Are firms interested in collaborating with universities? An open-innovation perspective in countries of the South West European Space.

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Abstract.

This paper explores the determinants of a firm's interest in collaborating with universities and whether they differ by the technological level of the company's industry. Based on the conceptual framework of Open Innovation (OI) model, it is included some aspects related to the transaction costs and roles of innovation diffusion that justifies the study of firm´s interest as previous step of an open-innovation relation among firms and partners. The evidence is based on data collected through semi-structured interviews between January 2009 and October 2009, on a sample of 375 firms from three countries: Spain, Portugal and France. The results indicate that more innovative firms tend to be more interested in collaborating with universities. The paper provides evidence that country factors also affect a firm's intention of collaborating with universities. Finally, the results show that the determinants of a high-tech firm's attitudes to cooperation differ from those found in a non high-tech firm. In the future, the study of the determinants of those firms' formal decision to cooperate may let us to understand whether the driving forces of both interest in and decision to cooperate differ.

Code JEL: M12; key words: university industry collaboration, innovation transfer, R&D, academic entrepreneurship.

1. INTRODUCTION

Innovation is strongly and positively linked to a firm's ability to absorb external information, knowledge and technologies (Segarra and Arauzo, 2008). A way to improve the innovative performance of a firm is engaging in R&D cooperation with different partners. The number and quality of liaisons between the agents who take part

in the National System of Innovation determine the rate of technological change in a particular region and the efficiency of its firms (Freeman, 1987). Thus, the country that encourages an infrastructure of links among companies, universities and the government therefore gains a competitive edge (Marques et al., 2006).

According to Etzkowitz and Leydesdorff's Triple Helix model (1996), as university produces and disseminates scientific and technological knowledge, it plays a crucial role to industrial innovation. Nevertheless, innovation transfer through university-industry collaboration is a complex problem. Research institutions and firms perceive certain aspects of collaboration differently, and it often leads to a lack of confidence and problems of communication within both subsystems (Cotec Foundation 2007; 2011). In particular, the lack of understanding of which are the determinants of university-firms collaboration is one of the reasons that makes it difficult to take advantage of the scientific and technological capacity of the academic R&D system.

In recent years R&D cooperation has stimulated a rich stream of literature (Okamuro et al., 2008; Segarra and Arauzo, 2008). Theoretical and empirical literature has increasingly focused on analyzing the determinants of R&D cooperation by firms. This approach takes as dependent variable the R&D collaboration agreements engaged by the firm. However, the firm's interest in R&D cooperation is the previous step of the open-innovation relation between firms and partners. This paper explores the determinants of a firm's interest in collaborating with universities and whether they differ by the technological level of the company's industry.

The analysis is addressed from a database that was constructed from a survey administered to companies and research groups in eight of the regions that belong to three countries of the South West European Space; Spain, Portugal and France. As Segarra and Arauzo (2008) mention in their studies, the Spanish and Portuguese cases are interesting because they have fewer R&D activities than other European countries (see Table 1). Additionally, Spanish and Portuguese universities have been characterized by a short tradition of ties with industry, but in the last decades these countries have tried to develop policies focused on facilitating the creation of networks between universities and industry.

In Portugal, the University Technology Enterprise Network (UTEN) has considerably strengthened this movement to emphasize the transfer and commercialization of technology on an international scale. UTEN was launched in March 2007 by the promotion and support of The Foundation for Science and Technology. The Portuguese Institute of Industrial Property (INPI), and the Council of Rectors of Portuguese Universities participated in its Foundation, with the support of Institute at The University of Texas at Austin. This is a clear sign of the interest in the commercialization of Science and Technology in global markets. Since its creation, UTEN has strengthened and consolidated an emerging network of Portuguese technology transfer offices (TTOs).

In Spain, in 1986 the Law of Promotion & General Coordination of Scientific & Technical Research (Law of Science) designed a new scientific and technological policy, in order to face certain deficiencies of the national research system. Later, the Government established in 1988 the universities' TTOs to support and promote the dissemination of scientific knowledge and technology transfer activities.

Twenty years later, Spanish and Portuguese universities have substantially improved their contribution to the National Research System, by increasing the activities related with the commercial exploitation of knowledge. Between 1999 and 2009, Spain and

Portugal have increased the Gross Domestic Expenditure on R&D (GERD) and specifically, Higher Education Expenditure on R&D. This increase of budget has reduced the difference in the ratio of Gross Domestic Expenditure on R&D as a percentage of Gross Domestic Product (GDP) of Spain and Portugal, compared to countries like France, where ties between university and industry have been supported for years (Table 1).

		1999	2009	Increase
Gross Domestic Expenditure on R&D (GERD, million current PPP $)	France	30,762.85	49,143.48	60%
	Portugal	1,169.43	4,349.21	272%
	Spain	6,817.91	20,546.62	201%
Higher Education Expenditure on R&D (HERD, million current PPP $)	France	5,279.73	10,183.66	93%
	Portugal	451.22	1,583.37	251%
	Spain	2,053.56	5,718.52	178%
GERD as a percentage of GDP	France	2.16	2.26	5%
	Portugal	0.69	1.64	139%
	Spain	0.86	1.39	62%

Table 1: Science and Technology Indicators. Source: Main Science and Technology Indicators (OECD)

The main objective of this paper is exploring the determinants of firm´s intention of cooperating with universities. Previous studies on R&D cooperation have focused on cooperation agreements, but they have ignored the role of the firm's interest. Nevertheless, a firm's interest in R&D cooperation might be considered as the previous step of an open-innovation relation between firms and universities. Most of previous research is focused on the American and British cases. Therefore, this analysis offers interesting opportunities for a better understanding of the university-industry collaboration in South European countries, whose universities have been characterized by a short tradition of ties with industry and whose technology transfer model presents important institutional differences with the Anglo-Saxon model.

This paper is organized as follows. Section 2 introduces the conceptual framework used to lead the hypothesis. In Section 3, the methodology is explained. Section 4 presents the outcomes of the econometric models, and finally, Section 5 summarizes the main results, and does some proposals for decision-makers and future research.

