The funnel model of firms' R&D cooperation with universities

Abstract

This paper explores the determinants of firms' attitudes towards R&D cooperation with research groups understanding university-industry cooperation as a sequential process. In so doing, we study the determinants of both firms' interest in and decision to engage in cooperation agreements. We applied both probit models and regression models for count data on a sample of 375 firms from Spain, Portugal and France. Although most of these firms showed interest in collaborating with universities, actually only 10% of the firms ended up cooperating with them. Our findings firstly indicate that innovative firms tend to show a more proactive attitude towards R&D collaboration. Secondly, within the group of firms interested in R&D collaboration, the firms really involved are the independent or small firms and we also provide evidence that country factors affect firms' attitudes to R&D cooperation with universities.

Introduction

Many firms have gained different types of benefits from R&D collaboration. The existence of potential spillovers, the strategic focus on innovation or R&D, and the interest in sharing costs and risks associated with R&D efforts are the main motivations of firms to collaborate (Caloghirou et al., 2003; Cassiman and Veuguelers, 2002; Dutta and Weiss, 1997; Hagedoorn, 1993).

In the last decades, universities have become knowledge producers as sources of innovation for companies, especially for small and medium firms (Etzkowitz, 1998; Giuliani and Arza, 2009; Sherwood and Covin, 2008; Urban and Von Hippel, 1988) and for those companies involved in technology-intensive industries (Darby and Zucker, 2006).

From the life-cycle approach to innovation, the low economic impact of university-industry (U-I) cooperation (Polt et al., 2001) is due to the differences between the type of knowledge usually provided by universities and the firms' demand for such. Thus, firms demand knowledge regarded to the latter stages of the innovation cycle (i.e. redesign of existing products or diffusion of existing technologies), while universities create knowledge for the early stages of the innovation process (i.e. new products or technologies). In this sense, firms collaborate with universities to increase their absorptive capacity for innovation (Franco et al., 2014; Owen, 2015). Additionally, universities and firms have different goals regarding the conditions of the collaboration (Cotec Foundation, 2007, 2011; Pérez-Astray and Calvo, 2011), which affects the trust building (Hemmert et al., 2014).

Despite previous arguments, there is still a lack of understanding of the sequence of interest-engagement involved in the beginning of the U-I collaboration. Thus, previous literature has studied the drivers of the firms' cooperation with universities from two approaches: the analysis of the interest in collaborating (Fitsch and Lukas, 2001; Tether, 2002; Cohen et al., 2002; Laursen and Salter, 2004; Fernandez-López et al., 2015), and the analysis of the cooperation agreements (Grandstrand, 1999; Veugelers and Cassiman, 2005; Fontana et al., 2006; Segarra-Blasco and Arauzo-Carod, 2008; Eom and Lee, 2010; Okamuro et al., 2011). In so doing, both attitudes (interest and engagement) have been considered independently by the literature on U-I cooperation. This framework makes difficult to answer questions such as: Is it possible that a firm engages in R&D cooperation without previously showing interest in it? Moreover, why firms interested in collaborating with universities eventually fail?

In this paper we try to fill this gap. More specifically, we argue that both firms' attitudes towards cooperation with universities (interest and engagement) are two stages of an only sequential process. Following this approach, we analyse the determinants of firms´ attitudes towards R&D cooperation with research groups in two steps. First, we explore the

determinants of firms´ interest in collaborating with universities (first research question). Second, we study the drivers of firms´ engagement with universities by considering only those firms that showed previous interest in R&D cooperation (second research question). The underlying assumption of this approach is that the firm's interest in R&D cooperation acts as necessary condition for the final engagement in R&D collaboration with universities. Finally, we analyse whether the determinants of both issues (interest in and engagement) differ.

