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Facultad de Ciencias Económicas y Empresariales

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Internal Capabilities, R&D Cooperation with Universities and Firms' Innovativeness Level: Evidence from Spain

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The aim of this paper is to investigate the effect of internal R&D factors and external R&D cooperation with universities on the innovativeness level of firms using Spanish data collected from the Surveys of Technological Innovation of the Spanish Statistics Institute (INE). The results show that, while firms, specifically those introducing more advanced innovations, are relying to a higher extent on cooperation with universities, both R&D strategies are shown to be important determinants of firms' innovativeness level. Moreover, firms endowed with higher absorptive capacity have greater propensities to develop new knowledge. I also find that when associated to R&D cooperation, internal R&D capacity is likely to reduce the influence of the cooperation strategy on the innovativeness level of the firm.

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ABSTRACT

The aim of this paper is to investigate the effect of internal R&D factors and external R&D cooperation with universities on the innovativeness level of firms using Spanish data collected from the Surveys of Technological Innovation of the Spanish Statistics Institute (INE). The results show that, while firms, specifically those introducing more advanced innovations, are relying to a higher extent on cooperation with universities, both R&D strategies are shown to be important determinants of firms' innovativeness level. Moreover, firms endowed with higher absorptive capacity have greater propensities to develop new knowledge. I also find that when associated to R&D cooperation, internal R&D capacity is likely to reduce the influence of the cooperation strategy on the innovativeness level of the firm.

JEL classification: M21; O31; O32; Keyword: Innovativeness level, Cooperation with universities, internal R&D

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1 INTRODUCTION

Innovations are to a large extent a prominent factor of competitiveness upon which firm growth, performance and even survival are based. Hence, meeting this challenge has led firms to take a special interest in the specific mechanisms that may allow them to reach higher levels of innovativeness, in order to face up competitors' increasingly innovative products (Nieto and Santamaría, 2007). To achieve this goal firms need to develop their internal technological capabilities. However, in-house generated innovations may lack of sufficient "expertise" that could be derived from external sources (Becker, 2004). Competitiveness may induce firms to not only develop their internal capabilities, but also to exploit external technological skills. Investigating the patterns of both sources of knowledge and their subsequent impact on product innovation is thus a key factor in understanding the determinants of increasing innovative capacity of firms.

On the one hand, several studies have pointed to the importance of internal R&D competencies of a firm for innovation generation activity. As firm increases its efforts in developing internal R&D activity, the more likely it will be able to generate innovative products. Hence R&D intensity is expected to be positively correlated with knowledge contained in innovation outputs. On the other hand, R&D partnership is also seen as a key factor for industry to respond to the increasing technology demand and to face competitors' fast technological growth. Recent researches on firms' cooperation with universities have shown the increasing importance of industry-science collaboration. Science is more likely to be a good source of information for innovation activity especially for firms in science-based sectors (Veugelers and Cassiman, 2005). Actually, the major industry motivations for engaging in this kind of partnerships are to profit from research results reached in complex research projects developed by universities and research centers and to have access to qualified and relatively "cheap" scientific personnel (Hall et al., 2003). Lööf and Broström (2008) find evidence that collaboration with universities positively influences innovative performance of large Swedish manufacturing firms.

Additionally, a growing interest has been devoted, during the last years, to examine the relationship between internal and external knowledge and their impact on innovation. Several researches show the complementarity between internally developed knowledge and external know-how (Cassiman and Veugelers, 2002; Arora and Gambardella, 1994). In line with the notion of absorptive capacity introduced by Cohen and Levinthal (1990), these studies suggest that firms endowed with considerable technological competences are more likely to better use knowledge obtained from external sources. However, there are also arguments to highlight the substitutability modes of in-house and sourced R&D activities, as transaction costs based literature suggests (Williamson, 1985; Pisano, 1990). Similarly, Vega-Jurado et al. (2008) argue that external technology and own R&D can be considered as substitutes in the generation of innovation sustaining that firms endowed with high internal R&D capabilities use less technology derived from external sources to generate innovation. I aim to provide evidence on complementarity or substitutability in firms' innovation strategies and their impact on the generation of innovation.

The main existing empirical researches on firms' innovation activity focus on examining the relationship between internal and external knowledge and firm's likelihood to innovate. Little attention has been devoted to investigate the impact of R&D efforts on firm's innovativeness level. I address this question in the context of Spanish manufacturing firms. I will extend the existing literature on the role of internal and external firm R&D strategies on business innovation in the Spanish context, using recent data.

The contribution of this paper is to examine the impact of developing in-house R&D activity and sourcing knowledge through cooperation with scientific agents on the innovativeness level of firms located in Spain. I consider four firm levels of innovation: no product innovation by the firm, innovation products new only to the firm, innovation products new to the market; and innovation new to the firm and to the market. I also control for additional factors such as the share of qualified staff in the firm and the proportion of basic research carried out, as well as some firm and industry characteristics that may affect the innovation activity of firms. I am specifically interested in answering the following questions: How do internal R&D capabilities and cooperation of firms with universities influence their innovativeness level? How does the interaction between collaboration and firms' R&D characteristics influence their innovativeness level?

I empirically asses these questions using a sample of 2857 firms that have answered the questionnaire of the Spanish Technological Survey administrated by the Spanish Statistics Institute (INE) for the years 2003 and 2006. I use two surveys to allow for leading the depending variable by more than one period and hence minimizing the simultaneity problems that might characterize the relationship between some independent variables and the innovation variables. Actually, the independent variables are collected from the 2003 and 2004 surveys, whereas the innovation variables are gathered from the 2006 survey.