2. THEORETICAL FRAMEWORK

The spiral triple-helix model positions the university as a strategic actor in the whole innovation process. This model assumes that research bodies, the government and industry can contribute to a country's economic growth through the development of "generative relationships" (Etzkowitz & Leydesdorff, 2000), i.e., reciprocal relations that persist over time and induce changes in the way agents come to conceive their environment and how to act in it. However, because research institutions and firms perceive certain aspects of collaboration differently, new conceptual models are required to provide a better explanation of the university-industry collaboration.

In this sense, the Open Innovation (OI) model posits that firms' internal research and development are elements that come from the market itself and from society in general. This means that valuable ideas can come from inside or outside the firm (Chesbrough, 2003; Van de Vrande, 2009). This model places the firm instead of university at the centre of the system.

Focusing on the firm´s interest as motivator of the university-industry collaboration, according to the approach of the Theory of Transaction Cost, cooperation is considered a hybrid between the coordination of transactions through the market or through the organization (Hagedoorn &Schakenraad, 1990). In certain circumstances, cooperation can be a better alternative to the market because it creates a level of trust between the parties which reduces the likelihood of opportunistic behavior.

The Theory of Transaction Cost (Coase, 1937; Williamson, 1975, 1985) focuses on organizational efficiency, and provides the use of external sources of knowledge as an appropriate strategy to achieve greater flexibility and reduce the uncertainty associated with innovative activity. Following this approach, the main motivations for collaboration are primarily related to the reduction of risks and uncertainty. Cooperation helps reduce costs to the extent that allows members to benefit from economies of scale and share the fixed costs associated with innovation activities. Hence, by combining efforts, companies can reduce uncertainty of research activity and increase the likelihood of a positive result (Dodgson, 1992; Hagendoorn, 1993).

However, as Rogers stated in the Diffusion of innovation Theory (Rogers, 1962), the adoption of a innovation is a process whereby some people or institutions are more interested in the adoption of this innovation than others. So, the low economic impact of university-business cooperation (Polt et al., 2001) can be explained if one takes into account the type of knowledge that usually provides science in relation with the demand for such knowledge in the innovation cycle of companies. Scientific institutions primarily offer new knowledge required by the firms in order to develop their innovations and sell them in the market. As such innovation activities are characterised by high uncertainty and low demand for the outcomes of innovation activities, only a few, pioneering firms are engaged in such activities. However, most of the innovation activities of firms are developed in later stages of the cycle, that is, the redesign of existing products according to market needs, the diffusion of new technologies in new areas implementation or the adoption of new technologies invented elsewhere.

Nevertheless, the literature in innovation economics suggests that from a wider perspective, the use of scientific knowledge by setting up and maintaining industry-science relations positively affects innovation performance, as measured by the share of sales due to new products or services (Kline & Rosenberg 1986, Dodgson 1994, David & Foray 1995, Rothwell 1992). In this sense, when looking on framework conditions for the university-industry collaboration from the demand side (i.e. firms), one has to bear in mind that only a small fraction of firms can be relevant partners in this R&D collaboration (Polt et al., 2001).

According to previous literature, firms usually choose to university as a partner for the following reasons: a) to access to knowledge for their innovations development (Bayona et al., 2002, Hall, 2003; Schartinger et al., 2001 Tether, 2002, Wu, 2001), b) to solve specific problems (Bayona et al, 2002. Wu, 2001), c) to address the lack of own technical staff (Tether, 2002, Wu, 2001); d) to reduce costs and risks through the use of university infrastructure (Santoro & Chakrabarti, 2002. Tether, 2002), the access to international cooperation networks (Bayona et al, 2002) and co-finance research (Bayona et al ., 2002).

Since 1992, when Hauschildt first put forward a framework for university-firm collaboration, some studies have tried to classify the university-industry collaborative relations according to how demanding they are: a) far-range (this implies that there is complex collaboration which is resilient, and in which researchers and business

professionals work together on projects and jointly produce outputs), b) medium-range (involving the mobility of researchers towards firms, either temporarily or permanently in the form of spin-offs or permanent contracts), and c) short-range (the commercial transfer of intellectual capital in the form of knowledge or technology). Lines of collaboration can be inter-combined within what has been labelled "open innovation" (Perkmann & Walsh 2007). However, far-range collaboration is particularly important, because it entails a decision to cooperate and not just a decision to purchase knowledge, and it usually favours setting up learning communities which go beyond geographical and entrepreneurial boundaries.

The conceptual framework of our analysis divide determinants for collaboration in two groups: a) those studies focused on general determinants, and b) those based on considering prior innovation and the strategic approach of the firm as determinant of the university-industry collaboration.

Table 2 summarizes the results of some of the most recent and relevant empirical studies on these topics.

