Cooperation with National and International Users and its Effects on Innovation

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Abstract

This paper analyzes the role of user proximity in the effects of firms' cooperation with users on innovation activity. The study concerns four different groups of firms: those cooperating with users in general, firms cooperating with national users, firms cooperating with international users and firms cooperating with both kinds simultaneously. A separate analysis for each sample of the effect of cooperation on different activities of technological knowledge creation and the economic returns stemming from such knowledge shows significant differences in how firms allocate their R&D expenditures to basic research, applied research and technological development, according to the proximity of the user. Regarding economic returns, firms cooperating with national users increase sales of products new to the market in comparison with firms not cooperating, but no significant differences are observable in the samples of international and simultaneous cooperation. All these effects have been observed in the short and long term.

Resumen

En este artículo se analiza el papel que juega la proximidad al usuario en los efectos de la cooperación con estos agentes sobre la actividad innovadora de la empresa. El estudio tiene en cuenta cuatro tipos de empresas: las que cooperan con usuarios en general, las que cooperan con usuarios nacionales, las que cooperan con usuarios internacionales y las que cooperan con ambos tipos de usuarios simultáneamente. Se analizan para cada muestra de empresas los efectos de la cooperación sobre diferentes actividades de creación de conocimiento tecnológico y sobre los retornos económicos generados por dicho conocimiento. Lo resultados muestran diferencias significativas en el modo en que las empresas distribuyen sus gastos de I+D entre investigación básica, investigación aplicada y desarrollo tecnológico, en función de la proximidad al usuario. En cuanto a los retornos económicos, las que cooperan con usuarios nacionales incrementan las ventas de productos nuevos para el mercado en comparación con las empresas que no cooperan, pero no se observan diferencias significativas en las muestras de cooperación internacional y simultánea. Estos efectos se han observado en el corto y largo plazo.

1. Introduction

Interest in studying cooperation with users and its impact on firms' innovation activity has grown significantly in recent years. A large body of studies based on the *open innovation* framework (Chesbrough, 2003a, b; Laursen and Salter, 2006; Lichtenthaler, 2008) and user innovation literature (Rosenberg, 1982; Neale and Corkindale, 1998; Urban and von Hippel, 1988; Lilien *et. al.* 2002) has promoted the idea that close relationships with users in innovation activities can improve firms' performance and innovativeness (Foss *et. al.* 2010).

Literature analysing the effects of cooperation with users shows that it influences both the input and output of the innovation process. In the input case, the results are not conclusive: while some studies suggest that there is a positive relationship between collaboration with users and innovation effort (Lilien *et. al.* 2002; Tether, 2002), others find a negative relationship (Herstatt and von Hippel, 1992; Thomke and Nimgade, 1998; Jeppesen, 2002, 2005; Bayona *et. al.* 2003; Henkel and von Hippel, 2004; von Hippel, 2005; Lettl *et. al.* 2006; Santamaría and Rialp, 2007a). In the output case, stress has been on the likelihood of developing different types of

innovation (Kline and Rosenberg, 1986; von Hippel, 1988; Rothwell, 1994; Miotti and Sachwald, 2003; Tether, 2003). Empirical studies conclude, on the one hand, that these agents provide valuable resources for the development of processes, as well as product innovations (von Hippel, 1976, 1977; Shaw, 1985; Urban and von Hippel, 1988; VanderWerf, 1990; Shah, 2000; Franke and Shah, 2003; Lüthje, 2004; Lüthje *et. al*. 2005) and on the other hand, that collaboration with users is very convenient for obtaining radical as well as incremental innovations (Meyers and Athaide, 1991; Veryzer, 1998; Lüthje and Herstatt, 2004; Amara and Landry, 2005; Lettl *et. al.*, 2006; Nieto and Santamaría, 2007).

In general, these studies analyse the effects of cooperation without taking into account the moderating effect that some characteristics of the user can have on innovation, such as the level of their experience in the innovation field, being an individual or an industrial user, the time users take to adopt innovations or the user's location. In this paper we take the novel step of including one of these factors, user's proximity, in the analysis, because recent studies have shown that proximity is an important variable in the analysis of innovation activity (Weterings and Boschma 2009). The basis of cooperation in general is knowledge interchange and several authors have pointed out that proximity can be seen as an important precondition for this (Gertler, 1995). It facilitates face-to-face contacts (Rosenthal and Strage, 2033; Stoper and Vanables, 2004), which are the basis for exchanging and co-creating knowledge (Lawson and Lorens, 1999). Additionally, it has been demonstrated that firms nearer to knowledge sources show a better innovative performance (Jaffe *et. al.*, 1993; Audrestsch and Feldman, 1996) and that access to knowledge sources located in diverse innovation environments is likely to influence firms' innovation performance (Frenz and Gillies 2009). With this in mind, we distinguish between national and international users.

To our knowledge, no extensive research has yet been carried out into the importance of proximity in cooperation with users. Some of the closest studies to ours are those of Weterings and Boschma (2009) and Laursen (2011), the former concerning software firms, for which they concluded that, although cooperation with users had a positive effect on performance, geographical proximity did not strengthen the effects of face-to-face relationships on innovation output. These authors also suggested that geographical proximity is now less important, as long-distance interactions are easily established by different means (e.g., the Internet). Laursen (2011), however, found support for Lundvall's idea (1988) that interaction with both national and international users on innovation seemed equally important for sales of innovative products. Interaction between users and producers is often more efficient over short geographical distances, especially if market needs are ever-changing and complex. He also concluded that firms should adopt an international perspective when the necessary knowledge is not available locally or nationally, even if it involves more difficult communication.

