Cooperation-based innovators and peripheral cooperators: An empirical analysis of their characteristics and behaviour

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Abstract

There are many controversies in the literature over the influence of different firm characteristics on the importance to the firm of cooperation for innovation. Empirical studies have focused on the fact of cooperation but have not measured its importance for the firm. The purpose of this work is to go a step further by investigating the characteristics and cooperative behaviour of firms that use cooperation as the main way to achieve innovation (cooperation-based innovators). We draw on the 2004 Spanish Innovation Survey and employ a two-step Heckman model. Our main results show that there are sharp differences among firms. More precisely, we find that smaller firms and firms outside the high-tech sectors are more likely to be cooperation-based innovators. We also find that the type of cooperative behaviour influences. Cooperation with providers, with a few agents and with national partners are strong features of cooperation-based innovators. We discuss some management and policy implications of our results.

Keywords: cooperation, innovation, behaviour, strategic decisions, size, R&D, sectoral differences, technology policy.

JEL: O30, O32

1. Introduction

In this paper we analyse what characterizes firms that use cooperation as their main way to innovate. Studies have verified empirically the growing importance of cooperation for innovation (Hagedoorn, 2002; Howells et al., 2003), which has attracted the attention of both

academics and policy makers. From a theoretical point of view, several strands in the economic, management and geography literature have analysed the rationality, implementation and consequences of firms` cooperation for innovation, with other entities. Public support for innovation increasingly has focused on fostering collective efforts, rather than providing direct financial assistance (Bozeman, 2000; Bougrain and Haudeville, 2003).

Empirical work based on large samples of firms (rather than the more usual firm case studies) is not very abundant, has produced sometimes contradictory results and has mainly focused on the determinants of cooperation and less attention has been paid to what determines its impact. Some authors who have tried to analyse the determinants of cooperation point to the shortcomings of their studies; due to lack of data they are able only to measure the existence of cooperation rather than the resources devoted to it, and are not able to assess its impact on or importance to the firm (Tether, 2002; Becker and Dietz, 2004; Belderbos et al., 2004a). These areas should be tackled by future studies. At the same time, there are studies that analyse the impact of cooperation which have examined econometrically the influence of cooperation on some measures of output, such as sales of new products (e.g., Miotti and Sachwald, 2003; Negassi, 2004; Belderbos et al., 2004b) or increases in added value per worker (Belderbos et al., 2004b), but say nothing about the type of firms for which cooperation is more important, despite this being very relevant for both managers and policy makers (Stuart, 2000).

We tackle this issue empirically by analysing the distinct characteristics and cooperative behaviour of firms that use cooperation as the main way to achieve innovations (cooperation-based innovators) and firms that, although they do cooperate, innovate mainly through their internal efforts (peripheral co-operators). It is important to know more about both types of firms for several reasons.

First, although the academic literature on cooperation and networking is quite vast, the issue of firms innovating through cooperation has been tackled from a theoretical perspective or, in some cases, through selected case studies (Ham and Mowery, 1998; West et al., 2006), some more generalized empirical evidence could bring new insights to existing debates.

Second, firms' managers want to learn from others` experience. Knowing more about the features of the firms that innovate mainly through cooperation, should help them in their decisions about whether to cooperate or not and the effort that should be devoted to collaboration.

Third, policy-makers are increasingly formulating innovation policy initiatives directed to supporting cooperation among different organizations. If these initiatives are to be better targeted, they would benefit from more knowledge about the features of those firms who innovate mainly through cooperation.

The paper is organized as follows. In Section 2 we reprise the existing evidence . Section 3 describes the sample and the variables used and presents some descriptive results. Section 4 describes the model specification as well as its main results. Finally, we discuss the results and identify some implications and conclusions.

2. An overview of the research on cooperation for innovation

First, we summarize the arguments proposed in previous work to understand the relationships among the influences provided by the different characteristics of firms, and the importance of cooperation. We highlight the results from previous empirical studies that use similar surveys (Community Innovation Survey-type) surveys to the one in the present analysis.

2.1. Understanding the relationships among characteristics of firms and the importance of cooperation

This section briefly revisits the arguments proposed in previous analyses alongside current debates on the relationship among the characteristics of firms, and the importance of cooperation. A thorough review of the literature shows that several characteristics are considered to be important including: size, internal R&D efforts, sector, export behaviour, degree of novelty of the innovations pursued, obstacles to innovation, spillovers and type of cooperation partner.

2.1.1. Size and the importance of cooperation

Cooperation can positively affect the innovation results of both big and small firms (Pittaway et al., 2004), although the relationship between size and cooperation is very complex (Johnson et al., 2007). However, some there is some controversy over which types of firms would profit more from cooperation for innovation.

On the one hand, many authors have argued that cooperation is more relevant for big firms because they are better situated to exploit its benefits (Veugelers, 1998) due to their greater resources and complementary capacities which ease both the search for partners and the management of collaboration agreements. Some examples of the resources owned by such firms are information services, libraries, large pools of qualified people and specialist staff, etc. (Rothwell and Dodgson, 1991; Tether, 2002).

On the other hand, there is also an argument based on the "need effect" that applies to small firms, which is that due to their shortage of internal resources small firms have a greater need to collaborate with other entities to develop innovation activities, and to cope with certain projects (Bayona et al., 2001; Tether, 2002). In addition, small and medium sized enterprises (SMEs) are more affected by the uncertainty of innovation projects because the failure of a project could compromise the future of the entire firm; thus, they prefer to share this uncertainty. These arguments have led some authors to conclude that cooperation is more important for small firms (Freel, 2000).