AUTHORS	COUNTRY: UNIT OF ANALYSIS - SOURCE (YEAR)	DEPENDENT VARIABLE	RESULTS
Cohen et al. (2002)	USA: 1.186 firms Source: Carnegie Mellon Survey on industrial R&D (1994)	Suggesting new R&D projects (1, 0). Logit model	Firm size (+) Firm age (-)
Eom & Lee (2010)	Korea: 538 firms Source: Korea Innovation Survey (2001-2002)	Technological cooperation: whether a firm cooperates with universities or government research institutes for its innovation effort	Firm size (marginally + significant) R&D intensity (marginally + significant) Product innovation (+) Process innovation ( )
Fritsch & Lukas (2001)	Germany: 1800 manufacturing enterprises Source: postal research questionnaire in three German regions (Baden, Hanover-Brunswick-Göttingen and Saxony) (	Propensity to cooperate Number of cooperative relationships	Firm size (+) Firm age ( ) Firm focus on external markets ( )
Fontana et al. (2006)	7 EU countries (Denmark, France, Germany, Greece, Italy, The Netherlands and UK): 558 innovative SMEs Source: KNOW Survey + 70 in-depth interviews (2000)	Number of R&D projects between firms and Public Research Organizations (PROs)	Firm size (+) Firm R+D activity (+) Product innovation ( ) Process innovation ( )
Grandstrand (1999)	Japan and Sweden: 24 and 23 large corporations in Japan and Sweden, respectively, representing chemical, electric and mechanical engineering sectors Source: questionnaire survey (1992)	R&D collaboration between firms and universities	Firm focus on external markets (+)
Jin et al. (2011)	China: case of study based on the open innovation strategy of Royal Philips Electronics and its cooperation relationships with Chinese universities (2005)		
Laursen & Salter (2004)	UK: 2.655 manufacturing firms Source: UK Innovation Survey (2001), based on the core Eurostat Community Innovation Survey (CIS)	Degree of importance of universities and other research institutions as sources of knowledge or information in innovation activities of firms. Ordered logit	Openness to the external knowledge environment (+) Firm size (+) R&D intensity (+) Long term R&D (+) Industry (+)
Levy et al. (2007)	France: 1.020 firms partners of Louis Pasteur university (ULP) Source: database of Louis Pasteur university (1990-2002)	Collaboration profile of the private partners of ULP. Multinomial model	Large groups (+) Firms in high-tech industry (+) Location: France (+) Location: Alsace (+)
Mora-Valentin et al. (2004)	Spain: 88 cooperative agreements between Spanish firms and research organizations Source: database of the national projects run by the Centre for Technological and Industrial Development (CDTI) (1995-2000)	The success of the cooperative relation (evolution of the relationship and global satisfaction of the partners)	Prior cooperative experiences firms-research organizations (+)
Okamuro et al. (2011)	Japan: 499 firms in manufacturing and software industries Source: postal questionnaire survey from a database compiled by Tokyo Shoko Research (2008)	Engaging in R&D cooperation with universities or public research institutions Binary variable (1,0). Probit model	Firm size ( ) R&D intensity (+) Independent (-) Appropriability (+) Founder´s prior innovation output (+) Founder´s prior experience of patent applications (+) Founder´s research capabilities (educational background) (+) Founder´s affiliation to academic associations (+)
Petruzelli (2011)	Europe: 796 university-industry joint patents developed by 33 universities located in 12 European countries Source: European Patent Office (EPO) (1998-2003)	Value of university-industry innovations	Prior cooperative experiences firms-research organizations(+)
Santoro & Chakrabarti (2002)	USA: 21 university research centers and 202 industrial firms (reduced to 189 after the data aggregation) Source:semi-structured interviews and mailed survey questionnaire	Firm´s level of intensity in Industry/University relationships	Firm size (partially confirmed) Firms in high-tech industry (+)

Segarra & Arauzo (2008)	Spain: 4.150 innovative firms Source: The Community Innovation Survey (CIS-3) (1998-2000)	Engaging in R&D cooperation with universities or public research institutions Binary variable (1,0). Logit model	Firm size (+) Domestic group(+) Innovation sources (+) Firms in high-tech industry (+) Product innovation (+) Process innovation (+) Access to R&D public funds (+)
Tether (2002)	UK: 1.270 manufacturing and services enterprises Source: Second European Community Innovation Survey (CIS-2), carried out for the UK Government by the Office for National Statistics (1997).	Propensity to engage in innovation activities Participation in co-operative arrangements for innovation	Enterprise size (+) High-tech intensity of the firm (-) Firm R&D intensity (+)
Veugelers & Cassiman (2005)	Belgium: 748 innovative manufacturing firms Source: Community Innovation Survey (CIS-I)(1993)	R&D cooperation agreements between firms and universities.	Firm size (+)
Woerter (2012)	Switzerland: 920 firms with patent activities Source: Swiss Innovation Pannel + questionnaire survey (2005)	Firm´s transfer intensity	Firm size (+) High-tech intensity of the firm (-) Firm R&D intensity (+)

Table 2: Summary of empirical research

Notes: (+/ -,)Positive/ negative / not significant

In recent years, the literature on the driving forces of R&D transference discusses the university-industry collaboration from multiple perspectives. Most of the empirical studies consider firm-specific and industry-specific characteristics as general determinants of the firm´s R&D collaboration with academic research institutions. However, they do not show a definitive model of determinants that appear to be conductive to entering into university-industry collaboration.

Traditionally, literature has related firm size to its propensity to collaborate. According to previous research, larger firms are more likely to have the capability to exploit external knowledge sources and to build links with universities. This fact could be explained because larger firms have more resources which can help them to exploit external knowledge sources and to build links with universities (Fontana et al., 2006; Laursen & Salter, 2004). Moreover, they are also more likely to employ staff with a professional background in science and engineering, which encourages them to draw from their links with universities (Laursen & Salter, 2004).

Additionally, Santoro & Chakrabarti (2002) find that large firms have higher research support relationships in order to strengthen skills and knowledge, and gain access to university facilities for advancing in non-core technologies, while, in contrast, small firms have higher intensity technology transfer and cooperative research relationships for advancing in core technologies. Hence, we propose the following hypothesis:

H1: Larger firms are more likely to be interested in collaborating with research groups in R&D projects.

Few studies investigate the link between firm age and the use of universities in the innovative activities (Laursen & Salter, 2004). Thus, Cohen et al. (2002) suggests that young firms (no more than five years old), are more likely to collaborate with universities. However, Laursen & Salter (2004) cannot confirm this relation, since older firms tend to have internal resources that make cooperation arrangement easier and effective than otherwise (Tetcher, 2002).

H2: Younger firms are more likely to be interested in collaborating with research groups in R&D projects.

According to Mohnen & Houreau (2003), firms that belong to large corporate groups might be able to tap information from universities/government laboratories or establish contact with them more easily through this network. Hence, hypothesis can be stated as:

H3: Independent firms are less likely to be interested in collaborating with research groups in R&D projects.

In high-tech industries, universities and public research centers play a key role as external sources of open science and R&D cooperative activities (Cohen et al. 2002). Firms in industries with a high technological level are more likely to set up collaborations with research institutions as they are active at the technological frontier and more reliant than other companies on scientific innovations (Fontana et al., 2006). Firms whose product innovation activity is characterized by a relatively high aspiration level have a special need for obtaining external know-how by means of R&D cooperation (Fritsch & Lucas, 2001; Segarra & Arauzo, 2008). Additionally, Levy et al. (2007) show that firms belonging to innovative sectors (as instrumentation and information technologies or pharmacy industries) have a higher chance of being privileged partners of prestigious universities.