The remainder of the paper is organized as follows: section 2 provides a review of the main contributions in the literature on R&D cooperation and firms' innovative activity. Section 3 presents the data. In section 4, I describe the econometric methodology and the empirical results. Finally section 5 presents some conclusions and suggestions for future research.

2 LITERATURE REVIEW

In this section, I report an overview of the firm innovation literature on the specific topic of the internal technological capacities and acquired knowledge through cooperation with universities as determinant factors in firms' innovation activity. A wide range of studies provide evidence of the prominence of disposing of own R&D activity to the generation of innovation output (Love and Mansury, 2007). Less attention has been paid to the study of external knowledge sourcing as the major driver of corporate innovation activity. Actually, the concept of absorptive capacity developed by Cohen and Levinthal (1990) stresses the need to have in-house R&D activities to increase firms' assimilation of knowledge developed outside the firm. Based on the work of Cohen and Levinthal (1990), more recent researches explore the effect on firm innovation of the interaction between internal technological capabilities and external R&D sourcing. These studies confirm the existence of an indirect effect, generated by absorption capacity on the use of external knowledge acquired through cooperation activities and its impact on the generation of innovation at the firm level.

3.2.1. Internal R&D and innovation

The empirical literature specially stressed the influence exerted by internal R&D intensity on the innovation activity. Love and Mansury (2007) consider that internal R&D is the most important determinant of innovation. Firms need to develop their own technological capabilities to be able to enhance the performance and innovativeness level of their products. Kaufmann and Tödtling (2001) argue that internal capabilities are still more important factors than external relations in enhancing firms' ability to generate "far-reaching innovations". In their study applied to US business services firms, Love and Mansury (2007) find that in-house R&D is a significant determinant of firms' likelihood to innovate and that it is positively associated with innovation intensity of firms. Specifically, their results show that informal R&D is particularly important for the generation of services that are new to the firm, rather than new to the market. Moreover, previous research highlighted the importance of internally developed R&D activity to the exploitation and better understanding of the externally gathered information (Freel, 2000; Arora and Gambardella, 1994).

3.2.2. Firm-Science cooperation

Arguments in favor of the increasing importance of sourcing external knowledge to develop innovation state that acquiring external resources within the framework of R&D cooperation can be cheaper and more effective for firms than in-house R&D (Becker and Dietz, 2004). Romijn and Albu (2001) examined, in their work, factors explaining firms' innovativeness in a sample of High-technology companies in England. They show that universities and scientific institutions are effective external sources that firms rely on to enhance their propensity to generate product and process innovations. Tödtling et al. (2009) investigate how firms' innovativeness level is related to particular kinds of external knowledge links in a sample of Austrian firms. They find that firms' ability to generate more advanced innovations is enhanced by cooperation with universities and research organizations. Also, in their study applied to seven European countries, Kaufmann and Tödtling (2001) investigated the impact of location and types of partners on innovation activity of 517 firms. They show that universities are more likely to stimulate firms' advanced innovations than other external partners, mainly because universities' primary focus is production of new knowledge independently from economic considerations, that could motivate some other partners. Indeed, they find that firms that cooperate with science have a greater ability to develop more radical innovations and to introduce new to the market products.

Based on a sample of 2056 Dutch innovating firms, Belderbos et al (2004) have analyzed the impact of R&D cooperation with external partners on firms' productivity in innovative sales new to the market. They find that cooperation with universities and research institutes stimulates creation and generation of product innovations that are novel to the market. Another interesting study on Canadian firms concludes that generally available sources of information do not have a significant impact on novelty of firm innovation. However, higher firm's innovativeness level can be reached when firms cooperate with universities and public laboratories (Amara and Landry, 2005). Another branch of the literature provides evidence on the existence of a positive influence of firms engaging in R&D collaboration with universities on their innovation intensity (Vuola and Hameri, 2006, Lööf and Broström, 2008). In line with the previous findings, Becker and Dietz (2004) and Faems et al. (2005) show, in their studies applied to German and Belgian firms respectively, that implementing external capabilities has a positive effect on innovation performance of firms. Moreover, one of the most recent works that evaluated the impact of external collaboration on the degree of novelty of firms' innovation (Vega-Jurado et al., 2008) shows that cooperation with external entities tends to be less important as determinant of innovation of Spanish firms and that it is, conversely, determined by the existence of high internal competencies.

3.2.3. Interaction between internal and external R&D strategies

There is little evidence showing that cooperation with external partners can not generate innovation if it is not combined with firms' internal R&D abilities. A number of relevant studies report evidence on the complementarity between both R&D strategies for the generation of new knowledge. Becker and Dietz (2004), Cassiman and Veugelers (2006) and Su et al (2009) show that the simultaneous use of firms' internal capabilities and knowledge acquired through external partnership has a sizable impact on firms' innovativeness.

Another branch of the literature shows that internal R&D intensity of firms has a negative and moderating effect on the relationship between R&D collaboration with external non-industrial sources, specifically universities and research institutes and product innovation (Vega-Jurado et al., 2008; Tsai and Wang, 2009). In fact, in their study applied to Spanish firms, Vega-Jurado et al. (2008) find that in the presence of high internal R&D intensity, technological opportunities derived from externally non-industrial sources tend to lose their impact on firms' innovativeness level. Moreover, they show that the increase of in-house developed R&D activities implies a decrease in the effect of technological opportunities from external non-industrial sources on the generation of product innovation, which emphasizes a substitution relationship between these variables, rather than a complementary one. Indeed, Tsai and Wang (2009) admit that the existence of a knowledge gap between firms and research organizations, whose knowledge does not focus on commercial ends, makes it more costly for firms to improve their innovations and even affects negatively their innovation performance.