2.1.2. R&D and the importance of cooperation

The traditional view of the relationship between research and development (R&D) and cooperation is based on Cohen and Levinthal’s (1989; 1990) absorptive capacity theory, which holds that the benefit a firm can obtain from cooperating is highly dependent on the firm’s existing knowledge. Accordingly, firms with higher internal R&D activity will find cooperation with other agents more relevant than firms with low internal R&D capabilities.

However, some authors have argued that from the perspective of the literature on resources and capabilities, it would be logical to think that those firms with good R&D capacity would not need to cooperate in order to innovate (Bayona et al., 2001). Along the same lines, Pittaway et al. (2004) argue that firms with high levels of technical competence do not see the value of networks for innovation. And relatedly, Abramovski et al. (2008) argue that firms with high R&D effort can benefit from free knowledge (because of their higher levels of absorptive capacity), which might mean that the incentives to cooperate will be lower.

2.1.3. Sectoral importance of cooperation

Cooperation is thought to be particularly important in those sectors described as 'high-tech' (Tödtling et al., 2006), because the innovation processes in these sectors will be highly complex. Thus, firms in the high tech sectors are likely not to encompass all the capacities needed to develop their innovations (Narula and Hagedoorn, 1999) and will need to cooperate, especially to enable them to follow several lines of research simultaneously (Bayona et al., 2001).

However, some authors (Tether, 2002) maintain that when other factors are taken into account, it is not entirely clear that cooperation is more important for innovation for firms performing in these high tech sectors, and some researchers (Pittaway et al., 2004; Chesbrough and Crowther, 2006) have suggested that perhaps this view has been influenced by the bias in cooperation studies towards high-tech sectors.

2.1.4. Export and the importance of cooperation

Cooperation has been considered important for exporting firms: it is believed that their knowledge and resources requirements will likely exceed what are available in house, which motivates them to turn to cooperation (Johnson et al., 2007). In addition, for exporting firms, cooperation is seen as a way to access new markets (Hagedoorn, 1993), which brings greater prestige, which, in turn, makes them more attractive innovation partners (Tether and Tajar,

2008). On the other hand, these firms are likely to find it more difficult to maintain a close surveillance of even relatively proximate sources of knowledge (Tether and Tajar, 2008).

2.1.5. Radicalness and the importance of cooperation

Firms pursuing radical (new to the market) innovations are likely to require greater inputs and/or greater novelty of inputs, which will usually involve greater technical and market uncertainty, making cooperation more important because it helps to spread the risks (Robertson and Gatignon, 1998; Tether, 2002).

On the other hand, radical innovations necessitate highly specific activities, so that, from a transaction costs perspective, internal development will be preferred (Williamson, 1991). In addition, the costs of opportunistic behaviour from a partner will be higher when the innovations are radical; thus, firms might prefer to keep them secret by opting for internal development (Veugelers and Cassiman, 1999; Gooroochurn and Hanley, 2007)

2.1.6. Obstacles to innovation and the importance of cooperation

Previous analyses have argued that firms encountering obstacles to their ability to innovate related to the high costs and uncertainty involved in the innovation process, see cooperation as a way to overcome these problems, making collaboration more important for them.(Porter and Fuller, 1986; Hagedoorn, 1993).

Along the same lines, it has also been argued that firms that perceive lack of information as an obstacle to their innovation activity will be drawn to cooperate to resolve this problem (Hamel, 1991; Teece, 1992; Sakakibara, 1997; Bayona et al., 2001).

On the other hand, it could be argued first, that the obstacles that hamper innovation might also be obstacles to cooperation, and second, that cooperation reveals the existence of other barriers to innovation that would otherwise were not discernible (D`Este et al., 2008)

2.1.7. Spillovers and the importance of cooperation

Spillovers play a dual role in cooperation relations (Belderbos et al., 2004a). On the one hand, firms that place a high value on incoming spillovers might exhibit greater scope for learning so

that the higher the spillovers, the greater will be the marginal benefit of cooperation (Abramovsky et al., 2008; López, 2008). On the other hand, there is a risk that the cooperation partners will appropriate some of the firm's internal knowledge. Thus, fears over these kinds of spillovers could jeopardize potential cooperation (Cassiman and Veugelers, 2002; Belderbos et al., 2004a).

2.1.8. Cooperative behaviour and the importance of cooperation

When analysing the importance of cooperation for innovation it is important to take account of with whom a firm cooperates, with how many different agents, and their locations.

2.1.8.1. Types of partner

Previous analysis has highlighted the importance of cooperation with each type of partner, according to the specific circumstances and characteristics of firms.

Cooperating with other firms in a group could be very important because the division of labour could be coordinated by the group as a whole. Also, concerns related to property rights can be resolved through a hierarchy that forces the different parts of a group to share knowledge (the network based view) (Zander, 2002).