This paper contributes to the literature in some ways. Firstly, it enlightens the debate about U-I cooperation, which is still limited (D' Este and Patel, 2007). More specifically, the attention is paid to the analysis of interest and engagement of firms in R&D cooperation with universities, considering attitude (interest) and behaviour (engagement) as two stages of an only sequential process. We based the empirical analysis on a sample of 375 firms located in eight regions of three Southwest European countries (Spain, Portugal and France). Similarly to Segarra-Blasco and Arauzo-Carod (2008), we believe that the Spanish and Portuguese cases are interesting because they have fewer R&D activities than other European countries as France. This will allow study the determinants of firms´ collaboration in countries that have not often been enough studied in previous research (Teixeira and Mota, 2012). Thirdly, our results lead us to propose some policies to improve U-I interactions.

This paper is organized as follows. First, we introduce the conceptual framework used to lead our hypotheses. Second, we explain the methodology and present the outcomes of the econometric model, and finally, we conclude the study and do some proposals for decision-makers and future research.

Theoretical Framework

According to Suseno and Ratten (2007), partners should manage alliances in terms of maintaining trust. From the perspective of the Theory of Transaction Cost (Coase, 1937;

Williamson, 1975, 1985), cooperation is a hybrid mechanism that coordinates the transactions through both the market and the organization (Hagedoorn and Schakenraad, 1990). In this sense, cooperation between the parties creates a level of trust which reduces the likelihood of their opportunistic behaviour and maintains the long-term benefits of the alliance.

Considering the absorption capacity, external cooperation can stimulate internal cooperation, and it is relevant as part of organizational learning of the firm (Hillebrand and Biemans, 2004). Thus, if the cooperation with universities works, firms could reduce the uncertainty of their own research activity and increase the likelihood of a positive result (Dodgson, 1992).

Some of the most relevant empirical studies signal the following determinants of the firm´s collaboration with universities: firm size, firm age, independence of the firm, industry, previous innovative activities and firm strategy. We have built the conceptual framework based on these factors. Additionally, we have also considered the country of origin a relevant moderator.

Firm size

Fontana et al. (2006) and Laursen and Salter (2004) indicate that larger firms are more likely to cooperate with universities because they have more opportunities to obtain benefits of this collaboration in the market. Thus, Kleinknecht and Reijnen (1992) and Schartinger et al. (2001) find that firm size is positively related to the collaboration with universities.

However, Eom and Lee (2010) and Okamuro et al. (2011) show that the effect of firm size on U-I cooperation is negligible in small and medium firms. A similar result is found by Fernández-Lopez et al. (2015) regarding firms' interest in R&D cooperation. In order to clarify the relation between size, type of innovation and cooperation, Santoro and Chakrabarti (2002) considered the difference between core and non-core technologies, and found that large firms looked for cooperating with universities to develop non-core technologies,

maintaining the internal control in core technologies, while small firms looked for cooperating with universities to advance in core technologies.

After the literature review, we assume that larger firms are more interested in cooperating with universities than smaller firms, because of the higher benefits that they can obtain taking advantage of the market opportunity detected with this cooperation, once discounted the associated risk of these agreements.

Because of this superior economic scope of the opportunity and the resources available for financing these agreements, we also assume that larger firms will engage more easily with research groups than smaller firms.

Thus, we propose the following hypotheses:

H1a: There is a positive relationship between firm size and the interest in R&D cooperation with university research groups.

H1b: Among the firms interested in cooperating, larger firms are more prone to be engaged with research groups in formal agreements.

Firm age

Cohen et al. (2002) conclude that firms of no more than five years old are more interested in collaborating with university research groups to develop R&D projects. However, Fernández-López et al. (2015), Laursen and Salter (2004) and Tetcher (2002) cannot confirm this relation, because although young firms may be more interested in collaborating with universities due to the lack (most of them) of enough resources to develop internal R&D, the resources and previous experience of older firms can act as strong motivators of the collaboration.

According to the second approach of the literature review, we consider that older firms provide more experience and organizational structure to take advantage of the collaborations.