External factors as the policy of the government on R&D has been determinant for the technology transfer from public research institutions to industry. This explains the different empirical results obtained for the industry-level characteristics and the firm propensity to collaborate in different countries. In the USA and the European countries, R&D intensity of the firm is a key factor to explain its propensity to collaborate. However, in other developing countries as Korea, this variable is positively related, but insignificant to explain this issue (Eom & Lee, 2010). Hence, we propose the following hypothesis:

H4: Firms in industries with a high technological level are more likely to be interested in collaborating with research groups in R&D projects.

One of the most recursive topics in R&D cooperation is the role of the firm's R&D intensity in encouraging the cooperation with partners. The argument contained in previous research is that investments in R&D provide to the firm of the capability to absorb external knowledge and be innovative (Cohen and Levinthal, 1990). Similarly, Tetcher (2002) concludes that engaging in cooperative agreements was only relevant to firms that consider themselves as innovative. Hence, we propose the following hypothesis:

H5: Firms with prior innovative activity are more likely to be interested in collaborating with research groups in R&D projects.

Firms carry out different types of activities which influence their opportunity to innovate (Fontana et al., 2003). Particularly, previous empirical studies have mainly focused on the effect of product innovations and process innovations on engaging in R&D cooperation, providing mixed results. Thus, Segarra & Arauzo (2008) found a positive relationship between the introduction of both radical product innovations and process innovations and R&D cooperation with universities. However, Eom & Lee (2010) stressed that firms involved in product innovation are more likely to collaborate with universities than those involved in process innovation. Instead, Fontana et al. (2003; 2006) found only support for the hypothesis that the more innovative firms in terms of process innovations rely more on cooperation engagement with universities.

To shed additional light on the links between the type of innovative activities carried out by firms and the interest of firms in collaborating with universities, we propose the next hypotheses:

H5a: Firms with prior product innovation are more likely to be interested in collaborating with research groups in R&D projects.

H5b: Firms with prior process innovation are more likely to be interested in collaborating with research groups in R&D projects.

H5c: Firms with prior commercial innovation are more likely to be interested in collaborating with research groups in R&D projects.

H5d: Firms with prior organizational innovation are more likely to be interested in collaborating with research groups in R&D projects.

Additionally to the previous factors, the literature on the motives for becoming involved in an R&D cooperation also includes the firm's strategy (Fristch & Lucas, 2001). However, most of the previous studies on R&D cooperation have ignored the role of the firm's strategy. Particularly, we highlight two types of strategies. Firstly, since the value creation comes from exploiting investment opportunities, the investment strategy is one of the most important strategies of the firm. Hence, we propose the following hypothesis:

H6a: Firms with an investment strategy related to innovative activities are more likely to be interested in collaborating with research groups in R&D projects.

Secondly, we also expect that the interest in collaborating increases with the need for cooperation. Thus, sometimes the firm is engaged in R&D cooperation to overcome internal problems. Therefore, we formulate the following hypothesis:

H6b: Firms with a set of problems related to innovative activities are more likely to be interested in collaborating with research groups in R&D projects.

As our sample contained firms from three different countries, in addition to the hypotheses described so far, we decided to include an additional hypothesis referred to the origin country of firms in order to capture idiosyncratic cultural or institutional factors for each country (France, Portugal and Spain).

H7: The origin country of the firm has an effect on the interest on collaborating with research groups in R&D projects.

3. METHODOLOGY

3.1. The data and sample

The data used were collected in the European Project CREATINN (Creativity and Innovation) for 2009-2012. The CREATINN Project is an initiative funded by the South West European Space (SUDOE) Territorial Cooperation Programme, which aims to create a Territorial Cooperation Space among the different regions and countries of the Southwest of Europe in the fields of competitiveness and innovation, and to strengthen the social and economic cohesion of the European Union.

A questionnaire was designed for obtaining information, and a standardized methodology was defined for data processing. The result of this work allowed us to obtain information of both innovation demand by firms and research offer by university research groups in the eight regions participants (Spain: Galicia, Vasque Country, Andalusia, Cantabria, Castilla León; France: Aquitannie, Centre; Portugal: Lisbon).

Particularly, with regard to the firms, 439 semi-structured interviews were conducted (262 in Spain, 127 in France and 50 in Portugal) between January 2009 and October 2009. During the interviews, we asked the founders about firm-specific characteristics

and their innovation demand throughout the time horizon 2009-2012. Thus, we obtained information on the next topics:

a) Scientific and technological services that could help companies to develop their innovations.

b) Interest in taking part in R&D cooperation projects with university groups that could apply for a public tender for funding.

d) Specific needs of technological management tools to support innovation in the company.

From among the responses, we discarded 64 questionnaires for considering them not valid or incomplete. As a result, we obtained 375 firms in the final sample because of missing values for some variables. The country distribution was as follows: Spain (243), France (107) and Portugal (25).

3.2. Definition and measurements of the variables

On the basis on the questionnaire survey, the dependent variable was defined as a dummy variable coded as 1 if the firm wanted to engage in R&D cooperation with universities and zero otherwise (INTCOLLU).

As independent variables, we had selected a number of factors that could be grouped into five different vectors of explanatory variables: firm-specific characteristics, industry-specific variables, innovative activities, firm strategy and country variables.

As most of previous studies, firm size was measured as the natural logarithm of both the firm sales (LN_SALES) and the number of employees (LN_EMPLOYEES) working for the firm. We also used the number of employees (EMPLOYEES) and the employees squared to capture potential non-linearities (EMPLOYEES_SQUA).

Similarly to Fritsch & Lukas (2001) and Laursen & Salter (2004), to test the effect of the firm's age on its interest in collaborating with universities, we used the age of firms (AGE), as well as a log transformation of this variable (LN_AGE) and the age squared to capture potential non-linearities (AGE_SQUA).

According to Okamuro et al. (2011) and Segarra & Arauzo (2008), a dummy variable for independent firms (INDEP), as compared to subsidiaries or affiliated firms, was used as an independent variable in the model.

Similarly to Santoro & Chakrabati (2002) and Segarra & Arauzo (2008), we created a dummy variable for firms in high-tech industries (HIGHTECH), according to the Eurostat classification. Eurostat uses the aggregation of the manufacturing industry according to technological intensity and based on NACE Rev.2 at 2-digit level.