The present study aims to contribute to the debate on the role of proximity in the context of cooperation with users. We test the general hypothesis that proximity to the user can influence the inputs and outputs of the innovation process. For this purpose, we analyse the innovation activity of three different groups of firms: firms cooperating with national users, firms cooperating with international users and firms cooperating simultaneously with both kinds of users. Unlike other studies, our analyses include some variables not previously taken into account and which could shed light on which aspects of the innovation process proximity is important. More concretely, in the three cases we analyse the influence of cooperation with users on proxy measures of technological knowledge generation (inputs) and the economic returns generated by this knowledge (outputs).

Firstly, although the literature points out that there exists a positive relationship between cooperation with users and R&D investment (Fritsch and Lukas, 2001; Belderbos *et. al.* 2004; Santamaría and Surroca, 2004; Motohashi, 2005), to our knowledge, no previous work has shown how this kind of cooperation affects the allocation of R&D expenditures to basic research, applied research and technological development. However, we have decided to analyse this topic because it will make it possible to determine how cooperation with users contributes to expand the firm's frontier of technological knowledge (basic and applied research), and/or to stimulate exploitation of existing knowledge with a clear market orientation (technological development). Secondly, we

analyse whether user cooperation has any influence on the sales of innovative products (outputs). This analysis is important because the final aim of developing an innovation, regardless of its type, is not the innovation itself but improving the economic results of the firm (usually expressed as sales figures) and/or achieving a superior competitive position. In this way we do not just take into account the type of innovations developed but also their commercial success.

Our contribution is important not only conceptually but also practically. It is quite difficult to find empirical studies with a statistical approach in this field of research. Cooperation with users has traditionally been analysed from a descriptive point of view (see for example, Ashcroft *et. al*. 1994; Roper and Thanki, 1995; Braczyk *et. al.* 1998). Besides, studies of this kind usually focus on specific sectors of industry, which limits the possibilities for generalizing the results. In this paper we have adopted an empirical perspective and considered a large number of sectors in both manufacturing and services.

The paper is structured as follows. Section two is a review of the literature focusing on the implications of users' proximity on the analysis of the effects of cooperation with them on the inputs and outputs of the innovation process. Section three details our methodology and Section four describes the data sample and the variables of the study. In Section five the findings of the analysis are presented and discussed. Finally, Section six summarizes the main conclusions of the paper.

2. Literature Review

It is widely accepted by scholars and professionals that agents from outside the firm constitute an important resource in today's competitive environment, particularly as far as the development of new products and processes is concerned (Barney, 1991; Peteraf, 1993). Firms need to complement their internal resources and capabilities with ideas imported from outside, interacting with a wide range of actors in the innovation system (von Hippel, 1988; Szulanski, 1996; Laursen and Salter, 2006). This idea is the central point of the so-called "Open Innovation" model (Chesbrough, 2003a, b), which emphasises the interactive character of the innovation process, suggesting that firms need not and indeed should not rely exclusively on their own R&D but should also use ideas from outside in order to exploit the potential of their innovation capabilities and investments (Chesbrough, 2003b; Dogson *et. al*. 2006; Chesbrough and Crowther, 2006). Laursen and Salter (2006) also suggest that the more widely and deeply the firm uses search strategies, the greater will be its ability to adapt to change and therefore to innovate.

In this context, cooperation with users is emerging as an important source of knowledge for innovation and many studies have focused on analysing this phenomenon. The literature has pointed out that there are advantages and disadvantages for firms cooperating with users. On the one hand, it may provide the firm with information on new technologies and markets' evolution (Rothwell, 1994; Whitley, 2002), which could be useful for the generation of ideas with a high degree of novelty (Meyers and Athaide, 1991; Amara and Landry, 2005). This type of cooperation also helps the firm to identify unsatisfied needs which in some cases the user is unaware of having (von Hippel and Katz, 2002) and reduces the cost of the process of developing and implementing new products and services (Herstatt and von Hippel, 1992; Thomke and Nimgade, 1998; Lilien *et. al*. 2002; Jeppesen, 2002). On the other hand, the main drawbacks of this kind of cooperation concern transaction costs and problems of appropriability (Tomlinson, 2010). The former involve risks for both users and manufacturers in cases of a specific technology, when the manufacturer that invested in that technology would have little chance of selling it on the market without it losing value, while users are at risk if that technology is owned just by an income-seeking monopolist (Williamson, 1985). The appropriability problem concerns the existence of some externalities such as spillovers and knowledge diffusion that make it difficult for firms to maximize returns on their own innovation activities. In addition, over-dependence on users may lead firms to obtain negative returns through the inertia and conservative behaviour of some users who oblige them follow established technological paths instead of seizing new opportunities (Laursen, 2011).

Existing studies of cooperation with users analyse the effects of this kind of relationship on firms' innovation activities, on the inputs as well as on the outputs of the innovation process. Regarding the inputs, the literature offers no consensus about the possible influence of collaboration with users on the intensity of a firm's involvement in innovation activities. On the one hand, such studies as Lilien *et. al.*'s (2002) state that, when firms collaborate with these agents, innovation expenditures rise, while Tether (2002) observes a positive relationship between collaboration with users and innovation intensity. Other authors, however, suggest that this type of collaboration during the development of innovations reduces the expenditures related to these activities (Herstatt and von Hippel, 1992; Thomke and Nimgade, 1998; Jeppesen, 2002, 2005; Henkel and von Hippel, 2004; von Hippel, 2005; Lettl *et. al.* 2006) and leads to higher degrees of efficiency in the innovation process (Tether, 2002; Bayona *et. al.* 2003; Santamaría and Rialp, 2007a). This implies that firms collaborating with these agents need to put less effort, in terms of time and money, into a given innovation (Lettl *et. al*. 2006).

With regard to the outputs, a characteristic dimension of the innovation activity, but one hardly dealt with in the literature on cooperation with users, is just how novel the innovation developed is (Tether, 2003). Some lines of research have indicated that when the manufacturing firm innovates by itself the result can only be incremental improvements in existing product lines (Anderson and Thusman, 1990; von Hippel, 2005), whereas cooperation with users gives rise to ideas about new product lines -radical innovations- (von Hippel, 1988; Shah, 2000; Lettl *et. al*. 2006) as well as incremental innovations (Knight, 1963; Hollander, 1965). This means that the extent of the user's participation depends on the type of innovation required (Veryzer, 1998; Lüthje and Herstatt, 2004). If incremental innovation is the target, all that is required is limited participation by the user (e.g., interviews or questionnaires), but if the aim is a more novel innovation, then much greater involvement will inevitably be sought.