Hence, considering the firm´s age as determinant of the collaboration, we propose the following hypotheses:

H2a: There is a positive relationship between firm age and the interest in R&D cooperation with university research groups.

H2b: Among the firms interested in cooperating, older firms are more prone to be engaged with research groups in formal agreements.

<u>Independence of the firm</u>

Mohnen and Houreau (2003) conclude that those firms belonging to a business group only collaborate with universities following the guidelines of their headquarters. However, Tether (2002) and Eom and Lee (2010) find that the links with the business group can work in both senses, by reducing the need of external cooperation (an affiliated firm could obtain technology from other firms within the corporate group), or by facilitating the collaboration with universities as corporate group.

We consider that the belonging to a business group serves as corporate umbrella for the firms, because it reduces the entry barriers of contacting and selecting the research groups to collaborate, compared to independent firms. Hence, considering the firm´s belonging to a business group, we propose the following hypotheses:

H3a: There is a negative relationship between the independence of the firm and the interest in R&D cooperation with university research groups.

H3b: Among the firms interested in cooperating, independent firms are less prone to be engaged with research groups in formal agreements.

<u>*Industry*</u>

Tether (2002) and Fontana et al. (2006) argue that high-tech firms are more interested in maintaining collaborations with research institutions since they are more dependent on scientific innovations to obtain outcomes from the market. This idea is also reinforced by

Fritsch and Lukas (2001), Veugelers and Cassiman (2005), Segarra-Blasco and Arauzo-Carod (2008) and Eom and Lee (2010). According to these authors, high-tech firms obtain external know-how through R&D cooperation to maintain their market aspirations in selling innovative products. Similarly, Cohen et al. (2002) conclude that firms involved in high-tech industries are more interested in collaborating with universities in R&D projects. In turn, Fernández-López et al. (2015) find that R&D collaboration becomes especially interesting for high-tech firms that develop product and process innovations.

According to the previous literature review, we assume that the dynamism of the industry and its innovation capacity are key reasons for building alliances with universities. This explain that firm of the high-tech industry are more available to be engaged with research groups than firms belonging to other industries.

Thus, we propose the following hypotheses:

H4a: There is a positive relationship between the belonging of the firm to the high-tech industry and the interest in R&D cooperation with university research groups.

H4b: Among the firms interested in cooperating, high-tech firms are more prone to be engaged with research groups in formal agreements.

Innovation activity

Cohen and Levinthal (1990) conclude that those firms involved in previous innovative activities are more likely to be engaged in collaboration with universities. This conclusion is also reinforced by Tetcher (2002) in 1.270 manufacturing and services enterprises of UK. Petruzelli (2011), who studied 796 university-industry joint patents developed by 33 universities located in 12 European countries also conclude that prior cooperative experiences firms-research organizations increase the value of the university-industry innovations.

In this sense, we consider that previous experience of firms in innovation reduces the risk associated to the collaboration with research groups. Hence, we propose the following hypotheses:

H5a: There is a positive relationship between the prior innovative activity of the firm and the interest in R&D cooperation with university research groups.

H5b: Among the firms interested in cooperating, those firms that have innovated before are more prone to be engaged with research groups in formal agreements.

Although Bercovitz and Feldman (2007) show how firms' innovation strategies influence their involvement in university relationships, most of the previous empirical studies have just focused on the effect of different types of innovative activities carried out by firms, providing mixed results. Thus, Segarra-Blasco and Arauzo-Carod (2008) conclude that firms involved in the introduction of both radical product innovations and process innovations are more likely to be engaged with universities. Following this approach, Fontana et al. (2004, 2006) find that firms involved in process innovations are more likely to be engaged with universities. Additionally, Eom and Lee (2010) confirm that those firms involved in product innovations are more likely to be engaged with universities than those involved in process innovations. Regarding firms' interest in R&D collaboration, Fernández-López et al. (2015) also find a positive relationship between carrying process and product innovations and firms' intention to collaborate with universities, whereas no evidence is found for commercial and organizations innovations.