As the data used do not show the firm's R&D expenditure, we used as a proxy of R&D intensity a dummy variable coded 1 if the firm had introduced any type of innovation, and 0 otherwise (INN_D). We also classified 4 types of innovative activities introduced by the firm (INNTOT). A log transformation of this variable was used as a proxy of their R&D intensity (LN_INN). Including this variable did not substantially alter the results reported here (data not shown).

According to Eom & Lee (2010), Fontana et al. (2006) and Segarra & Arauzo (2008), to test the effect of the types of innovative activities carried out by firms, we defined four dummy variables to capture whether the firm had introduced product innovation

(PRODINN), process innovation (PROCINN), commercial innovation (COMINN) or organizational innovation (ORGINN).

Additionally, to test the effect of a firm's strategy on its intention of cooperating with universities, we used two dummy variables. Firstly, the investment strategy was tested by asking "Does the firm plan significant investments (as modernizing and expanding its facilities) that might result in innovative activities (2012-2014)?" (SINV_D). The variable was coded 1 if the firm answers yes and 0 otherwise. Secondly, we also asked companies "Does the firm expect any serious problem (affecting products, production process, commercial process or organizational design) whose solution might result in innovative activities (2012-2014)?" (SPROB_D). The variable was coded 1 if the firm answers yes and 0 otherwise.

Finally, three country dummy variables were considered (FRANCE, PORTUGAL and SPAIN). Each one was coded as 1for the referenced country and 0 otherwise.

Group	Factor	Variable	Pred.	Definition
FIRM-SPECIFIC CHARACTERISTICS	*SIZE*	LN_SALES	+	Natural logarithm of sales
		EMPLOYEES		Total number of employees
		LN_EMPLOYEES		Natural logarithm of the number of employees
		EMPLOYEES_SQUA	-	The square of the total number of employees
	AGE	AGE	-	Age of firm: 2011 – year of creation
		LN_AGE		Natural logarithm of age
		AGE_SQUA	+	The square of the age
	INDEPENDENT	INDEP	-	Whether or not firm is founded as an independent firm (1 or 0)
INDUSTRY-SPECIFIC CHARACTERISTICS	*INDUSTRY*	HIGHTECH	+	Whether or not firm belongs to high-tech industries (1 or 0)
INNOVATIVE ACTIVITIES	*INTENSITY*	INNTOT	+	Total number of the innovative activities introduced by the firm (1 to 4)
		LN_INN		Natural logarithm of the total number of the innovative activities introduced by the firm
		INN_D		Whether or not firm has carried out any types of innovative activities (1 or 0)
	TYPES OF INNOVATIVE ACTIVITIES	PRODINN	+	Whether or not firm has introduced product innovation (1 or 0)
		PROCINN	+	Whether or not firm has introduced process innovation (1 or 0)
		COMINN	+	Whether or not firm has introduced commercial innovation (1 or 0)
		ORGINN	+	Whether or not firm has introduced organizational innovation (1 or 0)
FIRM STRATEGY	*INVESTMENT*	SINV_D	+	Whether or not firm plans significant investments that might result in innovative activities in 2012-2014 period (1 or 0)
	PROBLEMS	SPROB_D	+	Whether or not firm expects any serious problem whose solution might result in innovative activities in 2012-2014 period (1 or 0)
COUNTRY	*COUNTRY*	FRANCE, PORTUGAL, SPAIN		Whether or not firm is French/ Portuguese/ Spanish (1 or 0)

Table 3: Definitions of independent variables and predictions

3.3. Model specification

Most of the empirical studies test the hypotheses established in the theoretical framework by means of conditional likelihood models. Therefore, we have chosen to

apply a *probit* model in order to analyze a firm's interest in collaborating with universities. This model establishes a nonlinear relation between a dummy dependent variable and a set of independent variables. The following relation was proposed:

(1)

$$Probability(Y_i = 1) = \phi(\beta_0 + \beta_1 Size_i + \beta_2 Age_i + \beta_3 Indep_i + \beta_4 Hightech_i$$
$$\beta_5 Inn\_d_i + \beta_6 \Pr odinn_i + \beta_7 \Pr ocinn_i + \beta_8 Co\min n_i +$$
$$\beta_9 Orginn_i + \beta_{10} Sinv\_d_i + \beta_{11} Sprob\_d_{ii} +$$
$$\beta_{12} Spain_i + \beta_{13} Portugal_i$$

The dependent variable (Y_i) quantifies the firm's probability of showing interest in collaborating with universities, i is the index of firms and ϕ denotes the standard normal distribution function.

As we mentioned, we divided the explanatory variables into five categories: firm variables, industry variable, innovative activities, firm strategy and country variables. The size, age and independent nature of the firms were included in the model as the firm-specific characteristics affecting the interest in collaborating with universities. The industry variable involves characteristics shared by all firms in high-tech industries, as compared to companies in non high-tech industries. Types of innovative activities point out where innovation activity has been developed. The existence of both, an investment strategy and a set of problems related to innovative activities, were included in the model as the firm's strategies affecting the intention of collaborating with universities.

Finally, the equation included two country dummy variables in order to capture idiosyncratic cultural or institutional factors for each country (Spain and Portugal). These were aspects shared by the firms in one country that determined their interest for collaborating with research groups in R&D projects. In summary, these dummy variables reflected the support for this interest in each country once the firm and industry factors had been discounted. France dummy variable was omitted to avoid perfect multicollinearity, so that the institutional country effects could be interpreted in relation to France.

4. EMPIRICAL RESULTS

4.1. Descriptive analysis

Table 4 reflects the results of a t-test of the differences in means between firms that are interested in collaborating and firms that are not.