In this line of research we can cite studies by Amara and Landry (2005) and Nieto and Santamaría (2007). The descriptive analysis of the formers' data suggests that information provided by users is used more frequently by firms introducing innovations which are new on a national and worldwide level but less by those choosing innovations only new for the firm. Simultaneously, the authors mention that sources of market information reduce the likelihood of obtaining innovations hitherto unknown on a worldwide level, although it does not mean that they have no influence on the likelihood of innovating. In the same way, Nieto and Santamaría (2007), using data on Spain, found that information provided by the market (users and suppliers) had a positive, significant effect on both types of innovation outputs.

Taking into consideration all the above, it could be said that nowadays no consensus exists on the magnitude and direction of the effects of user cooperation on innovation activity. Although different arguments can be formulated to explain these outcome disparities, it may be possible to improve the knowledge of this phenomenon by taking some of user's characteristics into account, which means that it is possible to speak of different types of users, for example: lead users or early adopters (Rosenberg, 1976; Urban and von Hippel 1988; Herstatt and von Hippel 1992; Thomke and Nimgade, 1998; Lilien *et. al.* 2002; Lüthje and Herstatt, 2004; Droge *et. al*. 2009), industrial users or individual users (von Hippel 1988; Shah, 2000; de Jong and von Hippel, 2009; Flowers *et. al.* 2010), hobbyist or professional users (Jeppesen and Frederiksen, 2006; Aoyama and Izushi, 2008), etc.

In the present study we propose to include the proximity of the user as another level of analysis. Abundant literature makes the point that the proximity of firms, agents, institutions and resources is a key factor in developing the innovation process (Storper, 1997; Asheim *et. al.* 2003; Asheim and Gertler, 2005). This is because proximity facilitates inter-organizational transmission of tacit knowledge (Powell *et. al.* 1996), generates economic externalities (Audrestsch and Feldman, 1996; Feldman, 1994) or makes collective learning more efficient (Belussi, 1999). Moreover, the more tacit the knowledge exchanged, the higher the potential relevance of spatial proximity, because short geographical distances bring organizations together, favouring the interaction of agents and the exchange of codified knowledge (Howells, 2002; Knoben and Oerlemans, 2006; Weterings and Boschma, 2009).

Contrary to the most generalized opinion, a positive perspective of proximity, some authors stress that excessive proximity may also be harmful for interactive learning and innovation (Boschma, 2005). When regions become too inward-looking, the learning ability of local actors may be weakened so much that they lose their innovative capacity and cannot respond to new developments. Nevertheless, in order to solve the lock-in problem, firms can establish non-local linkages, providing access to the outside world. In this regard, some studies have shown that for knowledge creation a balance is necessary between local and non-local relations (Camagni, 1991; Oinas, 1999; Asheim and Isaksen, 2002; Boschma, 2005).

The study of the relationships between cooperation, innovation and proximity is very complex for many reasons, including the use of ICT technologies (Zaheer and Manrakhan, 2001), the spatial location of production (Audestrsch and Feldman, 1994), the role of foreign firms and multinationals (Kearns and Görg, 2002) and different approaches to innovation and the growth stage of the industry (Davenport, 2005). Furthermore, the proximity concept is being redefined. Although it is usually interpreted from a geographical perspective, the development of transportation and telecommunication technologies have made people more mobile, so geographical proximity has lost its importance because nowadays it is also possible to transfer tacit knowledge across large distances (Rallet and Torre, 1999) and networks, which are not necessarily spatially delimited (Bochman, 2005). Thus, despite the abundant literature on the impact of geographical proximity on learning, knowledge creation and innovation (Amin and Wilkinson, 1999), we must take into account other dimensions because this interpretation is very restricted. Recent studies have shown that it is also possible to speak in terms of institutional (Kirat and Lung, 1999), organizational (Meisters and Werker, 2004), cultural (Gill and Butler, 2003), social (Bradshaw, 2001) and technological (Greunz, 2003) proximities.

Although many factors are involved in technological cooperation in general, there is evidence that proximity has an important moderating role on the final results of cooperation. The study by Monjon and Waelbroeck (2003) analyses the effects of collaboration with domestic and international partners on the degree of novelty of the resulting innovation. Outstanding among its findings is that cooperation with domestic universities has a negative effect upon the degree of novelty of innovation, while cooperation with foreign universities (EU) has a positive effect. The results of this study suggest that the partner's proximity in cooperation moderates the relationship between cooperation and innovation activity. Arndt and Sternbert (2000) studied the relationship between cooperation and the performance of firms differentiating between regional and extra-regional cooperation as well as types of innovations. They showed that cooperation has no influence on incremental innovations, but firms with high shares of new products usually have both intra- and extra- regional relationships. They also found that firms engaged mainly in inter-regional cooperation developed more radical innovations.

To our knowledge there is no extensive prior research analysing the role of proximity in the effects of cooperation with users on inputs and outputs of firms' innovation activities simultaneously. The closest studies to ours are those of Davenport (2005), Weterings and Bochma (2009) and Laursen (2011). Davenport (2005) explores the role of geographical proximity in SME knowledge-acquisition in New Zealand, one of his most outstanding results being that interfaces with international users have been shown to be the most important source of knowledge for firms and also the major driving factor for innovation. This is particularly true when the firm follows an innovation strategy based upon high levels of customization, because this implies a deep understanding of users' needs and context. When high levels of customization are required, firms seek collaboration with international users instead of local sources of knowledge to find a solution tailor-made to users' requirements. Conversely, geographical proximity is favoured in contexts of low levels of customization. This author also concludes that international users turn into one of the most relevant sources of knowledge as international resources become accessible.