Cooperating with providers is especially important when development of process innovations is involved. This type of cooperation has been shown to be very essential to reduce the risks of the innovative process, for example by reducing quality problems, and to exploit the benefits from knowledge complementarities (Ragatz et al., 1997; Miotti and Sachwald, 2003; Belderbos et al., 2004a). Also, some authors have highlighted its relevance for product innovation (Sako, 1994)

Cooperating with customers traditionally has been seen as a way to reduce market uncertainty when developing product innovations, because clients help to define the characteristics required of the novel product, provide feedback and enable an acceptable price/performance compromise (von Hippel, 1988; Freel, 2000). In addition, Ragatz et al. (1997) show that customers are the most important partners for incremental innovation.

Cooperation with competitors has received considerable attention from theoretical authors, who see it as a way to reduce the costs of the innovation process (Katz, 1986; D'Aspremont and Jacquemin, 1988), although other reasons, such as the reduction of uncertainty through standards setting or strategic vigilance over rival technology, have also been highlighted (Tether, 2002; Narula, 2001). Cooperation with competitors could be potentially dangerous if 'outgoing' spillovers are high (Cassiman and Veugelers, 2002).

Cooperation with research institutions has developed considerably over recent decades and focuses mainly on access to knowledge not available in the firm, but which is required to carry out in-house projects (Bozeman, 1997; Cohen et al., 1998). It has been argued that cooperation with research institutes is not aimed specifically at developing new products or processes, and that many different channels of cooperation exist (Cohen et al., 2002), both of which are reasons for the inconsistence observed in terms of relationships with universities and the product and process innovativeness of firms (Perkmann and Walsh, 2007).

2.1.8.2. Cooperation with different agents

In addition to the types of partner with whom a firm cooperates, it has been highlighted that the cooperation with a variety of agents is helpful for innovation (Amara and Landry, 2005, Nieto and Santamaría, 2007) because it extends the firms sources of information and enables new combinations of knowledge and technologies (Nelson and Winter, 1982). On the other hand, there can be problems related to 'over-searching' (Katila and Ahuja, 2002; Laursen and Salter, 2006): it can be difficult to manage and choose between too many ideas at the same time, with the result that potentially fruitful ones may be overlooked (Koput, 1997).

2.1.8.3. The localization of partners

It might be assumed that firms would benefit more from collaboration with agents located close by because this would facilitate the transfer of tacit knowledge through frequent face to face contact. Also, if partners are located nearby, there will be time and cost savings (Goe et al., 2000; Oughton et al., 2002) and the coordination of tasks will be easer (Carrinczeaux et al.,

2001). However, it has also been highlighted that the impact of geographical closeness can be indirect and subtle, and related to other forms of proximity (Howells, 2002; Boschma, 2005).

On the other hand, it might also be assumed that those firms that interact with international partners have been more selective and more targeted in their choice of a partner (Archibugi and Iammarino, 1999) and that they have deliberately sought crucial complementary R&D resources (Miotti and Sachwald, 2003), which makes these links vitally important.

2.2. Previous empirical evidence

In this subsection we revisit the results from previous empirical works analysing the relationships among the characteristics of firms and their cooperation behaviour, using data from CIS-type surveys.[1] The main advantage of restricting our review within these parameters is that they use similar sets of indicators and large samples of firms, thus allowing for detailed comparison of the results and for a broader view of the phenomenon of cooperation for innovation than would be possible if we included studies whose focus was on analysing very specific situations to better understand the mechanisms and effects of cooperation under different specific circumstances or groups of firms.

The studies fall into two groups. The first one focuses on the determinants of cooperation, and analyses both the determinants of the existence of any type of cooperation and those leading to the existence of cooperation with a specific type of agent (customers, providers, competitors, research organizations). To our knowledge, only Fritsch and Lukas (2001), Becker and Dietz (2004) and Negassi (2004) analyse other measures of cooperation, such as number of relationships and cooperation budget. The second includes studies aimed at analysing the effects of cooperation using variables for firms' outputs, such as the percentage of sales from innovative products (Klomp and van Leeuwen, 2001; van Leeuwen, 2002; Janz et al., 2003; Miotti and Sachwald, 2003; Caloghirou et al., 2004), total sales from innovative products

[1] Although some were not official surveys, the questionnaires used questions similar to those in the CIS.

(Negassi, 2004), increase in (Belderbos et al., 2004b) or degree of novelty of the most relevant innovative output (Monjon and Waelbroeck, 2003; Amara and Landry, 2005). However, it is important to note that these studies analyse the impact of cooperation on output; they do not say anything about which firm characteristics lead to higher impacts from cooperation, which is the main purpose of the current work. We thus focus on the first group of studies in order to highlight what the still developing empirical evidence tells us about the determinants of cooperation.

As can be seen from Table 1, previous empirical evidence suggests that the results obtained from these studies are, to a great extent, dependent on the estimation method, the definition of variables, and the countries involved. Firm size and R&D are generally found to positively affect the likelihood of cooperation, but some studies show a non-significant (Kleinknecht and Rejinen, 1992; Abramovsky et al., 2008) or, even, a negative relationship.[2] Also, the importance ascribed to cost and risk as obstacles to innovation is usually positively associated with the likelihood of cooperation, although some studies find no evidence of such a relationship (Tether, 2002; Miotti and Sachwald, 2003; Arranz and Fernández de Arroyabe, 2008). The evidence is more contradictory concerning the obstacles related to information, with some studies reporting a positive relationship (Bayona et al., 2001; Cassiman and Veugelers, 2002; Becker and Dietz, 2004), and some a negative one (Becker and Dietz, 2004). The influence of spillovers is usually found to be positive, although some studies find no relationship between spillovers and cooperation (Negassi, 2004) and some results depend on the indicators used (Kaiser, 2004). The evidence concerning the relationship between the sector's technological level and cooperation, is very mixed. And this also applies to the results of studies analysing the relationship between exporting and cooperation.