Because there is not a clear explanation about the relationship between the type of innovative activities carried out by firms (product, process, commercial and organizational) and the interest of firms in collaborating with universities, we additionally propose the following sub-hypotheses:

H5a1: There is a positive relationship between the prior product innovation of the firm and the interest in R&D cooperation with university research groups.

H5b1: Among the firms interested in cooperating, those ones that developed product innovation are more prone to be engaged with research groups in formal agreements.

H5a2: There is a positive relationship between the prior process innovation of the firm and the interest in R&D cooperation with university research groups.

H5b2: Among the firms interested in cooperating, those ones that developed process innovation are more prone to be engaged with research groups in formal agreements.

H5a3: There is a positive relationship between the prior commercial innovation of the firm and the interest in R&D cooperation with university research groups.

H5b3: Among the firms interested in cooperating, those ones that developed commercial innovation are more prone to be engaged with research groups in formal agreements.

H5a4: There is a positive relationship between the prior organizational innovation of the firm and the interest in R&D cooperation with university research groups.

H5b4: Among the firms interested in cooperating, those ones that developed organizational innovation are more prone to be engaged with research groups in formal agreements.

Firm strategy

In the last decades, some authors (Fernández-López et al., 2015; Fritsch and Lukas, 2001; Pérez-Astray et al., 2013) have considered firm strategy as a potential determinant of the U-I cooperation. In this sense, if the investment strategy of the firm is aimed at creating value in the market through innovation, managers are more likely to collaborate with universities.

In order to go in deep with this factor, we need to study the strategic focus of the firm. Particularly, Fernández-López et al. (2015) find that those firms with an investment strategy relying on innovative activities are less interested in R&D collaboration with universities. According to this approach, we consider that the investment in R&D as strategy is a substitute

of the need of the firm to collaborate with research groups, so we propose the following hypothesis:

H6a1: There is a negative relationship between the investment strategy related to innovative activities and the firm's interest in R&D cooperation with university research groups.

H6b1: Among the firms interested in cooperating, those ones with an investment strategy related to innovative activities are more prone to be engaged with research groups in formal agreements.

H6a2: There is a positive relationship between the existence of problems related with innovation and the firm's interest in R&D cooperation with university research groups.

H6b2: Among the firms interested in cooperating, those ones with problems related with innovation are more prone to be engaged with research groups in formal agreements.

Country

U-I cooperation is generally quite low in Europe, being at a considerable distance from the United States and R&D intensive Asian countries (Marzo-Navarro, 2007). As part of the EU, Spain and Portugal occupy positions still far behind. Thus, whereas one quarter of innovative enterprises in the EU-27 were engaged in any type of cooperation during 2004-2006, the percentage of the Spanish and Portuguese firms decreased to 17%. Particularly, both countries report low shares of academic cooperation; only 4.9% and 9.3% of innovative enterprises cooperated with universities and higher education institutions in Spain and Portugal, respectively (European Commission, 2010).

In a cross-national study of Fernández-López et al. (2015), comparing firms' interest in cooperation with universities in Spain, France and Portugal, the authors conclude that country factors significantly impact the firms' intention to cooperate. More specifically, the Spanish and Portuguese firms are about 25% less likely to be interested in R&D engagements with

universities than French firms. Given that our empirical analysis partly uses the same dataset, we include two additional hypotheses referred to the origin country of firms in order to capture idiosyncratic cultural or institutional factors for each country:

H7a: There is a positive relationship between being a French firm and the interest in R&D cooperation with university research groups.

H7b: Among the firms interested in cooperating, French firms are more prone to be engaged with research groups in formal agreements.

Figure 1 shows the conceptual framework of this analysis, as a summary of the previous hypotheses.