Laursen (2011) found support for Lundvall's idea (1988) that interaction between users and producers is often more efficient over short geographical distances, especially if market needs are ever-changing and complex. He points out that cooperation with users is associated with high levels of innovative sales, although emphasizing the use of this source of knowledge beyond a

certain point can have a negative effect on innovative sales. He concludes that cooperation with international users is less relevant for the development of incremental product innovations compared with cooperation with national users. Nevertheless, when radical innovations are taking into consideration, both kinds of cooperation are equally important. Finally, he also points out that firms have to look outside the national market when the necessary knowledge is not available locally.

Weterings and Bochma's study (2009) of the software sector shows that proximity does not strengthen the effects of face-to-face relationships on innovation output. They conclude that the importance of cooperation with users must not be exaggerated. Face-to-face contacts with users positively affect the propensity to be innovative, but increasing these contacts does not lead to greater commercial success when these innovations are launched onto the market. They also agree that geographical proximity has lost importance because nowadays is possible to keep contact with physically distant users.

Therefore, this review of the literature shows that the relationship between proximity and cooperation with users and its effects on firms' innovation activities are far from clear. It is generally recognized that exposure to international markets and access to knowledge sources located in diverse innovation environments may influence the firm's innovation performance (Frenz and Gillies, 2009), but it is not clear how. There is also some evidence that the geographic context –region, country or the international environment- is relevant to the generation and the transfer of knowledge (Asheim and Gertler, 2005; Cantwell and Iammarino, 2000) but we know very little about the role of partners' location in creating technological knowledge or in the economic returns stemming from such knowledge. In this paper we therefore analyse the effects of cooperation with national and international users on the inputs and outputs of the innovation process with a view to clarifying these questions.
Using these categories of national users and international users entails to adopt a wider perspective of the proximity concept, because this does not just imply considering the spatial dimension –usually denoted as territorial, spatial, local or physical proximity (Knoben and Oerlemans, 2006)-, but implicitly it also includes the dimensions of cultural proximity –understood as the culture in a continent, country or region (Knoben and Oerlemans, 2006)- and institutional proximity –related to sharing the same language, habits, legal system, etc. (Zukin and DiMaggio, 1990; Boschma, 2005)-. Knoben and Oerlemans (2006) suggested that these two aspects are closely related to the concept of cognitive proximity, which is based on the idea that the interaction of actors over geographical distances can be facilitated if they share cultures, norms, routines and values.

3. Methodology

In this study a *matching estimator* (*ME*) was applied to analyse the effect of cooperation with users C_i on firms' innovation activity in each group of firms under analysis: firms cooperating with national users, firms cooperating with international users and firms cooperating simultaneously with both.

The method specifically compares the inputs and outputs of the innovation process of firms that cooperated with users $Y_{i,c=1}$ (1) or factual state, with the results they would have obtained if they had not cooperated with $Y_{i,c=1}$ (0) or counterfactual state. Because a firm *i* cannot be observed simultaneously when it cooperates and does not cooperate, the counterfactual state poses a fundamental problem of assessment. The matching estimator estimates the counterfactual state with information stemming from a control group $Y_{i,c=0}$ (0). The construction of this control group is not easy since the decision to cooperate with users is not random. The literature shows that the profile of firms that cooperate differs from those that do not. This causes a problem known in econometric studies as "sample selection bias". The *ME* reduces this bias through a process of matching between comparable units and, for this purpose, uses a proximity criterion. In this way, each cooperating firm has in the control group a firm that is as similar as possible in terms of its propensity to cooperate with users (or propensity score). In this study we used a Probit model to

estimate this propensity and to analyse which conditional variables X_i influence the likelihood of cooperating with users (see Appendix, Table 1A).

We used the bias-corrected matching estimator proposed by Abadie and Imbens (2006) to carry out the matching process and obtain a net figure for the effect. Additionally, we imposed the condition that each cooperating firm will be matched with a similar one in the same sector of activity. Once the matching process was concluded, the bias-corrected matching indicator obtained the causal effect as the difference between the average value of a variable of interest in the group of cooperating firms $Y_{i,c=1}$ (1) and the value of this same variable in the control group $Y_{i,c=0}$ (0). Cooperation has a positive effect if the figure for this difference is significantly higher than 0. The bias-corrected matching estimator can be represented thus:

$$\tau = \frac{1}{N_1} \sum_{i|C_i=1} \left[Y_{i,c=1}(1) - Y_{i,c=0}(0) \right] \qquad (1)$$

Dwhejia and Wahba (2002) carried out a painstaking revision of this methodology and Abadie and Imbens (2006) give a detailed explanation of the bias-corrected matching estimator.

4. Sample and Variables

4.1 Sample

The data used in this research were supplied by the Technological Innovation Panel (PITEC), created with information from Spanish firms recorded by the Survey of Technological Innovation in Spain. The panel was created with the aim of providing a database for analysing the innovative behaviour of Spanish firms and their evolution. Since 2003, the panel has recorded information from more than 7,200 firms belonging to two sub-populations. The first consists of firms with more than 200 employees and the second of firms declaring the development of in-house R&D activities. The representativeness of the sub-populations is respectively 73% and 60% of Spanish firms.

The data used in the present paper, whose structure is time-dependent, cover the period 2003- 2007. In the case of the effects on inputs, we estimated them for the year in which the firm reported cooperation with users (2004) and the following years (from 2005 to 2007). In the case of the outputs, we estimated the effect for 2006 and 2007, as input proxies are measured annually whereas output proxies represent the sales of innovative products introduced in the preceding three years over total sales (as a percentage). As a result, the variable in the year 2006 records the percentage of sales stemming from innovations in goods and services introduced in the period 2004-2006 and its value in 2007 records the period 2005-2007.