(Insert Table 1 about here)

[2] In the French case, only R&D, and only after instrumenting the variable (Abramovsky et al., 2008).

The aim of this study is to contribute to work on the relationship between firms' characteristics and cooperative behaviour by analysing both their influence on the existence of cooperation and the importance to the firm of cooperation for new products and processes. Thus, we try to distinguish the characteristics of cooperation-based innovators and peripheral co-operators.

3. Methodology

3.1. Description of the database

The dataset used in this paper contains firm level data from the Spanish Technological Innovation Panel (PITEC) for 2004. This database is provided by the Spanish Institute of Statistics (INE) with the aim of improving the statistical information available on firms' innovation activities, and the conditions for scientific research on this topic. The data come from a CIS-type survey, based on the OECD's Oslo Manual.[3]

Although data are available from 2003, we use only 2004 data because it includes some questions very relevant to cooperation, which were not included in the 2003 survey. In addition, we restrict our analysis to cooperating firms that have internal R&D activities and belong to the manufacturing sectors.[4] This allows us to have a more homogeneous sample and to include in the analysis variables related to the characteristics of in-house R&D.

The total number of cooperating firms in the period 2002-2004 (the period referred to in the 2004 survey) is 1624, 1534 of which achieved at least one product or process innovation in the period. 49.9% of them innovated mainly through cooperation in products or processes, 47.7%

[3] More details about how the database has been built can be found in http://sise.fecyt.es/Estudios/PITEC.asp

[4] Abramovsky et al. (2008) point out that cooperation patterns differ between manufacturing and services so that separate analyses are required. In addition, our database is focused on R&D performing firms, so that the service sector would probably be underrepresented.

innovated mainly through their own efforts, and the 2.2% innovated mainly through the efforts of other enterprises or institutions[5].

(Insert Table 2 about here)

3.2. Definition of variables

3.2.1. The dependent variables

We use three dependent variables: COOPBASED_PROD which is a dummy variable that is equal to 1 if the new products of the firm were "mainly obtained by the enterprise together with other enterprises and institutions" and zero if these products were "mainly by the enterprise or the enterprise group"; COOPBASED_PROC, which refers to process innovation; and COOPBASED_INN, which refers to innovation based on cooperation, and is equal to 1 if either COOPBASED_PROD or COOPBASED_PROC are equal to 1, and zero if both of them are zero.

3.2.2. The independent variables

We use two types of independent variables: those related to the characteristics of the firm and its innovation processes, and those related to its cooperative behaviour (see Table 3).

The variables representing the characteristics of the firm are the most common in the literature and represent the dimensions analysed in the theoretical framework: size, internal R&D efforts, sector, export behaviour, degree of novelty of the innovations pursued, obstacles to innovation, and spillovers.

[5] In the regression analysis we performed multinomial logits in the second step, but no variables were found to be of relevance. Also, we added these firms to the cooperation-based innovators and the results did not change. We decided therefore to eliminate them as the independence of irrelevant alternatives shows that results do not change.

We analyse three different characteristics of firms' cooperative behaviour: type of partner with which they cooperate, number of different types of partners with which they cooperate, and geographical scope of the cooperation.

(Insert Table 3 about here)

3.4. Empirical strategy

We investigated which characteristics of firms and cooperative behaviours were associated with exploitation of cooperation as the main way to obtain innovation (in contrast to firms that, although cooperating, mainly achieved their innovations through their own efforts). We perform three analyses. The first (Model A) investigates the characteristics of firms that are cooperation-based innovators in products or processes, the second (Model B) analyses the achievement of new products, and the third (Model C) analyses the achievement of new processes. Each of these models is composed of three different equations: The first includes the different types of partners with which firms cooperate, the second includes the number of different partners with which firms cooperate and the third includes the geographical scope of cooperation.

As we can only observe whether firms are cooperation-based innovators if firms have cooperated, a selection problem exists.

Thus, we observe two dummy variables: C, indicating if the firm cooperates, and I, indicating if the firm is a cooperation-based innovator. C_i^* is a latent variable representing the likelihood of cooperation, which depends on the exogenous variables (x_i) and an error term (ε_i). I_i^* is a latent variable representing the likelihood of a firm being a cooperation-based innovator, explained by a set of exogenous variables (z_i) and an error term (u_i). We have to estimate the parameters β and γ in the following model:

$C_i^* = x_i\beta + \varepsilon_i$, $\varepsilon_i \sim N(0,1)$
$C = 1$ *if* $C_i^* > 0$ *(selection)*
$C = 0$ *if* $C_i^* \leq 0$ *(non-selection)*
$I_i^* = z_i\gamma + u_i$, $u_i \sim N(0,1)$
I is a missing value if $C = 0$.

We use the Heckman two-step procedure to estimate the model. This procedure is based on computing the inverse-Mill ratio from the first equation (see Heckman, 1976) and using it as an additional regressor in the second step[6].