Figure 1: The funnel model of firms' attitude and behavior towards R&D cooperation with universities
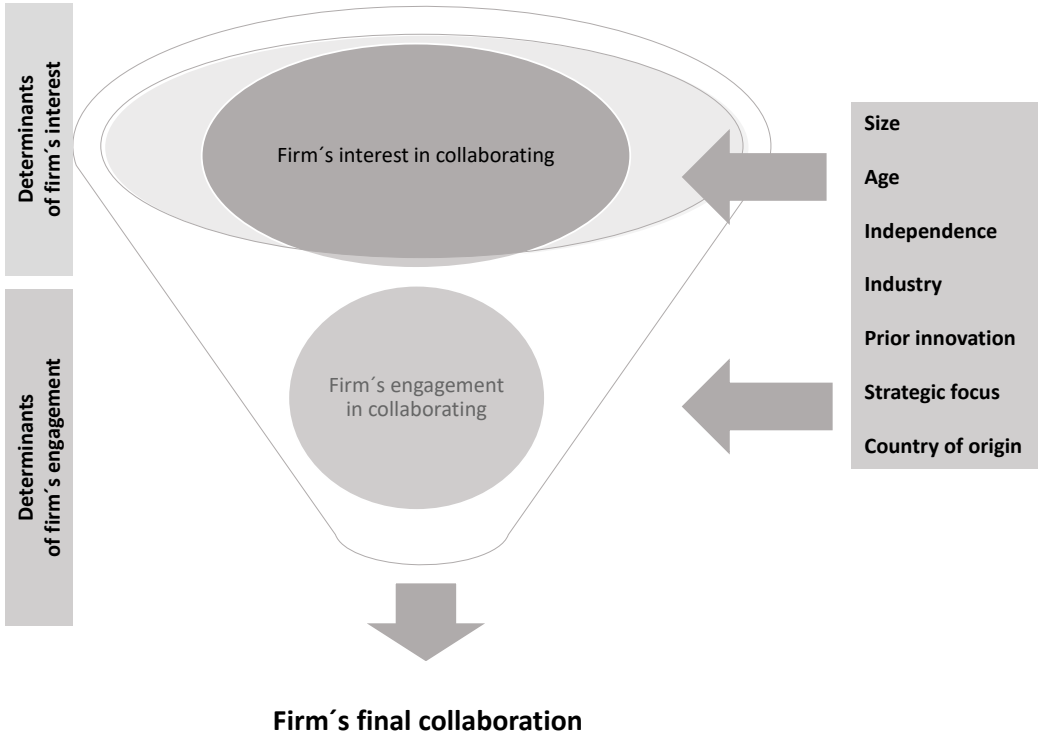
Methodology

The data and sample

The data used is an updated version on the dataset originally constructed by Fernández-López et al. (2015) based on the information collected in the European Project CREATINN (Creativity and Innovation) for 2009-2012, an initiative aimed at creating a Territorial Cooperation Space among Southwest European regions in the field of innovation and competitiveness.

More specifically, the data were collected from a survey to firm managers in eight Southwest European regions of three countries (Spain, France, Portugal) that was developed in two stages. In a first stage, 439 questionnaires were administered through semi-structured interviews (262 in Spain, 127 in France and 50 in Portugal) between January 2011 and October 2011. During the interviews, managers were asked about firm-specific characteristics and potential innovation needs in the period 2009-2012. They were also asked about the firm's interest in collaborating with academic research groups to cover its innovation needs. We discarded 64 questionnaires for considering them incomplete. As a result, we obtained 375 firms in the final sample.

In a second stage, those firms that had explicitly shown interest in collaborating with research groups were again contacted in 2012 and asked to describe in detail the innovative needs they faced. After showing such innovative needs to a set of research groups also interested in U-I collaboration and with enough innovation capacity for attending the firm's demands, firms and research groups were put in touch.