Variable C_i, that is, whether the firm cooperated or not in 2004, acquires its determination from lagged explanatory variables X_i, in other words, values for 2003. We adopted this time-dependence data structure in order to reduce the endogeneity problems arising when studying the relationship between cooperation and innovation and also to improve the quality of matching.

A sample of 4,720 firms replying to the survey during the period 2003-2007 was used in this study. Of these, 656 collaborated with users, 413 only with users from the same country (Spain), 88 only with international users located in “other countries”, and 155 simultaneously with both national and international users.

4.2 Variables

The co-variables vector X_i used to estimate firms’ propensity to cooperate with users includes variables influencing this propensity according to the literature (Kaiser, 2002; Santamaría *et. al*. 2002; Tether, 2002; Bayona *et. al*. 2003; Belderbos *et. al*. 2004; Bönte and Keilbach, 2005; Heijs *et. al*. 2005; Santamaría and Rialp, 2007a, b). Firstly, we included variables representative of the firm’s structural characteristics such as size (logarithm of the number of employees), age (dummy variable indicating whether the firm was of recent creation or not), ownership structure (dummy variable indicating whether the firm is private without foreign capital or not) and export propensity

(ratio between exports and sales). Next, we also included dummy variables such as indicators of firms' innovation activity, for example: whether the firm belonged to a high or medium-tech manufacturing or service sector. In addition, as studies have shown that indicators of previous innovation activity and cooperation with other agents have a strong influence on cooperation with users, we included a dummy variable with the value of 1 if the firm had introduced innovations in the past (t-2 to t), and 0 otherwise, together with another dummy variable with the value of 1 if the firm cooperated with other agents like competitors, suppliers, universities and technological centres and other firms in the same group, and 0 if not. Finally a dummy variable was introduced to ascertain the influence of public funding, with the value of 1 if the firm obtained subsidies in the previous period, and 0 otherwise.

Trying to measure innovation has always been difficult for researchers. In this study, proxy indicators of inputs and outputs of the innovation process have been combined to estimate the effect of cooperation C_i on innovation activity Y_i. Innovation input has been measured in terms of private innovative effort, calculated as the ratio between private innovation expenditures and firm's sales, multiplied by a hundred. Unlike other studies, this one also contains an analysis of the effect of cooperation on how firms allocate their private R&D expenditures to basic research, applied research and technological development. All these variables have been defined as a percentage of the total in-house R&D expenditures, multiplied by a hundred.

As for innovation output, it is worth pointing out that the indicators used in the literature are very diverse[1]. In this paper, we have distinguished between two types of product innovations, considering two variables that reflect the economic returns of the firm as well as the degree of novelty of the innovation developed: a) the ratio between the sales of products new to the market and the total sales of the firm, multiplied by a hundred (high novelty) and b) the ratio between the sales of products new for the firm and the total sales of the firm multiplied, by a hundred (low novelty). This way it will be possible to determine the effects of cooperation with users on the economics returns (sales figures) and on the degree of novelty of innovations.

5. Results and Discussion

In a preliminary step in the methodology we had to estimate the propensity to cooperate with users, or *propensity score*, for each firm in the sample in order to obtain the control group. We present the results of these estimations in a descriptive way because this is not the focus of the paper. In the four models under analysis, the dependent variable took the value of 1 if the firm cooperated with users (users in general, national users, international users and national and international users, respectively) and 0 if not. The results of these estimations are shown in Appendix (see Table 1A). Given the limitations of the methodology and the survey data, we are unable to fully account for all potential sources of endogeneity, so we interpret the coefficients of the probit model as reflecting correlations rather than causal relationships. Size, age and high-tech manufacturing sector are variables that do not show a significant relation with the propensity to cooperate with users in any of the four models. Nevertheless, we observe several significant differences in the models under analysis. In the general model, we found that belonging to a high-tech service sector, obtaining public funding in the past, having a previous innovation experience and maintaining cooperation with other agents are significant and positively related to the propensity to cooperate with users. However, if the firm is private, without foreign capital, the relation is significant but negative.

Taking into account proximity to the user, the profile of firms in the case of international cooperation is quite simple. Only export propensity and cooperation with other agents show a positive and significant relation, while we observe a more complex profile in the national

[1] Perhaps the most widespread is the count of cited patents. However, in our analysis patents have not been considered because innovations developed by users are usually characterised by a phenomenon called *free revealing. Free revealing* consists of "someone" (normally a user) revealing information about his innovations that could be used by other users or manufacturers to generate commercial products. The vast majority of innovative users freely reveal details of their innovations, which means that very few results from their innovation activity are going to be patented. This phenomenon is observed in the case of final users (individuals) as well as in the case of user firms (Flowers *et. al.* 2010).

cooperation sample. The influence of export propensity is significant but negative and the variables related to belonging to high-tech service sectors, obtaining public funding in the past, previous innovation experience and cooperation with other agents show a positive and significant relation with user cooperation. The simultaneous cooperation model is quite similar to the national model. However, in this case, export propensity shows a significant and positive relation to cooperation and also belonging to medium-tech manufacturing sector presents a positive coefficient. Considering the marginal effects, we observed that the variable cooperation with other agents showed the strongest relation with the propensity to cooperate with users in the main three models.

Table 1 presents the results of the analysis of the effects of user cooperation on the proxy variables representing the inputs and outputs of the innovation process, taking into account proximity to the user.