4. Results

All innovators

First, we find that the results for the determinants of cooperation (selection equation) agree with the most frequent results from previous studies. Size and internal R&D strongly and positively influence the firm's decision about whether or not to cooperate. Export intensity and the radicalness of new products are also positively associated with the likelihood of cooperation, as in Cassiman and Veugelers (2002) and Tether (2002), respectively. We also introduce a variable representing the weight of development over total R&D tasks. We find their influence to be significantly positive. Cost-risk obstacles to cooperation do not have much influence, as pointed out by, for example, Miotti and Sachwald (2003), while information obstacles positively affect cooperation (Bayona et al., 2001). Also, spillovers have a positive influence, as found by Cassiman and Veugelers (2002), López (2008) and Abramovsky et al. (2008).

These results show that the cooperative behaviour in the sample analysed is consistent with previous empirical evidence on the likelihood of cooperation. These results add to our understanding about which firms engage in cooperative arrangements but we would argue that they do not contribute to identifying those firms for which cooperation in innovation is more important. We thus investigated the sample of cooperating firms to analyse the differences

[6] We also performed a two part model, estimating separately both stages. Results were quite similar (and, accordingly, inverse Mills ratio was not found very significant). However, we have preferred to provide the results of the Heckman model, being those of the two part model available upon request to the author.

between cooperative firms that innovate mainly through cooperation, and cooperative firms that innovate mainly through their own efforts. This is the second step in our analysis.

The results from this second step show that smaller firms, firms with lower R&D intensity and firms in low, medium-low and, even medium-high sectors are more likely to be cooperation-based innovators. While exporting seems to slightly positively affect this likelihood, neither the radicalness of the new product nor the firm's R&D orientation, or the obstacles to innovation and spillover effects, influence the probability of being a cooperation-based innovator.

Concerning cooperative behaviour, firms involved in intragroup cooperation are less frequently cooperation-based innovators. This result can be explained by the fact that in the dependent variable innovation obtained through group efforts is computed as innovation obtained through the firm's own efforts. In addition, we find that cooperation with clients is negatively associated with cooperation-based innovators, while cooperation with providers is positively associated. It seems that collaboration with clients is for very detailed, non-core purposes, while cooperation with providers is crucial to develop innovations. On the other hand, cooperation with a variety of agents is behaviour that applies to peripheral cooperators as does cooperation with international agents.

(Insert Table 4 about here)

Product innovation

The results in Table 5 provide some evidence of the features of firms that use cooperation as their main strategy to obtain new products. Cooperation-based product innovators are also the smaller of the two groups of cooperators and are more frequently found in the low and medium low tech sectors, although the influence of these variables is not high. Also, the variable RD_INT (in-house R&D) is not significant. On the other hand, the influence of export activity is higher and positive and cost-related obstacles also positively affect the likelihood of being a cooperation-based innovator. The radicalness of products, the orientation of R&D, information-related obstacles and spillovers are also not significant.

In terms of cooperation behaviour, the results hold for intragroup cooperation and cooperation with customers while cooperation with providers and a number of different agents do not show significant effects. Finally, cooperation with international agents is associated with peripheral cooperators.

(Insert Table 5 about here)

Process innovation

The results in Table 6 show that the characteristics of firms are not significant in explaining the importance of cooperation for innovation. The only robust result is that firms in low-tech and medium-low sector are more frequently cooperation-based process innovators. However, the influence of the cooperative behaviour is still very high. Intragroup cooperation, cooperation with customers, cooperation with many different agents and with international partners are all associated with the probability of being a peripheral cooperator.

(Insert Table 6 about here)

5. Discussion, implications and conclusions

The analysis in this paper sheds light on the arguments developed in the Section 2 of the article. Need-effect stands out among firms` characteristics. Firms outside the high-tech sectors, smaller firms and, to some extent, firms with low R&D intensity are more frequently found to be cooperation-based innovators.

Other characteristics of firms, such as export intensity and the significance of cost barriers, explain the importance of cooperation only in terms of product innovation. The first result can be interpreted as that more outward-looking firms turn to cooperation to innovate. The second result supports the view that financial restrictions are a crucial motivation to engage in partnerships.

The type of cooperation behaviour influences the importance of collaboration for the firm. There is some evidence that cooperation with providers is associated with cooperation-based innovators while cooperation with customer is usually associated with peripheral cooperators.

However, two additional interesting results emerge from our analysis. First, firms with many different partners are more likely to be peripheral cooperators. This result points to the existence of a trade-off between breadth and depth of cooperation (Laursen and Salter, 2006). Peripheral cooperators follow a ´breadth strategy` while cooperation-based innovators decide to focus on fewer and deeper relationships. Second, cooperation-based innovators are less likely to have international links. This result points to the importance of geographical proximity to establish key partnerships. Saving in costs and time and other types of benefits accrue if partners are geographically close (Howells, 2002; Boschma, 2005)

These results could be interpreted in terms of the emergence and consolidation of markets for knowledge (Arora et al., 2001), which have facilitated forging of relationships, usually for low value-added activities (Howells et al., 2003), allowing firms to focus on their core competences (Archibugi et al., 1999). The firms that seem to rely most on such arrangements are large firms and firms the high tech sectors. They usually have many different links including international partnerships. They are precisely the types of firms that have been the focus of most case studies (West et al., 2006), which has led some authors to conclude that cooperation is more important for these types of firms. Our results clearly refute this. Such firms may cooperate more frequently (although there is some disagreement about this if other characteristics are controlled for), but the importance of this cooperation for innovation is not as high.