VARIABLES	Full sample (Obs= 375)	Not interested in collaborating (Obs=129)	Interested in collaborating (Obs= 246)	p-value
INTCOLLU	0.656			
SALES	14,100,000	6,984,207	17,900,000	0.331
EMPLOYEES	84.117	46.640	104.153	0.320
AGE	18.195	18.225	18.180	0.980
HIGHTECH	0.512	0.698	0.416	0.000
INDEP	0.931	0.930	0.931	0.981
INNTOT	1.616	0.287	2.306	0.000
INN_D	0.621	0.178	0.853	0.000
PRODINN	0.533	0.093	0.763	0.000

PROCINN	0.392	0.062	0.563	0.000
COMINN	0.347	0.062	0.494	0.000
ORGINN	0.344	0.070	0.486	0.000
SINV_D	0.619	0.744	0.551	0.000
SPROB_D	0.520	0.558	0.498	0.285
SPAIN	0.648	0.845	0.547	0.000
PORTUGAL	0.067	0.016	0.090	0.004
FRANCE	0.285	0.140	0.363	0.000

Table 4: Mean values of the variables

Notes: INNTOT variable shows the total number of the 4 types of innovative activities carried out by the firm. SALES and EMPLOYEES variables are not in logs. We show the p-values of significance tests (t test for continuous variables and Wilcoxon rank-sum (Mann-Whitney) test for discrete variables) for the differences of the mean values between the sub-samples.

The final sample comprised 375 firms with a mean age of 18 years in 2011. Although the average number of employees was 84, the 50% of the companies had 15 employees or less. Therefore, the sample was composed mostly of small companies. As shown in Table 4, 93.1% of the sample firms were independent companies and 51.2% operated in high-tech industries.

Besides, 62.1% of the sample companies had introduced some type of innovation which was related to product (53.3% of the cases), production process (39.2%), commercial activities (34.7%), or organizational activities (34.4%).

With regard to the firms' strategies, Table 4 indicates that 61.9% of the firms expected to manage investments in short-term that might result in innovative activities. Similarly, 52% of the companies expected to overcome a set of problems by carrying out innovative activities.

The country distribution was as follows: 64.8% of the sample firms were Spanish (243), 28.5% were French (107), and 6.7% were Portuguese (25).

Finally, the significant differences of the mean values of several variables between firms that are interested in collaborating and firms that are not suggested that the companies that carried out innovative activities in a greater extent tended to be interested in collaborating with universities. Instead, the results showed that 70% of the firms in the high tech industries had not showed interest in cooperating with universities. Finally, the differences of mean values were also statistically significant for the country variables, suggesting that the French companies tended to be interested in collaborating with universities.

4.2. Econometric analysis: global models

As shown in Table 4, 246 of 375 firms (approximately 65%) were interested in collaborating with universities. To know the driving forces of the firms' interest, different empirical models were estimated (Table 5). While the models 1 to 4 included INN_D variable as the measure of the firm's R&D intensity, the models 5 and 6 considered the different types of innovative activities carried out by the firm.

As Table 5 shows, there are a group of variables that are significant in the estimated models. The results are discussed below.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
LN_SALES	0.014					
	(0.009)					
LN_EMPLOYEES		0.018			0.02	
		(0.018)			(0.016)	
EMPLOYEES			0	0		0
			(0.000)	(0.001)		(0.000)
EMPLOYEES_SQUA				0		0
				(0.000)		(0.000)
LN_AGE	-0.036	-0.021			-0.015	
	(0.026)	(0.023)			(0.021)	
AGE			0	-0.002		-0.001
			(0.001)	(0.003)		(0.002)
AGE_SQUA				0		0
				(0.000)		(0.000)
HIGHTECH	-0.093*	-0.100*	-0.081*	-0.081*	-0.051	-0.043
	(0.044)	(0.04)	(0.037)	(0.036)	(0.034)	(0.031)
INDEP	-0.052	-0.058	-0.056	-0.053	-0.049	-0.049
	(0.048)	(0.044)	(0.039)	(0.04)	(0.049)	(0.044)
INN_D	0.743***	0.677***	0.665***	0.658***		
	(0.042)	(0.035)	(0.032)	(0.032)		
PRODINN					0.407***	0.389***
					(0.08)	(0.074)
PROCINN					0.253***	0.230***
					(0.065)	(0.055)
COMINN					0.09	0.097
					(0.065)	(0.059)
ORGINN					0.063	0.067
					(0.046)	(0.043)
SINV_D	-0.084	-0.133**	-0.122**	-0.122**	-0.162***	-0.156***
	(0.047)	(0.041)	(0.038)	(0.037)	(0.039)	(0.037)
SPROB_D	0.004	0	-0.005	-0.004	-0.032	-0.036
	(0.046)	(0.044)	(0.041)	(0.041)	(0.033)	(0.031)
SPAIN	-0.208***	-0.289***	-0.271***	-0.270***	-0.268***	-0.255***
	(0.052)	(0.047)	(0.042)	(0.042)	(0.047)	(0.043)
PORTUGAL	-0.222*	-0.305***	-0.295***	-0.281***	-0.411***	-0.413***
	(0.102)	(0.086)	(0.085)	(0.085)	(0.071)	(0.079)
Obs	267	334	374	374	334	374
Wald χ^2(d.f.)	118.30*** (9)	116.12*** (9)	115.71*** (9)	123.97*** (11)	117.25*** (12)	116.38*** (14)
R^2 mcfadden	0.52	0.53	0.55	0.55	0.65	0.65
Pseudolikelihood	-85.32	-103.50	-109.55	-108.74	-79.97	-82.547
Akaike criterion (d.f.)	190.6(10)	207.0(10)	239.1 (10)	241.4(12)	179.9(13)	195.1(15)
Hosmer-Lemeshow χ^2 (8 d.f.)	5.87	15.39	20.86**	16.02*	4.61	10.03

Table 5: Average partial effects

Notes: table shows the average partial effects (APE). As noted by Tomás Bartus (2005), APEs provide a more realistic interpretation of the estimation results and more consistent estimates than marginal effects at the mean. The Stata *margeff* command was used to calculate the APEs. ***, **, * denotes significance at the 0.001, 0.01 and 0.05, respectively. Robust standard errors are in parentheses. d.f. denotes degrees of freedom.

Firm size failed to be significant for the estimated models (hypothesis 1). Our results differ from those of most previous studies which found positive and significant effects of firm size on R&D cooperation (see Table 2). The reason for this difference may lie in the fact that we analyzed the intention to collaborate with universities instead of the existence of cooperation engagement. On the other hand, our findings are consistent with those reported by of Okamuro et al. (2011), who found that the size effect on cooperation is negligible with small and medium firms. Moreover, Eom and Lee (2010) also highlight that the impact of firm size on firms' decision to cooperate with universities is obscure in most of empirical analyses.