I thus explore in the next sections the effect of R&D internal capabilities on the role of external knowledge acquisition from universities as a determinant of firms' innovativeness level.

3 METHODOLOGY

This paper contributes to the existing literature on internal and external R&D factors and firms' innovativeness by providing new evidence on the particular case of firms located in the Spanish market. In this section, I present a description of the data and the variables used in the empirical analysis.

3.1 Sample and data

The data used are collected from the PITEC database (Technological Innovation Panel), based on surveys of firms' technological innovation compiled by the Spanish National Statistics Institute (INE). Questionnaires were sent to firms located in Spain and having at least 10 employees. The purpose of the survey is to collect detailed information on several research and innovation activity aspects of firms from all industries. PITEC is designed as a panel survey, for which yearly data are available, starting from 2003. In the initial year, the sample did not include small firms with less than 200 employees that did not perform innovative activity. In the next years, the former type of firms was added to the sample. Firms in the database are classified according to their sector of activity and grouped into 53 different 2-digit sectors following the Spanish classification, CNAE-93 Rev.1.

The database provides information about whether or not firms undertake innovative activity during the two-year period prior to the survey, specifying whether it was a product and/or a process innovation. The database contains useful data about the type and characteristics of the innovation. In particular, it includes variables that indicate if the firm introduced new products that are new to the market or only new to the firm, if new products were generated through collaboration with external partners, by the proper means of the firm or by other firms from outside the group. PITEC also provides information on barriers that could impede or reduce the innovative activity of firms. Other information about firm and industry characteristics is also described in the database.

Data on firms' innovative activity are collected from the 2006 survey, whereas I consider lagged independent variables, collected from the 2003 survey[1]. This procedure allows for an appropriate time lag with which the impact of internal and external R&D strategies feeds through innovation activity, in order to reduce the potential simultaneity problems. In fact, firms are asked about their R&D and innovative activities performed during the two years prior to the surveys. For instance, innovation activity gathered from the 2006 survey refers to the activity performed in the years 2005 and 2004, while the R&D activity collected from the 2003 survey are related to the 2001-2002 time-period.

In the 2003 survey, the dataset does not include any information on non-innovative firms with less than 200 employees, while this kind of information is available in the 2006 survey. Hence, the estimation could be biased if I construct two samples with different firms' innovation specifications. Therefore and in order to include both innovative and non-innovative firms across the two different time periods, I chose to focus only on the samples of big firms (>200 employees). After removing small firms, I am left with a sample of 2857 firms.

3.2 The Variables

Table 1 summarizes the variables used in the present study. In the innovation literature, there is no generalized agreement regarding the conceptualization of the variable innovation. Most frequently, studies measure innovation by innovation sales, number of innovation outputs or innovation performance. The concepts of degree of innovation or innovativeness level have been less explored in the literature. In this paper, to measure the innovation output of firms I construct the dependent variable innovativeness level (LEVEL). It can take 4 possible values: 0, if no product innovation was introduced by the firm, 1: if firm introduced innovation products that are new to the firm, 2: if firm introduced innovation products that are new to the market; and 3: if products introduced are new to the firm and to the market. The specification of this variable allows for a distinction among the different effects of R&D strategies on the different innovativeness levels of the firm. I then distinguish two categories of independent variables: variables indicating if firms carry out in-house R&D activities and external R&D cooperation and a number of control variables indicating firms and industry characteristics. To measure the first category, I use the variables COOPER and INTENS. The first variable is a dummy variable taking the value one if firms specifically engage in cooperation with universities during the 2001-2003 time period and zero otherwise. A first caution must be made since the cooperation variable is observed only for innovative firms. That is, it is observed only when firms have generated new product or new process or have in progress or abandoned innovation

[1] I used the 2004 survey to collect some of the control variables that did not exist in the 2003 survey data.

activity during the 2001-2003 time-period. Thus, one would argue that a sample selection problem might characterize the data. However, the structure of the questionnaires is such that it is likely that firms declare to cooperate in innovation activities only if they already declare to have generated innovative activity during the 2001-2003 time-period. This is not surprising since the cooperation is an innovative activity. Hence, no firm would have declared to cooperate with external sources if it has not generated innovative activity during the same period of time. Therefore, since no cooperation exists when there is no innovation, I substitute the missing values of the variable COOPER by zeros when the firms declare to not to have innovative activity. The second variable measures the R&D intensity of the firm. It is a firm's total expenditures on innovation activities per employee. I considered lagged variables to allow for a delay between occurrence of the R&D strategy and its subsequent effects on innovation. The actual delay –albeit unknown- is likely to be longer than one year, thus it allows to avoid simultaneity problems and to leave the necessary time gap to firms to generate innovation output after engaging in internal R&D and collaboration with universities.