Table 1: Average effect of cooperation with on firm's innovation activity

	General Cooperation				**National Cooperation**				**International Cooperation**				**Simultaneous Cooperation**			
	2004	**2005**	**2006**	**2007**	**2004**	**2005**	**2006**	**2007**	**2004**	**2005**	**2006**	**2007**	**2004**	**2005**	**2006**	**2007**
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Inputs																
Innovation effort	**0.50****	0.32	**0.73*****	**0.59*****	0.26	0.30	**0.40***	**0.50****	0.81	**0.89***	**1.28*****	**1.06****	0.43	0.27	**0.76****	0.26
Basic Research	**-2.24***	0.76	0.34	0.41	-1.75	1.07	**0.98****	0.22	3.64	0.55	0.52	**2.14***	-2.70	1.38	-0.45	0.63
Applied Research	**4.31****	2.82	4.16	1.78	2.82	1.39	2.56	1.98	-2.48	-4.62	5.12	2.15	**10.39*****	**8.76****	**5.87***	5.28
Tech. Develop.	2.99	3.27	**5.51****	**7.15*****	3.53	3.01	**6.48*****	**6.29****	-2.24	7.84	1.64	1.87	-4.86	-3.93	-1.88	-0.56
Outputs																
% Sales of products new to market			**2.48***	**2.47***			**2.61***	**3.14****			0.03	-0.94			0.66	3.53
% Sales of products new for firm			-1.21	-0.58			-0.66	0.92			1.71	-1.76			0.65	-0.62
% of exact matching (sector)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Potential control group (nº of firms)	2624				1651				352				620			
Firms cooperating (nº of firms)	656				413				88				155			

***p<0.01; **p<0.05; *p<0.10

The coefficients shown in this table represent the difference between the average value of the key variable in the group of firms that cooperate and its value in the control group (according to equation 1). Different analyses have been made for the sake of certainty of the matching quality and the robustness of the results. Student's *t*-test was used to check whether the means of the *propensity score* were equal before and after the matching or not. The results of this test are shown in Table 2A (see Appendix). As can be observed before matching, there are significant differences in the propensity scores. After the matching, these differences between cooperating firms and the control group disappeared[2], which evidences the matching quality and the fulfilment of the methodological assumptions.

As regards inputs, the results of the four models reveal that firms cooperating with users show a higher innovation effort than those not cooperating. Our findings are in line with those indicating that collaboration increases firms' innovative effort (Colombo and Garone, 1996; Kaiser, 2002; Lilien et al., 2002; Tether, 2002). In this way, collaboration with users may become a source of competitive advantage, by strengthening innovative efforts and their continuity. We noticed differences regarding the time when these effects are observed, there generally being a delay compared with the reference year when firms declared having cooperated with users (2004). This lag is greater for firms cooperating with national users and in the model of simultaneous cooperation. In the general model, beside these lags, we also observed immediate effects that may have been the result of cooperation relationships in previous years, but we do not have the necessary data to confirm this.

Regarding the magnitude of the significant effects, the innovation effort in the group of firms cooperating with users was between 0.4 and 1.28 percentage points higher than in the group of

[2] To analyse the robustness of our results, we use the 4 nearest-neighbour observations for each firm cooperating with users.

firms not cooperating in the four models. This effect is important if we take into account that the average value of innovation effort (innovation expenditures/sales, multiplied by a hundred) of the firms in the sample varies from 2.13 to 3.15 percentage points over the period analysed (see Table 3A). Taking proximity into account, we observed a major difference between the last three models. In the case of international cooperation, the difference between the innovation effort of firms cooperating and the control group was higher than that estimated in the other models (0.89, 1.28 and 1.06 in 2005, 2006 and 2007, respectively). Firms with international relationships continued to increase their innovation effort year after year without the discontinuities observed in the other models. There are two explanations for the greater effort and continuity of innovation activity of these firms. Firstly, international markets are more competitive and firms require innovation to survive and remain in them. Secondly, the fact of serving users located far away from the firm entails adapting products to these international demands, which implies an increase in the innovation effort.

We also analysed the effects of cooperation with users on the way firms allocate their private R&D expenditures to: 1) basic research, 2) applied research and 3) technological development. In fact, the study demonstrates that the R&D portfolio of cooperating firms is different from those that do not cooperate in the general model. Findings show a significant lower investment in basic research (-2.24 percentage points) and a significant higher investment in applied research (4.31 percentage points) in the year when cooperation occurs. Investments in basic research are carried out without a specific aim and serve as a way of keeping in touch with the latest technological advances. It permits access to knowledge that may later be very useful in developing other types of R&D activities (Beesley, 2003). According to some authors, these investments are crucial for the development of new products and largely determine a firm's competitiveness level (Cohendet and Meyer-Krahmen, 2001; Henard and McFadyen, 2006). Firms cooperating with users in general will probably invest less in basic research because the knowledge provided by these agents may be highly useful for undertaking activities close to the market. Contact with users may be an exploratory method for obtaining information about market requirements, proving particularly useful for the subsequent development of technologies and complex products (Tether, 2002). As a result, firms cooperating with users make less effort to extend their frontier of technological knowledge, in other words, they do not perhaps can stop making their own efforts, but may be able to reduce them. On the other hand, applied research generates knowledge with a specific practical objective. The technological knowledge of this activity is nearer to firms' technological domain (Roper *et. al*. 2004). It must be taken into account that the type of information owned by the user comes from their experience in the use and handling of products, whereas the manufacturer is the agent who has the necessary knowledge to design and physically make the products that meet the expressed needs (von Hippel, 1994, 1998; Sánchez-González *et. al*. 2009). Thus, when cooperating with users, the firm becomes aware market's needs and on that basis applies its knowledge to designing products to meet its needs (applied research). The study also shows that firms cooperating with users gave greater emphasis to investment in technological development in the years 2006 and 2007. Such investment must have led them to focus more on *advancing core technologies* and to invest less in technologies outside their *core domain* (Santoro and Chakrabarti, 2002). It is to be observed that the effects on technological development activities appeared some time after the reference year (2004). These results show that time elapses from when the user provides their knowledge until the phase of technological development. This situation was also observed in the model of national cooperation.