The coefficients of **firm age** were not significant in any of the models shown in Table 5. These results are consistent with the findings of Laursen & Salter (2004). Therefore, we did not find support for hypothesis 2.

The dummy variable for **independent firms** (INDEP) showed not to be significant in any of the models in Table 5 (hypothesis 3). Our results differ from those of Okamuro et

al. (2011) and Segarra & Arauzo (2008), who found that independent firms were less likely to engage in R&D cooperation with universities.

Contrary to expected, **belonging to high-tech industries** was strongly and negatively associated with the intention to collaborate with universities in four of the estimated models (hypothesis 4). Our results differ from those of Levy et al. (2007), Santoro & Chakrabarti (2002) and Segarra & Arauzo (2008). In addition, these finding are rather confusing since this industry effect was not significant after controlling for the type of innovation (models 5 and 6). In order to know the real effect of technological level of the industry on the firms' interest in collaborating with universities, we decided to analyze it more in depth in next section.

Carrying out **innovative activities** increases the interest in collaborating with universities (hypothesis 5). For instance, the APE in the Model 4 indicated that the intention to cooperate for firms that perform innovative activities was 65% higher than for those who did not. In this sense, our results were consistent with those of most previous studies which found positive effects of a firm's R&D intensity on cooperation agreements (see Table 2).

We also found evidence that firms that carry out both **product and process innovation** are more likely to be interested in cooperating with universities (hypotheses 5a and 5b). These findings are similar to those found by Segarra and Arauzo (2008).

With regard to the effects of the **firm's strategy** on interest in collaborating, we found only support for the hypothesis 6a. Contrary to expected, the firms that foresee investments in short-term relied less on cooperation engagement with universities. This result could be partially explained by the fact that engaging in cooperation agreements with universities may be considered as costly and time-consuming resources by firms. Therefore, when a firm plans to invest in short-term, it might decide to concentrate financial efforts on those investments and to put off, or even discard, cooperating with universities.

On the other hand, we did not find evidence that firms concerned about issues related to innovative activities tend to be more interested in collaborating with universities (hypothesis 6b). Our findings suggest that R&D cooperation with universities is not seen as a source of innovation that could be used to overcome some of their problems by firms.

Finally, Table 5 shows that the **country** dummy variables were highly significant (hypothesis 7). Therefore, in addition to the firm-specific characteristics, institutional country factors also affected the firm's attitudes towards collaboration. Thus, the APEs of the country dummies implied that, compared to the French companies (omitted group), the Spanish and the Portuguese firms were about 25% less likely to be interested in collaborating with universities.

4.3. Econometric analysis: industry models

As we shown, the technological level of the firm's industry matters in intention to collaborate with universities, however this industry effect is rather confusing since it was not significant after controlling for the type of innovation carried out by the company (models 5 and 6 in Table 5). Therefore, we will analyze it more in depth in this section.

In order to investigate whether industry differences influence the driving forces of the firms' interest in R&D cooperation, we followed two alternative strategies. Firstly, we

estimated the model 6 by interacting both the variables referred to innovative activities and all the independent variables with HIGHTECH variable (see the models 7 and 8, respectively, in Table 6). Since the interaction terms for SINV_D and SPAIN variables were significantly different from zero (model 8), we conclude that the impact of those variables differs between industries.

Secondly, we divided the data into two sub-samples (high-tech and non high-tech firms) and re-runned the model 6. In this second approach, we discarded the Portuguese firms since none of them belonged to high-tech industries (see model 9). Henceforth, the results for both the full sample with interactions and the industry sub-samples are discussed below.

	Model 7		Model 8		Model 9 HIGHTECH=1	Model 9 HIGHTECH=0
EMPLOYEES	0		0	0	0	0
	(0.000)		(0.000)	(0.001)	(0.001)	(0.000)
EMPLOYEES_SQUA	0		0	0	0	0
	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)
AGE	0		-0.004	0.006	0.002	-0.004
	(0.002)		(0.003)	(0.005)	(0.003)	(0.003)
AGE_SQUA	0		0	-0.000*	0	0
	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)
HIGHTECH	-0.049		0.029			
	(0.036)		(0.087)			
INDEP	-0.052		-0.008	-0.083	-0.081*	-0.008
	(0.04)		(0.042)	(0.07)	(0.039)	(0.045)
PRODINN	0.290**	0.075	0.262**	0.105	0.483***	0.263**
	(0.095)	(0.08)	(0.088)	(0.084)	(0.092)	(0.087)
PROCINN	0.115	0.132	0.087	0.124	0.268***	0.091
	(0.064)	(0.077)	(0.053)	(0.071)	(0.077)	(0.054)
COMINN	0.202*	-0.144	0.169	-0.13	0.019	0.165*
	(0.089)	(0.086)	(0.09)	(0.091)	(0.056)	(0.072)
ORGINN	0.121	-0.055	0.113*	-0.041	0.064	0.116*
	(0.068)	(0.071)	(0.057)	(0.07)	(0.047)	(0.046)
SINV_D	-0.157***		-0.245***	0.104*	-0.083	-0.269***
	(0.036)		(0.055)	(0.052)	(0.045)	(0.05)
SPROB_D	-0.054		-0.035	-0.013	-0.046	-0.037
	(0.031)		(0.04)	(0.057)	(0.041)	(0.043)
SPAIN	-0.231***		-0.094*	-0.225*	-0.365***	-0.096*
	(0.04)		(0.046)	(0.104)	(0.06)	(0.044)
Obs	350		350		192	158
Wald □²(d.f.)	115.14*** (17)		174.67*** (25)		90.19*** (12)	77.73*** (12)
R^2 mcfadden	0.63		0.63		0.74	0.57
Pseudolikelihood	-89.24		-74.03		-33.59	-40.48
Akaike criterion (d.f.)	214.5(18)		200.0(26)		93.10(13)	106.96(13)
Hosmer-Lemeshow χ^2 (8 δ.φ.)	90.26***		10.59		8.13	9.93

Table 6: Average partial effects (by industry)

Notes: table shows average partial effects (APE). As noted by Tomás Bartus (2005), APEs provide a more realistic interpretation of the estimation results and more consistent estimates than marginal effects at the mean. The Stata *margeff* command was used to calculate the APEs. ***, **, * denotes significance at the 0.001, 0.01 and 0.05, respectively. Robust standard errors are in parentheses. d.f. denotes degrees of freedom. In the model 7, the second column shows the APEs for the interaction between the independent variables referred to the type of innovative activities and the industry variable. In the model 8, the second column shows the APEs for the interaction between all the independent variables and the industry variable.