I also include controls for firm specific factors and industry characteristics. I specifically consider the share of researchers in the firm (RESEAR), firm size (EMPL), exportation activity indicator (EXPORT), the share of basic research undertaken by the firm (BASIC) and two dummy variables for firms in high and medium-tech sectors (Hi-MEDIUM) and manufacturer sectors (MANUF) respectively. Size is measured by total number of employees (EMPL). The RESEAR variable indicates the proportion of researchers in total R&D personnel of the firm. This variable captures the absorptive capacity of the firm to use knowledge acquired from outside the firm. I also include a variable indicating the share of fundamental research applied by the firm to their total R&D activity (BASIC). To control for the degree of firm's internationalization, a new dummy variable is constructed (EXPORT) which equals one if the firm reports to target the international market, and zero otherwise. This variable is constructed using data from the 2004 survey, since the 2003 survey does not provide information on exportation activity of firms. Finally, I include two dummy variables that indicate if firms belong to high and medium-tech industry sectors (HI-MEDIUM) and manufacturing industries (MANUF), respectively, to control for the industry effects on firms' innovation.

I further apply an extension of the estimation analysis by introducing the interactions between cooperation and fundamental research activity of firms (COOPER*BASIC) and cooperation and the proportion of researchers in the firm (COOPER*RESEAR).

Table 2 gives summary statistics and correlations of the variables used in the present paper. From the surveyed firms in 2003 and 2006, a total of 2847 are present in the two surveys and satisfy the necessary condition of size (firms with more than 200 employees). The highest correlation coefficient is found between the variables COOPER and COOPER*RESEAR (0.78). This result is not surprising since the correlation between the interaction terms and their individual variables is generally high. However, in the next section, to estimate the model, I use Stata routine for multinomial logit models, which allows for a control of the multicolinearity problem that might exist between the variables.

In figure 1, I report some industry averages of firms cooperating in R&D strategies with universities in high and medium-tech sectors. It is likely that, as has been shown in a wide range of empirical research, firms in Pharmaceutical, Chemical and Electrical Machinery sectors are those that cooperate the most in R&D with universities, mainly due to the rapid growth of these sectors and to the frequent need of these firms to generate new products.

Figure 2 presents a description of innovation characteristics of firms in the sample according to their level of innovativeness. The results show the following pattern in the proportion of firms with higher innovativeness level: firms generating products that are new to the market or both new to firm and to the market represent respectively 16.76% and 10.68% of the whole sample, comparing to 23.86% of firms with products new only to the firm. Also, one may notice that the sample of manufacturing firms produce more innovative products than firms' sample where both manufacturing and services firms are included.

4 EMPIRICAL ANALYSIS

The focus of this paper is to investigate the impact of firms' internal capabilities and their cooperation with universities in R&D activity on the level of innovativeness, controlling for other influential factors. In the following subsections, I expose the basic and extended empirical models that I use to study the impact of internal and external R&D factors on innovativeness level of firms.

4.1 Empirical models

In the empirical literature, researchers used different types of models to study the relationship between cooperation with external partners and firm's innovation. Amara et al. (2005) and Vega-Jurado et al. (2008) used a multinomial logit model to explain the innovativeness level in their sample applied to Canadian and Spanish samples, respectively. However, Nieto and Santamaría (2007) used a bivariate probit model to study the two levels of innovation that they considered in their Spanish sample.

In order to study the impact of internal R&D and cooperation with universities on the four levels of firms' innovativeness, I propose to study four econometric models. The first model is the basic multinomial logit model where I take as independent variables cooperation with universities, R&D intensity and R&D characteristics of firms and other control variables.

$$
\begin{aligned}
LEVEL &= \alpha_0 + \alpha_1 COOPER + \alpha_2 INTENS + \alpha_3 RESEAR + \alpha_4 EMPL + \alpha_5 EXPORT \\
&\quad + \alpha_6 BASIC + \alpha_7 HI-MEDIUM + \alpha_8 MANUF \qquad (1)
\end{aligned}
$$

In the second step of the analysis I want to investigate some additional interactions between cooperating in innovative activity and some firm R&D characteristics on the innovativeness level of firms. In fact, since the literature provides controversial conclusions on the impact of this kind of interactions on the innovation activity of firms, I want to shed more light on this question in the study. Therefore, I analyze the importance of firm's internal capabilities to develop new knowledge when associated to R&D cooperation with universities to the innovativeness level of the firm. For instance, I want to investigate if the effect of cooperation with universities on firms innovativeness level is enhanced by internal corporate R&D capabilities, in this case working as a complement, or decreased, in that case working as a substitute to external cooperation with universities. I further include two interactive terms calculated as the products of multiplying the collaboration variable times two different variables: internal

R&D capabilities and the share of the fundamental research activity in the firm[2]. I actually study three additional models. The second model includes an interaction term between co-operation variable and fundamental research activity of firms (BASIC). In the third model, I rather use the interaction between cooperation variable and the share of researchers in the firm (RESEAR). Finally, in the last model I include both interaction terms in the regression.

$$\begin{aligned} LEVEL &= \alpha_0 + \alpha_1 COOPER + \alpha_2 INTENS + \alpha_3 RESEAR + \alpha_4 EMPL + \alpha_5 EXPORT + \alpha_6 BASIC \\ &\quad \alpha_7 HI - MEDIUM + \alpha_8 MANUF + \alpha_9 COOPER * BASIC \end{aligned} \tag{2}$$

$$\begin{aligned} LEVEL &= \alpha_0 + \alpha_1 COOPER + \alpha_2 INTENS + \alpha_3 RESEAR + \alpha_4 EMPL + \alpha_5 EXPORT + \alpha_6 BASIC \\ &\quad \alpha_7 HI - MEDIUM + \alpha_8 MANUF + \alpha_9 COOPER * RESEAR \end{aligned} \tag{3}$$

$$\begin{aligned} LEVEL &= \alpha_0 + \alpha_1 COOPER + \alpha_2 INTENS + \alpha_3 RESEAR + \alpha_4 EMPL + \alpha_5 EXPORT + \alpha_6 BASIC \\ &\quad \alpha_7 HI - MEDIUM + \alpha_8 MANUF + \alpha_9 COOPER * BASIC + \alpha_{10} COOPER * RESEAR \end{aligned} \tag{4}$$

where right-hand side variables are measured at time (t) and (t+1) and where the dependent variable LEVEL is the level of innovation measured at time (t+3).