It might be that collaboration activity in these large, high tech firms is not aimed at obtaining new products or process, but is used to explore new opportunities, promote awareness and learn from others' experience (Hamel, 1991; Sakakibara, 1997; Pittaway et al., 2004). We have tried to control for this influence by incorporating a variable for the type of R&D performed (research or development). Firms more oriented to research are likely to cooperate to explore or learn and not directly to innovate (Belderbos et al., 2004a). However, this variable was clearly non-significant. Of course, it is possible that this effect has not been fully controlled for, so that the interpretation cannot be ruled out. More empirical and detailed studies are needed.

One quite robust result relates to the existence of barriers to signing cooperation agreements in those firms that are cooperation-based innovators. That is, firms with lower internal capabilities, as reflected by their lower size, their belonging to non-high tech sector and, their lower R&D intensity.[7] From this point of view, in an era when innovation policy is mostly directed towards cooperation, some interesting implications emerge. First, policy should not overlook firms with high barriers to cooperation but also high potential benefits from cooperative activity and, second, initiatives should be implemented aimed specifically at firms that have not so far engaged in cooperation agreements - one of the main problems of policies that try to foster cooperation are that they usually benefit firms that have already engaged in this activity and are mainly big firms in the high tech sectors. (Vence, 1998; Heijs, 2002; 2005).

The design of these specific measures is beyond the scope of this paper, but we can highlight some issues. The design of such measures is by no means straightforward. Some authors (Smallbone et al., 1993; Lambrecht and Pirnay, 2005) have warned that forcing firms to collaborate could be counterproductive if the partners are not well prepared. That is, encouraging firms to enter into potentially unsuccessful partnerships could worsen the situation by creating a climate of mistrust towards external collaboration. More indirect less intrusive interventions would be more effective, for instance, fostering the internal capabilities of firms and their abilities to interact might be more beneficial than the fostering cooperation per se (Vega-Jurado et al., 2008), for example, by reducing the costs involved in hiring qualified people, either technical or managerial. Also, the creation of or support for organizations with´ technoeconomic` capabilities (Rolfo and Calabrese, 2003; Barge-Gil et al., 2008) would provide an example of customized experience suitable for cooperation for innovation. These organizations can be very useful partners for firms if attention is paid to their design (Arnold et al., 1998; Barge-Gil and Modrego-Rico, 2008). Of course, more research is needed on these and related issues to be able to design more specific initiatives.

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[7] And note that, our analysis is restricted to firms performing R&D. It is likely that the barriers will be higher for non-R&D performing firms. This could be a fruitful area for future research.

The contribution of this paper has been to reveal the importance of these types of issues by clarifying the characteristics of firms that use cooperation as their main way to innovate (cooperation-based innovators) compared with those that use cooperation for non-core activities (peripheral cooperators).

Some limitations to our study should be highlighted. First, it is likely that many firms are cooperation-based innovators in some projects and peripheral cooperators in others, thus using a mix of both strategies. Unfortunately, we have only a measure for the entire firm. Second, the characteristics of specific relationships may influence their importance to the firm. However, these are not available.[8] Third, other, more objective, measures of the impacts of collaboration could be used to complement the results. Fourth, the study applies only to Spanish firms. Although we have no reason to believe that nationality would bias the results in a predictable direction, only by extending this research to other countries could the findings be generalized.

These limitations point to avenues for future research. We plan to gather more detailed data on firm collaborations and it impact. We also plan to apply this analysis to other countries' firms which should prove relatively straightforward as similar datasets (CIS) are readily available for several countries.

[8] E.g., we measure the breadth of cooperation by the number of different types of partners, while the number of partners in the same category (e.g., universities) would help to better capture the concept.

Table 1. Studies analysing the determinants of cooperation using surveys based on Oslo Manual[9]

	Dependent variable	Size	R&D	Technological level of sector	Exports	Obstacle: cost-risk	Obstacle: information	Spillovers
Kleinknecht and Rejinen (1992)	Dummy cooperation	Non significant	Positive/Non significant*		Non significant	Non significant	Non significant	
Bayona et al (2001)	Dummy cooperation	Positive	Positive	Positive		Positive	Positive	
Tether (2002)	Dummy cooperation	Positive	Positive	Non significant		Non significant	Non significant	
Cassiman and Veugelers (2002)	Dummy cooperation	Inverted U	Positive		Positive	Positive	Positive	Positive
Miotti and Sachwald (2003)	Dummy cooperation	Positive	Positive	Positive		Non significant	Non significant	
Becker and Dietz (2004)	Dummy cooperation	Positive	Positive	Negative	Negative / Non significant**	Positive	Positive / Negative**	
Kaiser (2004)	Dummy cooperation	Positive						Positive / Non significant*
López (2008)	Dummy cooperation	Inverted U	Positive			Positive		Positive
Arranz and Fdez de Arroyabe (2008)	Dummy cooperation	Positive	Positive	Positive		Non significant	Non significant	
Abramovsky et al, (2008)	Dummy cooperation	Inverted U / Non significant***	Negative / Non significant / Positive***			Positive / Non significant***		Positive / Non significant***
Becker and Dietz (2004)	Number of cooperation partners	Positive	Positive	Negative	Negative	Positive	Positive / Negative**	
Negassi (2004)	Cooperation budget	Positive	Positive					Non significant

* Depending on the indicator used.