Regarding user proximity, we found clear differences in the portfolio of R&D activities between the three models, which is evidence that proximity influences firms' strategies for generating technological knowledge. The coefficients show that firms cooperating with national users were more involved in basic research (0.98 percentage points in 2006) and especially with a higher emphasis on technological development (6.48 percentage points in 2006 and 6.29 percentage points in 2007). These firms are more focused on activities providing immediate solutions to critical problems and those affecting the core areas of business. Firms cooperating with international users invested significantly more in basic research activities (2.14 percentage points), probably to develop a broader knowledge base to enable them to maintain their competitive position in the

international markets. On the other hand, firms with a simultaneous cooperation strategy invested more in applied research to enlarge their specific knowledge base in their core domain, presumably to put distance between themselves and their competitors in the short term (10.39 percentage points in 2004, 8.76 percentage points in 2005 and 5.87 percentage points in 2006).

The findings summarised in Table 1 also show that cooperation with users has a positive influence upon outputs of the innovation process. Firms cooperating with users, in general, increased their sales of products new to the market by 2.48 percentage points in 2006 and 2.47 percentage points in 2007, as compared with firms that did not cooperate. According to the literature, this effect can be understood as an increase in the production of radical innovations. These innovations are obtained by firms with a marked innovation orientation (Ettlie *et. al*. 1984) and their development requires a firm to renew and extend its knowledge base by creating competences that it did not have previously (Herrmann *et. al*. 2006).

Taking into account proximity, we observed that only firms cooperating with national users showed significantly higher figures of sales of products new to the market (2.61 percentage points in 2006 and 3.14 percentage points in 2007). Non-significant differences between firms cooperating and not cooperating with users were found in the other two models. These results appeared to show that proximity to the user made it easier to transfer technological knowledge, particularly tacit knowledge, which can be the base for radical new ideas, as has been suggested by other authors (Davenport, 2005). So, this knowledge will materialize into economic results and increase the competitiveness of the firm.

Previous studies have demonstrated that according to the location of the agent it is possible to distinguish different strategies for developing innovative products (Monjon and Waelbroeck 2003; Laursen 2011). Laursen's study (2011) is the closest to ours. He concludes that when firms cooperate with national users their objective is to obtain incremental innovations, an imitation strategy, and that national and international cooperation with users is equally important in the case of radical innovations. However, he also observes a relatively higher importance of formal international user cooperation when the aim is to obtain more radical innovations and the necessary knowledge is not locally available. So in these cases a differentiation strategy seems to be the rule. From our study, we cannot draw a similar conclusion because cooperation only with national users was significant. However, our results seem to point in the opposite direction: our analysis demonstrates that Spanish firms cooperating with national users look for a differentiation strategy and not for one of imitation, as Laursen proposes. This is in line with the study of Gittelman (2011) which analyses different kinds of alliances. She concludes that local ties are related to unplanned and opportunistic search that ends up in technological variety (radical innovations) whereas distant alliances are connected to problem-oriented search in order to exploit the firm's technological knowledge base (incremental innovations). Consequently, we could posit that firms cooperating with national users seek to improve their competitive position in the national market through the development of radical innovations via differentiation with their competitors.

Thus, our study allows us to conclude that proximity influences the economic results of firms and the degree of novelty of the innovation obtained. However, in the Spanish case, more research would be necessary on international cooperation to conclusively determine the existence or otherwise of different strategies depending on the user's proximity.

6. Conclusions

In the present paper we analyse the role of user's proximity in the effects of cooperation with these agents on the inputs and outputs of the firm's innovation process. These effects were estimated by comparing the innovation activity of cooperating firms with those that did not cooperate but with the same propensity to do so (control group). With the aim of understanding this role, the study includes a comparative analysis of the cooperation effects in three samples of firms: firms cooperating with national users, with international users and cooperation with both kinds of users simultaneously.

Regarding inputs, the study reveals that regardless of proximity, firms cooperation with users show higher innovation effort compared to those not cooperation. This paper also offers new evidence on the impact of cooperation with users on the generation of technological knowledge during the early phases of the innovation process and on the importance of user's proximity in this regard. The study shows that cooperation with users affects how firms allocate their R&D expenditures to basic research, applied research and technological development activities and that these effects change with user's proximity. R&D activities are geared to increasing the firm's stock of technological knowledge but with different aims. We find that, in general, firms cooperating with users managed to increase investments geared to extending the firm's knowledge base in its technological domain (applied research) but did not encourage activities aimed at expanding the technological knowledge frontier (basic research), in the short term. When we take into account the proximity to the user, we find different results, which reveal that firms cooperating with users have different aims when they generate technological knowledge in order to serve national or international markets. We observe that proximity (national cooperation) significantly encourages activities geared towards expanding the frontier of technological knowledge (basic research) and especially led to increased investments geared to find solutions for specific problems in the firm's technological domain (technological development). On the other hand, firms cooperating with international users invest significantly more in basic research probably to be aware of the latest technological advances in those international markets and to improve their competitive advantage in the future. In this study we also find that firms following a simultaneous cooperation strategy are significantly more involved in applied research activities, presumably to put a distance between themselves and their competitors in the short term in the global marketplace.

On the output side, we observe significant differences between firms cooperating with users compared to firms in the control group in the sales and degree of novelty of new products. From the analysis of the general sample, we can interpret that information provided by users makes it easier for firms to compete with products that are new to the market. Collaboration with these agents makes it easier for firms to identify novel needs that in many cases the users are not aware of, and which can be the basis for the development of completely new products (von Hippel and Katz, 2002). Taking into account proximity, we observed that firms cooperating with national users managed to increase the sales of products new to the market in comparison with firms not cooperating. However, no difference could be observed between these two groups of firms in the samples of international cooperation and simultaneous cooperation. This could be interpreted as showing that proximity facilitates the exchange of knowledge that improves the competitive position of the firm in its local market while distance makes no significant difference to the economic results of Spanish firms, al least in the short term. Firms cooperating with national users increase their innovation effort, particularly in activities of technological development, presumably with the aim of obtaining economic returns from radical innovations in a short period of time.