Providing that the dependent variable can take four values, I propose to use a multinomial logit model to study the impact of firms' internal and external R&D strategies on the formers' level of innovativeness. I consider that the probability of occurrence of each level of innovation k (k= 0,1,2,3) is the following:

$$Probik = \frac{e^{\beta_k X_i}}{1 + \sum_{k=0}^{3} e^{\beta_k X_i}}$$

where X_i is the matrix of level of innovation attributes and β_k is a vector m x 1 parameters. I take as reference category that where firm product innovation equals zero (k=0) during the period 2004-2006. The estimated parameters can be interpreted as follows:

$$\frac{Prob_{i1}}{Prob_{i0}} = \frac{e^{\beta_1 X_i}}{e^{\beta_0 X_i}} = e^{(\beta 1 - \beta 0)Xi}$$
$$\frac{Prob_{i2}}{Prob_{i0}} = \frac{e^{\beta_2 X_i}}{e^{\beta_0 X_i}} = e^{(\beta 2 - \beta 0)Xi}$$
$$\frac{Prob_{i3}}{Prob_{i0}} = \frac{e^{\beta_3 X_i}}{e^{\beta_0 X_i}} = e^{(\beta 3 - \beta 0)Xi}$$

Which can be written as:

$$Ln\frac{Prob_{i1}}{Prob_{i0}} = (\beta_1 - \beta_0)X_i$$
$$Ln\frac{Prob_{i2}}{Prob_{i0}} = (\beta_2 - \beta_0)X_i$$

[2]Firms are asked about the share of fundamental research as a percentage of their total R&D activity (fundamental and applied research and technological development).

$$Ln\frac{Prob_{i3}}{Prob_{i0}} = (\beta_3 - \beta_0)X_i$$

Accordingly, the estimated coefficients β are interpreted as the marginal change in the logarithm of the odds of the assessment by the firms of the introduction into the market between 2004 and 2006 of products that are new to the firm, new to the market, or both over the category assessing the non introduction of a new product, due to the marginal change in the explanatory variables[3].

4.2 Empirical results

Table 3 below presents results of multinomial logistic estimation of regression (1). In columns (I) and (II), I report two alternative analyses to check for robustness of the results. In the first column, I use the whole sample of firms, whereas in the second I restrict to the subsample of manufacturing firms.

The results indicate that for both samples cooperation variable (COOPER) affects positively the firms' innovativeness level. For instance, in column (I) the Exp (β) shows that when COOPER variable equals one the probability that firms develop products new to the firm, new to the market and new to both categories increases by 2.7; 3.2 and 5.4 times, respectively, in comparison to no innovation category. These results suggest that the effect of cooperation is higher and more significant for the more intensive categories of innovation suggesting that firms are more likely to generate more radical product innovation when they cooperate with universities in R&D activities. This is not surprising, since the main motive behind firms' cooperation with scientific agents is their need to develop increasingly innovative products that cannot be developed through exclusive firms' internal R&D activity, due to high costs considerations or to lack of qualified personnel. Moreover, although it has a significant impact in the regression of whole sample and manufacturing firms sample, R&D intensity (INTENS) is likely to have a small positive impact on all the innovativeness levels of the firms. These results imply that firms conducting internal R&D activities are also shown to have a greater propensity to generate innovative products even if cooperation with universities seems to be the major factor of the development of product innovation. Similarly, RESEAR positively and significantly affects the innovativeness level of firms in both samples, with almost no difference among the three levels of innovation studied. The results therefore seem to join the previous research literature findings (Cohen and Levinthal, 1990), suggesting that the proportion of researchers in the firm, which may serve as a measure of firms' absorptive capacity, is an important driver for innovation activities. However, results show that the proportion of basic research activity of the firm has no significant impact in the regression.

Additionally, firm size, export activities and the industry dummies are important factors controlling for firms characteristics' impact on their innovativeness level. Results suggest that being a large firm (EMPL), an exporting firm (EXPORT), a firm operating in high or medium-tech sectors (HI-MEDIUM) or a manufacturing firm (MANUF) are factors that affect positively the firm's innovation performance.

[3] I also conduct an ordered model to check the robustness of the results. The results obtained are almost similar. However I decide to use the multinomial logistic model since it allows us not only to identify the determinants of firm product innovation, but it also allows to distinguish the impact of each factor over the different categories of firm innovation.