** Depending on the estimation method

*** Depending on the country and the estimation method

[9] Studies which report the results of determinants of cooperation only with specific types of agents (and not cooperation in general) are not included.

Table 2. Number of firms using each mode of innovation

	Product and process innovators	Product innovators	Process innovators
Total number of cooperation firms that have at least one innovation	1534	1289	1263
Innovations mainly obtained by the enterprise together with other enterprises and institutions	765 (49.87%)	452 (35.1%)	572 (45.29%)
Innovations mainly obtained by the enterprise or the enterprise group	735 (47.91%)	809 (62.76%)	631(49.96%)
Innovation mainly obtained by other enterprises or institutions	34 (2.22%)	28 (2.17%)	60 (4.75%)

Table 3. Description of variables

LABEL	**DESCRIPTION**
COOPBASED_INN	Variable which takes the value 1 if new products or new processes have been mainly obtained by the enterprise together with other enterprises and institutions
COOPBASED_PROD	Variable which takes the value 1 if new products have been mainly obtained by the enterprise together with other enterprises and institutions
COOPBASED_PROC	Variable which takes the value 1 if new processes have been mainly obtained by the enterprise together with other enterprises and institutions
LSIZE	Log of number of employees
RD_INT	R&D staff/Total number of employees
EXPORT	Exports/Total sales
RADICAL	Sales of products new to the market/Total sales
DEVELOPMENT	Development of R&D expenses/Total R&D expenses
OBS_COST	Sum of the scores for the following obstacles to innovation: lack of internal funds; lack of external funds; innovation costs too high and demand uncertainty. Rescaled between 0 (not relevant) and 1 (highly relevant)
OBS_INFORMATION	Sum of the scores for the following obstacles to innovation: lack of qualified personnel; lack of information on technology; lack of information on markets; problems to find partners. Rescaled between 0 (not relevant) and 1 (highly relevant)
SPILLOVERS	Sum of the scores for the following information sources: conferences, trade fairs and exhibitions; scientific journals and trade/technical publications and professional and industry associations
LOWTECH	Variable which takes the value 1 if the firm belongs to the following sectors: food, beverages and tobacco, textile and clothing, wood products, paper and printing.
LOWMEDIUMTECH	Variable which takes the value 1 if the firm belongs to the following sectors: petroleum refinng, rubber and plastic products, non-metallic mineral products, ferrous metals, non-ferrous metals, shipbuilding and other manufacturing.
MEDIUMHIGHTECH	Variable which takes the value 1 if the firm belongs to the following sectors: chemicals, non-electrical machinery, electrical machinery, scientific instruments, motor vehicles and other transport equipment.
COOP_GR	Variable which takes the value 1 if the firm cooperates with other firms in the same group
COOP_SUP	Variable which takes the value 1 if the firm cooperates with providers
COOP_CL	Variable which takes the value 1 if the firm cooperates with clients
COOP_COMP	Variable which takes the value 1 if the firm cooperates with competitors
COOP_RO	Variable which takes the value 1 if the firm cooperates with research organizations (including commercial laboratories/R&D enterprises, universities, public research centres and private non-profit research institutes
NCOOP	Number of different types of organizations with which the firm cooperates
COOP_ONLY_NAC	Variable which takes the value 1 if the firm cooperates with Spanish but not international organizations.
COOP_ONLY_INTERNAC	Variables which takes the value 1 if the firm cooperates with international but not Spanish organizations.

Table 4. Results of two-step Heckman regression for COOPBASED_INN (Model A)

	Model A1		**Model A2**		**Model A3**	
	Coef	Std Error	Coef	Std Error	Coef	Std Error
LSIZE	-.0612242***	.0183551	-.06901***	.0182466	-.062658***	.0181088
RD_INT	-.2322178***	.0888601	-.2550102***	.0892698	-.2528835***	.088391
LOWTECH	.1799949***	.0484574	.1947565***	.0485428	.1837895***	.0482055
LOWMEDIUMTECH	.160879***	.0474925	.1683824***	.0478474	.1555388***	.0475484
MEDIUMHIGHTECH	.0939869**	.0440471	.0914924**	.0444238	.0817035*	.0440897
EXPORT	.0508134	.0375814	.0558025	.0379549	.0655239*	.0376757
RADICAL	.0001619	.0007477	.0002231	.0007538	.0002386	.0007474
DEVELOPMENT	-.0003966	.0003919	-.0002861	.000392	-.0002454	.000389
OBS_COST	.1057736	.0872286	.0968498	.0879975	.0828234	.0872878
OBS_INFORMATION	-.1470667	.1376128	-.1162053	.1384353	-.1286261	.1374101
SPILLOVERS	-.0475629	.1183465	-.044119	.1194075	-.0618309	.1181192
COOP_GR	-.1297729***	.0332381				
COOP_SUP	.0500061*	.0291878				
COOP_CL	-.0758844**	.0307505				
COOP_COMP	.0237061	.0352062				
COOP_RO	.0092271	.0317515				
NCOOP			-.0255259**	.0128302		
COOP_ONLY_NAC					.1125827***	.03018
COOP_ONLY_INTERNAC					-.0975063	.0639232
Constant	.9064873***	.2592351	.956781	.2597754	.8300805	.2590216
Mills Ratio	-.182204*	.1078998	-.1922097*	.1084792	-.1822042*	.1075723
Number of observations	3549		3549		3549	
Number of censored observations	2242		2242		2242	
Number of uncensored observations	1307		1307		1307	
Wald test of full model: χ^2	338.63***		316.16***		334.4***	

