5
Micro – reference						
SME	0.725*** (0)		0.725*** (0)		-7.9	-7.9
Large	0.714*** (0)		0.713*** (0)		-7.9	-8.0
Constant	0.384*** (0)	139.7*** (0)	0.385*** (0)	139.8*** (0)	*minimum of * p<0.1*	
Observations	*397*		*397*			
Wald chi2(10)	*738.76*		*739.91*			
Prob>chi2	*0.000*		*0.000*			
Log Likelihood	*-702.10*		*-702.31*			

*Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1*

[4] The results were obtain with Stata 10.1

Table 6 – Model B: estimation results

	Coefficients – Odds ratios				*Marginal effects(Df/dx)*			
Dependent Variable	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Innovation Output	Product	Process	Product	Process				
Network Intensity	1,360***	11,013***			1.17	9.30		
	(2.43e-05)	(2.62e-05)						
Formal Network Intensity			47.18*	40.40*			0.62	0.89
			(0.0676)	(0.0865)				
Informal Network Intensity			34.80*	269.0***			0.57	1.35
			(0.0617)	(0.00777)				
Low Technology – reference								
Medium-Low Technology	1.348	2.485***	1.352	2.489***		0.91		0.22
	(0.368)	(0.00341)	(0.365)	(0.00330)				
Medium-High Technology	2.792**	1.691	2.798**	1.720	0.13		0.13	
	(0.0181)	(0.163)	(0.0188)	(0.151)				
High-Technology	1.270	3.083**	1.252	3.071**		0.27		0.27
	(0.639)	(0.0128)	(0.658)	(0.0132)				
Knowledge Services	1.430	2.440**	1.424	2.431**		0.21		0.21
	(0.336)	(0.0100)	(0.342)	(0.0104)				
Greater Lisbon and SP – reference								
Greater Porto	0.700	1.087	0.697	1.079				
	(0.212)	(0.766)	(0.205)	(0.786)				
Pinhal Litoral	1.548	2.152**	1.537	2.116**		0.18		0.18
	(0.301)	(0.0192)	(0.311)	(0.0231)				
Micro – reference								
SME	0.429	0.185**	0.430	0.180**		-0.39		-0.40
	(0.291)	(0.0114)	(0.299)	(0.0111)				
Large	0.475	0.223**	0.477	0.216**		-0.29		-0.30
	(0.394)	(0.0391)	(0.404)	(0.0372)				
Constant	0.288	0.0300***	0.267	0.0306***				
	(0.230)	(0.00330)	(0.214)	(0.00350)	*minimum of * p<0.1*			
Observations	*397*	*397*	*397*	*397*				
Wald chi2(9)	*27.93*	*43.20*	*28.25*	*43.39*				
Prob>chi2	*0.00*	*0.00*	*0.00*	*0.00*				
Log Likelihood	*-198.34*	*-231.07*	*-198.10*	*-230.73*				
Pseudo R2	*0.07*	*0.14*	*0.07*	*0.14*				

*Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Table 7 – Model C: estimation results

Dependent Variable	*Coefficients – Odds ratios*		*Marginal effects(Df/dx)*			
Innovation Intensity (output)	(1)	(2)		(1)	(2)	
			Output	**Total**	**Formal**	**Informal**
Network Intensity	2,656***					
	(3.82e-05)		Zero	-0.04	-0.01	-0.02
Formal Network Intensity		22.68*	One	-1.04	-0.41	-0.63
		(0.0870)	Two	-0.90	-0.33	-0.51
Informal Network Intensity		120.7***	Three	1.79	0.64	0.98
		(0.00489)	Four	0.37	0.12	0.19
Low Technology – reference						
Medium-Low Technology	1.668**	1.672**				
	(0.0470)	(0.0495)				
Medium-High Technology	1.717*	1.751*				
	(0.0597)	(0.0556)				
High-Technology	1.470	1.470				
	(0.264)	(0.320)				
Knowledge Services	1.751*	1.742*				
	(0.0642)	(0.0606)				
Greater Lisbon and SP – reference						
Greater Porto	0.911	0.906				
	(0.682)	(0.670)				
Pinhal Litoral	1.826**	1.809**				
	(0.0372)	(0.0393)				
Micro – reference						
SME	0.538**	0.529*				
	(0.0345)	(0.0991)				
Large	0.643	0.627				
	(0.284)	(0.317)				
cut1	0.156	0.157*				
Constant	(0.125)	(0.0633)				
cut2	4.995*	5.035*				
Constant	(0.0818)	(0.0532)				
cut3	32.77***	33.10***				
Constant	(0.000237)	(3.88e-05)				
cut4	566.5***	574.7***				
Constant	(1.84e-09)	(0)				
				*minimum of * p<0.1*		
Observations	*397*	*397*				
Wald chi2(1)	*47.44*	*54.42*				
Prob>chi2	*0.00*	*0.00*				
Log Likelihood	*-464.81*	*-464.39*				
Pseudo R2	*0.05*	*0.05*				

*Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Table 8 – Model D: estimation results

Dependent Variable	*Coefficients*	*Marginal effects (Df/dx)*				
Level Turnover	*Odds ratios*	***Level***	***Prod.***	***Proc.***	***Net. Int.***	***Inn. Cont.***
Product Innovation	1.255	**05-10**		-0.08	-0.62	-0.05
	(0.313)	**11-15**		-0.02	-0.18	-0.01
Process Innovation	1.563**	**16-20**				
	(0.0336)	**21-30**		0.02	0.17	
Network Intensity	27.55**	**31-50**		0.03	0.22	0.02
	(0.0226)	**>50**		0.05	0.40	0.03
Innovation Contexts	1.367*	*marginal effects: minimum of * p<0.1*				
	(0.0877)					
Control Variables						
Technological intensity	*NO*					
Region	*NO*					
Firm Size	*NO*					
cut1						
Constant	2.315					
	(0.168)					
cut2						
Constant	5.024***					
	(0.00830)					
cut3						
Constant	9.340***					
	(0.000281)					
cut4						
Constant	19.94***					
	(1.79e-06)					
cut5						
Constant	41.43***					
	(3.40e-09)					
Observations	*397*					
Wald chi2(4)	*23.96*					
Prob>chi2	*0.00*					
Log Likelihood	*-684.80*					
Pseudo R2	*0.01*					

*Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1;*

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