Table 3: Estimation Results of Regression (1) using a multinomial logit model

Variables	(I) Whole Sample		(II) Manufacturing Firms	
	Coef (β)	Exp (β)	Coef (β)	Exp (β)
level 1				
COOPER	1.011***	2.747	0.903***	2.468
INTENS	0.000	1.000	0.000***	1.000
RESEAR	0.017***	1.017	0.015***	1.015
EMPL	0.000	1.000	0.000	1.000
EXPORT	0.479***	1.615	1.043***	2.837
BASIC	0.002	1.002	0.003	1.003
HI-MEDIUM	0.567***	1.764	0.402**	1.494
MANUF	0.514***	1.672	-	-
_cons	-2.161***	0.115	-2.090***	0.124
level 2				
COOPER	1.161***	3.192	1.008***	2.741
INTENS	0.000**	1.000	0.000***	1.000
RESEAR	0.022***	1.022	0.018***	1.018
EMPL	0.000***	1.000	0.000**	1.000
EXPORT	0.504***	1.655	0.583**	1.792
BASIC	0.000	1.000	0.003	1.003
HI-MEDIUM	0.844***	2.325	0.490**	1.632
MANUF	0.661***	1.938	-	-
_cons	-3.351***	0.035	-2.682***	0.068
level 3				
COOPER	1.686***	5.399	1.619***	5.048
INTENS	0.000*	1.000	0.000***	1.000
RESEAR	0.019***	1.019	0.016***	1.016
EMPL	0.000***	1.000	0.000*	1.000
EXPORT	0.985***	2.679	1.437***	4.207
BASIC	0.000	1.001	0.003	1.003
HI-MEDIUM	0.790***	2.204	0.451**	1.570
MANUF	0.869***	2.385	-	-
_cons	-3.337***	0.036	-2.787***	0.062
N	2846		1262	
LR Chi-squared (df)	826.91		351.00	
Pseudo R2	13.64%		10.94%	

Significance levels: * $p<0.1$, ** $p<0.05$, *** $p<0.01$
(Level=0 is the base outcome)

Table 4 reports the results of regressions (2), (3) and (4) using a multinomial logit model, where I include the interaction terms in the regressions. In column (V), I report the results of the regression (2) estimation when I only consider the interaction term COOPER*BASIC. In column (VI), I alternatively report results of regression (3) estimation, where I include the variable COOPER*RESEAR instead. Finally, the column (VII) presents the estimation results of regression (4) when I include the two interaction terms in the regression. I also report an additional estimation applied to manufacturing firms to checks for the robustness of the results.

Results show that, as in the basic model, the cooperation variable (COOPER) is still positively and significantly affecting firms' innovativeness level. Also, one can notice that this variable has a small increasing impact on the more radical innovations, mainly those that are new to the market or those that are new to the firm and to the market. Also, when I include interaction variables into the basic model, the R&D intensity variable (INTENS) is found to have a positive but considerably small effect in the three estimation regressions. The RESEAR variable is highly and positively correlated with the innovativeness level of firms, suggesting that the proportion of researchers, which allow for a better understanding and assimilation of knowledge acquired from external sourced, is an important factor in the generation of innovation. The results also show that the coefficients on the interaction terms (COOPER*BASIC) and (COOPER*RESEAR) are significant and negative, especially in the sample including both manufacturing and services firms. These results suggest that internal R&D capabilities of firms, measured by either the proportion of basic research or the share of researchers in the firm, reduce the impact of cooperation with universities on firms' innovativeness levels. Hence, it is likely that, in line with evidence in Tsai and Wang (2009), internal R&D activity of firms and the external knowledge acquired through cooperation with universities do not generate a complementary effect on innovation.

Table 4: Estimation Results of Regression (2) using a Multinomial Logit Model

Variables	Whole Sample			Manufacturing Firms		
Level 1	(V)	(VI)	(VII)	(V)	(VI)	(VII)
COOPER	1.205***	1.541***	1.666***	1.003***	1.324***	1.394***
INTENS	0.000	0.000	0.000	0.000***	0.000***	0.000***
RESEAR	0.017***	0.019***	0.018***	0.015***	0.016***	0.016***
EMPL	0.000	0.000	0.000	0.000	0.000	0.000
EXPORT	0.474***	0.481***	0.476***	1.040***	1.043***	1.040***
BASIC	0.004	0.001	0.003	0.004	0.003	0.003
HI-MEDIUM	0.564***	0.561***	0.559***	0.401**	0.397**	0.396**
MANUF	0.514***	0.506***	0.508***	-	-	-
COOPER*BASIC	-0.022**	-	-0.019*	-0.012	-	-0.010
COOPER*RESEAR	-	-0.018***	-0.016**	-	-0.015*	-0.014
_cons	-2.165***	-2.166***	-2.169***	-2.091***	-2.093***	-2.093***
level 2						
COOPER	1.384***	1.814***	1.953***	1.118***	1.539***	1.613***
INTENS	0.000**	0.000**	0.000**	0.000***	0.000***	0.000***
RESEAR	0.021***	0.024***	0.023***	0.018***	0.020***	0.020***
EMPL	0.000***	0.000***	0.000***	0.000**	0.000**	0.000**
EXPORT	0.494***	0.505***	0.497***	0.579**	0.582**	0.578**
BASIC	0.003	-0.001	0.002	0.004	0.003	0.004
HI-MEDIUM	0.840***	0.834***	0.832***	0.488**	0.482**	0.481**
MANUF	0.663***	0.646***	0.651***	-	-	-
COOPER*BASIC	-0.026**	-	-0.023*	-0.013	-	-0.011
COOPER*RESEAR	-	-0.021***	-0.019**	-	-0.018*	-0.017*
_cons	-3.357***	-3.362***	-3.365***	-2.682***	-2.694***	-2.693***
level 3						
COOPER	1.861***	2.613***	2.714***	1.761***	2.559***	2.642***
INTENS	0.000*	0.000*	0.000*	0.000***	0.000***	0.000***
RESEAR	0.018***	0.024***	0.023***	0.016***	0.021***	0.021***
EMPL	0.000***	0.000***	0.000***	0.000*	0.000*	0.000*
EXPORT	0.980***	0.981***	0.978***	1.425***	1.421***	1.414***
BASIC	0.003	-0.001	0.001	0.005	0.002	0.003
HI-MEDIUM	0.788***	0.775***	0.774***	0.449**	0.442**	0.441**
MANUF	0.869***	0.829***	0.830***	-	-	-
COOPER*BASIC	-0.019**	-	-0.014	-0.017	-	-0.012
COOPER*RESEAR	-	-0.029***	-0.028***	-	-0.030***	-0.029***
_cons	-3.340***	-3.379***	-3.381***	-2.788***	-2.876***	-2.875***
N		2846			1262	
LR Chi-squared (df)	834.13	845.90	857.17	352.89	364.02	365.06
Pseudo R2	13.76%	13.95%	14.04%	11.00%	11.35%	11.38%