First Step (Dependent variable: Dummy of cooperation)		
	Coef	Std Error
LSIZE	.1810296***	.0199613
RD_INT	.4836544***	.1134328
EXPORT	.2880099***	.0803662
RADICAL	.0062292***	.0011106
DEVELOPMENT	.0028618***	.0005617
OBS_COST	.0528592	.1429938
OBS_INFORMATION	1.053128***	.1982128
SPILLOVERS	1.017172***	.1550083
Constant	-2.206367**	.1078998
Sectoral Dummies	Included	

*** p-value<0.01, ** p-value<0.05, *p-value<0.1

Table 5. Results of two-step Heckman regression for COOPBASED_PROD[10] (Model B)

	Model B1		**Model B2**		**Model B3**	
	Coef	Std Error	Coef	Std Error	Coef	Std Error
LSIZE	-.0807424***	.0201928	-.0866159***	.0201129	-.0763521***	.0199072
RD_INT	-.1458617	.0901729	-.1571355*	.090477	-.1443076	.0892115
LOWTECH	.1605916***	.049622	.1683087***	.0496365	.1562073***	.0490515
LOWMEDIUMTECH	.1804442***	.0478788	.1850369***	.0481711	.1705562***	.0476481
MEDIUMHIGHTECH	.1027658**	.043722	.1002113**	.0439929	.091443**	.0434437
EXPORT	.0855411**	.0371113	.0887701**	.0374264	.0991868***	.0369114
RADICAL	.0005251	.0008373	.0005571	.0008423	.0006576	.0008312
DEVELOPMENT	-.0003187	.0003915	-.0002562	.000392	-.000199	.0003871
OBS_COST	.199543**	.0871516	.1978648**	.0877302	.188932**	.0865556
OBS_INFORMATION	-.1854796	.1416254	-.1687827	.1422365	-.1706103	.140485
SPILLOVERS	-.1918303	.1292453	-.1894559	.1302295	-.195542	.1282553
COOP_GR	-.0934914***	.033327				
COOP_SUP	.0291646	.0293551				
COOP_CL	-.0576275**	.0307739				
COOP_COMP	.0308146	.0356537				
COOP_RO	.0346662	.0322486				
NCOOP			-.0162745	.0128367		
COOP_ONLY_NAC					.1114351***	.0301744
COOP_ONLY_INTERNAC					-.1085864*	.0637509
Constant	.8252031***	.2951478	.8826343***	.2960223	.73112***	.2938938
Mills ratio	-.17812	.1166744	-.1885638	.117383	-.1674254	.1159183
Number of observations	3379		3379		3379	
Number of censored observations	2242		2242		2242	
Number of uncensored observations	1137		1137		1137	
Wald test of full model: χ^2	379.39***		364.45***		386.94***	

*** p-value<0.01, ** p-value<0.05, *p-value<0.1

[10] We do not provide here the coefficients of the selection equation. They are available from the authors on request.

Table 6. Results of two-step Heckman regression for COOPBASED_PROC (Model C)

	Model C1		**Model C2**		**Model C3**	
	Coef	Std Error	Coef	Std Error	Coef	Std Error
LSIZE	-.025948	.0194863	-.0322405*	.0192388	-.0307352	.0191368
RD_INT	-.1362254	.1025762	-.1527284	.1024838	-.1627093	.1018476
LOWTECH	.1517992***	.0535572	.1626767***	.0533907	.1571507***	.0531739
LOWMEDIUMTECH	.1002844*	.053599	.1042516*	.0538198	.0961888*	.0536452
MEDIUMHIGHTECH	.0613523	.0504654	.0546293	.0506737	.0457515	.0504727
EXPORT	.0033428	.0457715	.0078252	.0460677	.0189057	.0459971
RADICAL	-.0000715	.000797	.0000003	.000802	-.0000338	.0007984
DEVELOPMENT	.0000119	.0004405	.000081	.0004398	.0001005	.0004381
OBS_COST	-.0096775	.1009127	-.0239368	.1014571	-.0407127	.1010308
OBS_INFORMATION	-.0666088	.1514536	-.0237872	.1519026	-.0366938	.1513135
SPILLOVERS	-.093828	.1267894	-.093607	.1275856	-.1167605	.1266278
COOP_GR	-.1284721***	.0369368				
COOP_SUP	.0412473	.0327396				
COOP_CL	-.0754541**	.0346748				
COOP_COMP	.0211391	.0391247				
COOP_RO	-.0024443	.0357371				
NCOOP			-.0299422**	.0141076		
COOP_ONLY_NAC					.0877886***	.0338817
COOP_ONLY_INTERNAC					-.1105185	.0718342
Constant	.7007683***	.2678668	.7422998***	.2674489	.6485285**	.2681752
Mills ratio	-.0902923	.1017818	-.0973357	.1019293	-.0891179	.1014609
Number of observations	3287		3287		3287	
Number of censored observations	2242		2242		2242	
Number of uncensored observations	1045		1045		1045	
Wald test of full model: χ^2	292.38***		276.84***		284.95***	

*** p-value<0.01, ** p-value<0.05, *p-value<0.1