These results are also interesting for policy makers. The open innovation paradigm promotes the division of innovation labour between universities, industry and government. As this study shows, cooperation with users increases the innovation effort and encourages the development of radical innovations. Therefore, policy makers should look at this cooperation as an opportunity to enhance the innovation and competitive levels of their country. The vast majority of Spanish firms are small and do not recognize the necessity to undertake R&D activities. Also, they usually lack the organizational capabilities and human resources necessary to exploit knowledge and undertake innovation activities by themselves. Public policies should stimulate cooperation with users in order to improve this situation to facilitate firms' access to new knowledge at a reasonably low cost. Policy makers might promote cooperation through initiatives that strengthen ties of this kind taking into account the positive effects on inputs and outputs of the innovation process.

Before concluding, some limitations of this paper should be mentioned. Extending the period of the analysis would make it possible to improve the conclusions on the dynamic effect of this type of cooperation in such a manner that long-term effects would also be visible. For example, when interpreting the results of an analysis of this kind, it should be borne in mind that in the case of international cooperation, distance makes the transfer of knowledge difficult, especially tacit

knowledge, which can necessitate a longer period of time for the effects of this cooperation to be observable. So, perhaps the period of analysis considered in this study could be extended. Due to the data base used and the country chosen, the sample of firms cooperating with international users is very small, as Spanish firms have a low propensity to internationalization. Future research will therefore need to increase the number of observations in order to properly analyse the effects on firms of this type. Finally, more extensive data on the characteristics of the project on which the users have participated would also be useful.

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APPENDIX

Table 1A
Estimation results of the Probit model and marginal effects

	General Cooperation		National Cooperation		International Cooperation		Simultaneous Cooperation	
Variables†	Coef.	M.E.	Coef.	M.E.	Coef.	M.E.	Coef..	M.E..
Size	-0.14		-0.03		0.01		0.03	
Age	-0.08		-0.17		0.39		0.06	
Domestic firm	-0.23***	-0.01***	-0.11		-0.11		-0.26***	-0.01**
Export propensity	0.06		-1.02***	-0.10***	1.46***	0.01**	0.68***	0.02***
High tech manufacturing sector	0.11		0.05		0.18		0.14	
Med tech manufacturing sector	0.09		0.02		0.15		0.20**	0.01*
High tech service sector	0.60***	0.12***	0.29**	0.03**	0.11		0.75***	0.04***
Past innovation (t-2)	0.36***	0.04***	0.38***	0.03***	0.01		0.18	
Public funding	0.29***	0.04**	0.22***	0.02***	0.09		0.23**	0.01**
Cooperation with other agents	1.44***	0.04***	1.19***	0.15***	1.61***	0.03***	1.28***	0.05***
N	4720		4720		4720		4720	
Nº cooperating firms	656		413		88		155	
Log Likelihood	-1415.03		-1107.14		-318.90		-529.61	
Pseudo-R^2	0.25		0.19		0.26		0.22	

† All variables are lagged one year respect to 2004

M.E.= Marginal Effects

***p<0.01; **p<0.05; *p<0.10

Table 2A
Means comparison of firms' propensity score before and after the matching

	General Cooperation		National Cooperation		International Cooperation		Simultaneous Cooperation	
	$C_i=1$	$C_i=0$	$C_i=1$	$C_i=0$	$C_i=1$	$C_i=0$	$C_i=1$	$C_i=0$
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
				Before the matching				
Propensity Score	0.18	**0.13 *****	0.11	**0.08*****	0.04	**0.02*****	**0.06**	**0.03*****
N	656	4064	413	4307	88	4632	155	4565
				After the matching				
Propensity Score	0.18	0,18	0.11	0.11	0.04	0.04	0.06	0.06
N	656	2624	413	1652	88	352	155	620

Note 1: Significances (***p<0.01; **p<0.05; *p<0.10) indicate that the means compared differ according to the two tailed t-test.

Note 2: C_i takes the value of 1 when the firm cooperates with users and 0 in the opposite case

Table 3A
Descriptive Statistics

	Obs.	Mean	Std. Dev.	Min.	Max
PROPENSITY SCORE VARIABLES					
Size	4720	4.36	1.61	0	11.368
Export propensity	4720	0.19	0.26	0	1.08
High tech manuf.	4720	0.89	2.29	0	1
Med tech manuf.	4720	0.25	0.43	0	1
High tech service	4720	0.04	0.20	0	1
Age	4720	0.02	0.15	0	1
Domestic	4720	0.82	0.38	0	1
Public funding	4720	0.28	0.44	0	1
Past innovation	4720	0.71	0.45	0	1
Coop. Other agents	4720	0.41	0.49	0	1
INPUTS VARIABLES					
Innovation effort 2004	4720	3.15	3.78	0	17.54
Innovation effort 2005	4720	3.15	3.89	0	17.59
Innovation effort 2006	4720	2.41	3.18	0	14.37
Innovation effort 2007	4720	2.13	2.88	0	12.99
Basic Research 2004	4720	12.42	27.62	0	100
Applied Research 2004	4720	31.27	38.01	0	100
Tech. Develop. 2004	4720	44.64	42.24	0	100
Basic Research 2005	4720	5.04	16.95	0	100
Applied Research 2005	4720	31.99	38.60	0	100
Tech. Develop. 2005	4720	41.81	42.01	0	100
Basic Research 2006	4720	1.62	7.19	0	100
Applied Research 2006	4720	30.32	38.58	0	100
Tech. Develop. 2006	4720	38.16	41.84	0	100
Basic Research 2007	4720	1.50	6.99	0	100
Applied Research 2007	4720	30.00	38.53	0	100
Tech. Develop. 2007	4720	36.90	41.62	0	100
OUTPUTS VARIABLES					
New to market 2006	4720	11.48	23.97	0	100
New to firm 2006	4720	15.44	27.72	0	100
New to market 2007	4720	11.29	23.49	0	100
New to firm 2007	4720	14.18	26.38	0	100