Significance levels: * p<0.1, ** p<0.05, *** p<0.01; (Level=0 is the base outcome)

These findings suggest that firms that develop high internal knowledge and engage in R&D cooperation with external sources, specifically universities, are likely to devote more efforts to coordinate their internally and externally acquired knowledge. Thus a firm with high levels of internal R&D activity that engages in collaboration with universities spends more time and communication efforts to develop novel products, which reduces its ability to generate innovations.

Finally, as for the control variables, the results show that, in both samples, the firm size variable (EMPL) has a significant and positive coefficient in the regressions only for the radical innovation categories. Also, one can notice that, apart from the variable BASIC, the coefficients on all the remaining control variables are significant and positive in the three augmented regressions.

5 CONCLUSION

Understanding the implementation of innovation mechanisms and the way to determine the effective drivers of higher innovation levels remains a complex and hard task for business managers. Given that firms' growth is directly related to their ability to generate novel innovations, a great attention has been dedicated to the examination of internal and external R&D factors affecting product innovation.

In this study, I examined the role of some internal R&D capabilities and cooperation with universities in R&D activities on innovativeness level of firms in Spain, using the 2003, 2004 and 2006 cross-sections of the PITEC dataset. I also looked at the issue whether in-house and externally acquired knowledge can be considered as complements or substitutes to firms' internal innovation activities.

The results show that internal know-how as well as sourcing knowledge through cooperation with universities have both a positive influence on the innovativeness level of the firm. Nevertheless, even if the findings show no difference in the impact of internal R&D activity among the different levels of innovativeness, the effect of cooperation with scientific sources is higher for more intensive innovations. The findings also support the idea that firms are likely to enhance their innovativeness levels when they rely on higher share of researchers in their staff of qualified personnel, suggesting that firms' capacity to absorb knowledge from external sources can be considered as an important factor in the generation of innovation.

However, when I considered the joint effect of in-house R&D activity and sourced knowledge through cooperation with universities on the novelty of innovation, these factors seem to be substitutes rather than complements. In fact, in Spain, firms relying on internal R&D capabilities have lower propensities to enhance their innovativeness level trough cooperation with universities in R&D activities.

These findings bring important implications regarding the use of different R&D strategies by firms located in Spain to generate innovative products. Further empirical work is however needed to prove the strength of these results. Future research should generalize these findings applied to a sample of Spanish firms to many other European countries. Actually, in line with the surveys of the Spanish Statistic Institute (INE) used in this paper, an equivalent dataset is available from European countries through the Community Innovation Survey (CIS). This makes it feasible to carry out a comparison of these findings with those for other countries. Furthermore, since more recent data are regularly being available, the use of a panel dataset would allow controlling for firm-specific effects and would bring more strength to the earlier findings.

APPENDIX

Table 1: Description of the Variables

Variable	Description	Measure
Innovativeness Level	Level 0	Dummy variable taking the value 1 if no product innovation has been introduced
	Level 1	Dummy variable taking the value 1 if firm introduces Product innovation new to the firm
	Level 2	Dummy variable taking the value 1 if firm introduces Product innovation new to the market
	Level 3	Dummy variable taking the value 1 if firm introduces Product innovation new to the firm and to the market
Independent Variables	Cooperation with universities (COOPER)	Dummy variable taking the value 1 if firm cooperates with universities
	R&D intensity (INTENS)	Total innovation expenses to total number of employees
	Researchers (RESEAR)	Proportion of researchers in total R&D personnel of the firm
	Fundamental research BASIC)	Share of fundamental research in total firm R&D activity
	COOPER*BASIC	Interaction between collaboration with universities and firm performing fundamental research
	COOPER*RESEAR	Interaction between collaboration with universities and internal R&D activity of the firm
	Size (EMPL)	Dummy variable taking the value 1 if number of employees is greater than 200
	Exportation activity (EXPORT)	Dummy variable taking the value 1 if firm exports to international markets
	Industry (HI-MEDIUM)	Dummy variable taking the value 1 if sector of activity belongs to high and medium-tech industry
	Manufacturer firms (MANUF)	Dummy variable taking the value 1 if firm belongs to manufacturer sectors

Table 2: Means and standard deviations

Variable	Mean	S.D	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) LEVEL	0.730	1.080	1										
(2) COOPER	0.108	0.310	0.36	1									
(3) INTENS	2400.689	15556.410	0.15	0.20	1								
(4) RESEAR	12.558	24.996	0.35	0.38	0.17	1							
(5) EMPL	921.746	2332.736	0.08	0.07	-0.01	0.03	1						
(6) EXPORT	0.494	0.500	0.31	0.20	0.12	0.26	-0.06	1					
(7) BASIC	4.093	16.893	0.12	0.09	0.09	0.32	-0.02	0.12	1				
(8) HI-MEDIUM	0.177	0.382	0.31	0.28	0.21	0.26	-0.01	0.33	0.06	1			
(9) MANUF	0.444	0.497	0.31	0.22	0.05	0.27	-0.09	0.45	0.13	0.34	1		
(10) COOPER*BASIC	0.895	6.735	0.12	0.38	0.22	0.18	0.03	0.07	0.37	0.10	0.08	1	
(11) COOPER*RESEAR	4.269	15.655	0.27	0.78	0.21	0.54	0.07	0.17	0.09	0.23	0.16	0.35	1