After controlling for industry, we concluded that **French** firms (compared to Spanish companies) as well as those that perform **product innovation** have a high interest in collaborating with universities. Therefore, the hypothesis 5a and the hypothesis 7 were

satisfied regardless the technological level of the industry, but the effect was greater for firms located in high-tech industries.

Apart from product innovation and country effect, the influence of the remaining factors on the firms' interest in collaborating with universities depends on the technological level of the firm's industry. Particularly, **in high-tech industries** we also found support for the hypothesis that the firms which carry out process innovation tend to rely more on cooperation engagement with universities (hypothesis 5b). This result is consistent with those by Segarra & Arauzo (2008). On the contrary, independent firms are less likely to be interested in cooperating, as compared to subsidiaries or affiliated firms (hypothesis 3). This result suggests that belonging to a group give the high-tech firms more opportunities of R&D engagement.

In contrast, companies in **non high-tech industries** which perform both commercial and organizational innovation tend to be more interested in cooperation agreements. These results partially confirmed the hypotheses 5c and 5d. It also suggests the need to include some additional measures of innovative activities as the analysis is focused on non high-tech firms. In addition, companies that foresee investments in short-term rely less on cooperation engagement with universities (hypothesis 6a). It is worth noting that, after controlling for the technological level of industry, this negative effect of future investments on the intention to collaborate is only found for firms in non high-tech industries.

In summary, previous results indicate that some of the determinants of the firms' interest in collaborating with universities are common while others differ across industries. Therefore, future research would be especially valuable if it provides a better understanding of the role of the technological level of industry on the firm's intention to collaborate with universities.

5. CONCLUSIONS

This paper has explored the determinants of a firm's interest in collaborating with universities. Using a sample from an original survey conducted in 2009, we analyzed the effect of firm and industry-specific characteristics, innovative activities, firm strategy and country on the intention to cooperate with university research groups.

Our findings indicate that firms that carried out innovative activities, and particularly product innovation, tend to be more interested in collaborating with universities. Therefore, a firm's cooperation attitudes may be explained by some characteristics of the firm's innovative activities. We also provide evidence that country factors affect a firm's intention of collaborating with universities. Spanish and Portuguese companies are less likely to be interested in cooperating than French firms.

Unlike most previous studies, our results show that the determinants of a high-tech firm's attitudes to cooperation differ from those found in a non high-tech firm. With respect to firms in high-tech industries, it was found that carrying out process innovation increases the interest in cooperation engagement with universities. In contrast, independent firms are less likely to be interested in cooperating, as compared to subsidiaries or affiliated firms. With regard to firms in non high-tech industries, performing both commercial and organizational innovation is positively linked with the firm's intention of cooperating. Furthermore, it was found that companies that foresee investments in short-term rely on less on cooperation engagement with universities.

However, our results are inconclusive for determinants related to firm´s characteristics (size, age, firm´s independence), probably because most of the firms were SMEs. We did not find evidence that firms concerned about issues related to innovative activities were more interested in collaborating with universities (firm´s strategy). In our opinion, this issue should be better addressed in the future, in studies more focused on specific aspects of the innovation models of the firms.

This study contributes to the literature in some ways. Firstly, unlike most previous studies, which focused on the determinants of R&D collaboration agreements engaged by the firm, we focus on a firm's interest in R&D cooperation, since we consider it the first step in an open-innovation relation between firms and partners. In the future, the study of the determinants of firms' formal decision to cooperate will let us to understand whether the driving forces of both interest in and decision to cooperate differ. Secondly, we analyse two countries with fewer R&D activities than other European countries, while most research have focused on more well-developed countries. Thirdly, our results confirm that it is worth exploring the role of a firm's strategy in collaborating with universities, as well as including some additional measures of innovative activities when the analysis is focused on firms located in non high-tech industries. Future research on this topic might benefit by collecting this kind of information, and so to provide a better understanding of the role of the technological level of industry on the firm's intention to collaborate with universities.

However, this paper also presents some limitations that could open the way for further research. In particular, the results are based on a cross section of data that show different firms at the same moment. Future research on this topic might collect data with a longitudinal nature, improving the representativeness. Moreover, the study also has quite a large gap in the sample by country (243 Spanish, 107 French and 25 Portuguese). While this may not change the overall direction of results, this imbalance should be considered in country comparisons.

Previous findings have some important policy implications. Firstly, our results showed that the non high-tech firms that plan to invest in short-term put cooperation with universities aside. We believe that government should offer either public funds or higher tax deductions to those companies that make investments in innovative activities. In this way, companies could manage both activities and get more opportunities of future growth. Moreover, universities should establish strategies to develop interactions with companies that actually have capacity of absorption of new knowledge. Absorptive capacity of knowledge developed in the universities varies significantly according on the sectors of activity, size or the business model of each company. In this sense, the universities could create a database of companies selected by industry, or if they operate in markets that include the area where is located the university or/and have previously innovation activities.

Secondly, our findings also indicated that R&D cooperation with universities is not searched by firms to solve innovative problems. For this reason, it is necessary a policy of potentiating links and undertaking proactive cooperation activities of technology transfer from both sides, helping to generate tangible outcomes for both universities and companies. From our point of view, the university governance teams should give greater visibility to the research results that have been utilized as solutions for companies near of the local scope of the university, and companies should also consider universities as a support to solve their R&D problems as part of their investment strategy.

Finally, the aforesaid policies should be implemented without delay in countries as Spain, where companies tend to be less interested in collaborating with universities.

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