Figure1: Firms Cooperating in R&D with Universities in High and Medium-Tech Industries

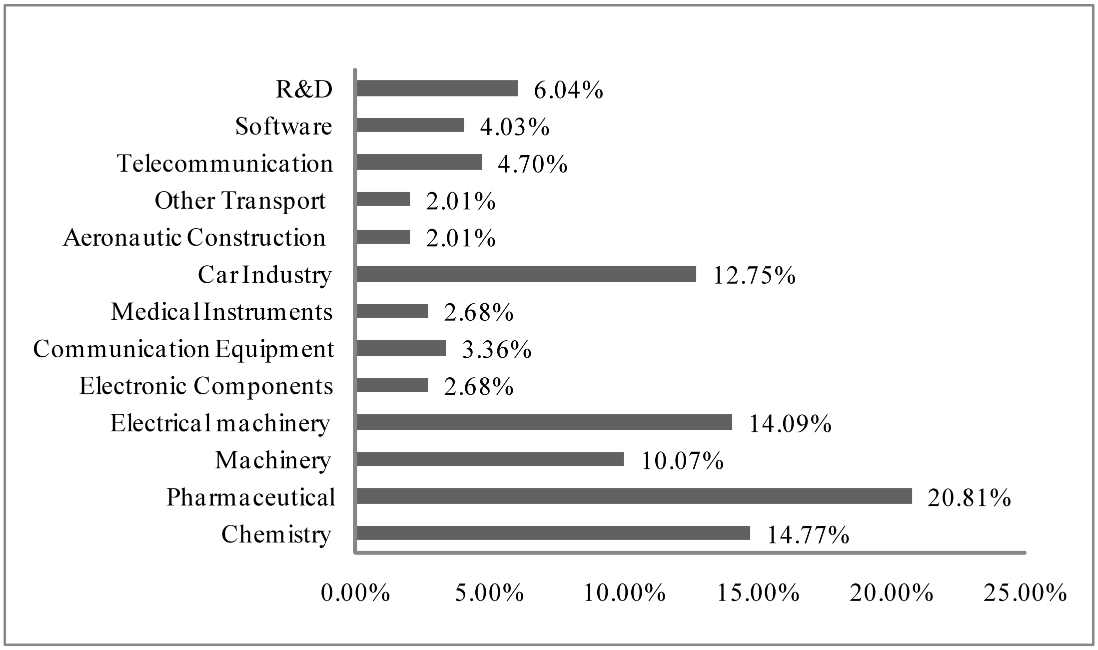
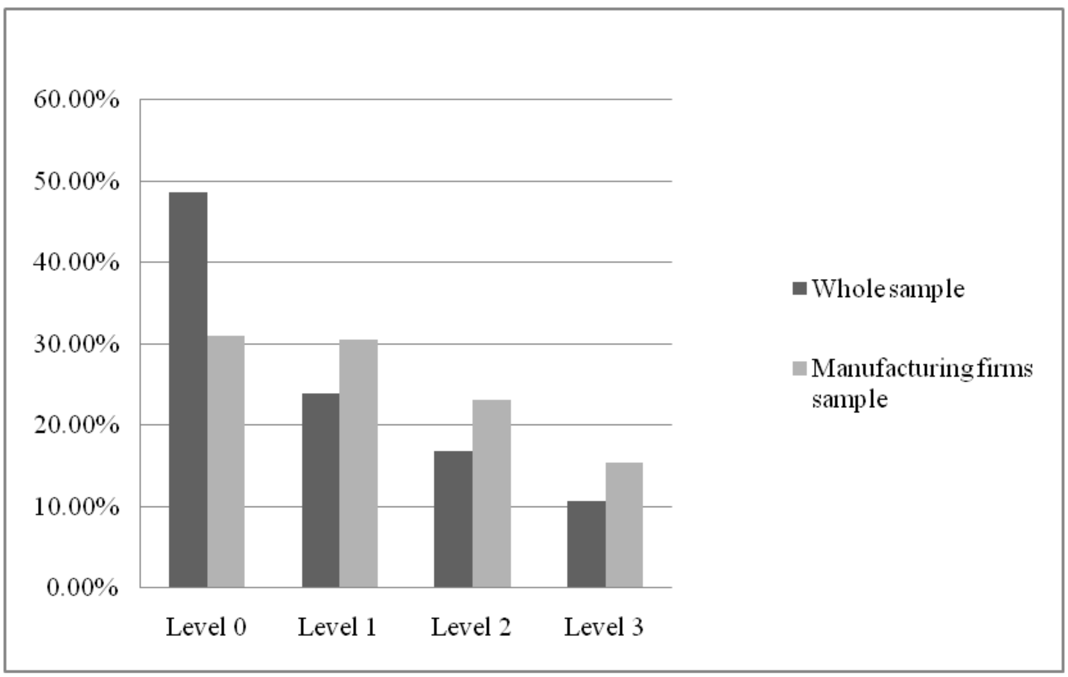


Figure 2: Distribution of Firms according to their Innovativeness Level



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