After several meetings, if a firm and a research group identified an innovative need likely to be jointly solved, they signed a formal agreement labelled as Agreement of Collaborative Activity (ACA) that both had to develop in next months. Furthermore, one firm could sign

several ACAs with one or more university research groups, one by one innovative need they wanted to cover working together.

Definition and measurements of the independent variables

As independent variables, we selected a number of factors that were classified in three different groups: firm-specific characteristics, innovative activities, and firm strategy (Table 1). In addition, three country dummy variables were also considered (FRANCE, PORTUGAL and SPAIN).

Table 1. Definitions of independent variables and predictions

Group	Factor	Variable	Expected sign	Definition
FIRM-SPECIFIC CHARACTE RISTICS	*SIZE*	LN_SALES	+	Natural logarithm of sales
		LN_EMPLOYEES		Natural logarithm of the number of employees
	AGE	LN_AGE	+	Natural logarithm of age
	INDEPEND ENT	INDEP	-	Whether or not firm is founded as an independent firm (1 or 0)
	INDUSTRY	HIGHTECH	+	Whether or not firm belongs to high-tech industries (1 or 0). The classification of the INE (National Institute of Statistics) was used which, in turn, follows the OECD (2003).
INNOVATIV E ACTIVITIES	*INNOVATI VE FIRM*	INN_D	+	Whether or not firm has carried out any types of innovative activities (1 or 0)
	TYPES OF INNOVATI VE ACTIVITIE S	PRODINN / PROCINN / COMINN / ORGINN	+	Whether or not firm has introduced product / process / commercial / organizational innovation (1 or 0)
FIRM STRATEGY	*INVESTME NT**	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 serious problems whose solution might result in innovative activities in 2012-2014 period (1 or 0)
COUNTRY	*COUNTRY*	FRANCE, PORTUGAL, SPAIN	- (compared to French firms)	Whether or not firm is French/ Portuguese/ Spanish (1 or 0)

Notes: * According to the literature review, the expected sign is always the same for both firms' interest in and engagement in R&D cooperation with the exception of the variable referred to investment strategy. In this case, the expected sign for firms' interest is negative whereas it is positive for firm's decision to collaborate. This is because the hypothesis related to the firm's interest has been based on previous empirical results.

As shown in Table 2, the final sample comprised 375 firms with a mean age of 18 years in 2011. Regarding firm size, whereas the mean of the number of employees was 84, the median was 15, in other words, the sample was formed mostly by small firms. 93.1% of the sample firms were independent companies and 51.2% operated in high-tech industries.

Sample companies showed to be relatively active in introducing product innovation (53.3%), process innovation (39.2%), commercial innovation (34.7%), and organizational innovation (34.4%). To sum up, 62.1% of the sample firms had introduced any type of innovation.

Table 2 also shows 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).

Table 2. Summary statistics of the independent variables

Variable	Observations	Mean	Standard Deviation	Min	Max
SALES*	375	14,100,000	102,000,000	-	1,860,000,000
EMPLOYEES*	375	84.117	527.349	0	9900
AGE*	374	18.195	16.614	-1	103
HIGHTECH	375	0.512	0.501	0	1
INDEP	375	0.931	0.254	0	1
INN_D	375	0.621	0.486	0	1
PRODINN	375	0.533	0.500	0	1
PROCINN	375	0.392	0.489	0	1
COMINN	375	0.347	0.477	0	1
ORGINN	375	0.344	0.476	0	1
SINV_D	375	0.619	0.486	0	1
SPROB_D	375	0.520	0.500	0	1
SPAIN	375	0.648	0.478	0	1
PORTUGAL	375	0.067	0.250	0	1
FRANCE	375	0.285	0.452	0	1

Notes: * variables are not in logs.

Results and Discussion

The first step: Interest in collaborating

To explore the determinants of firms' interest in collaborating with universities (first research question), we constructed a dependent dummy variable coded as 1 if the firm had shown

interest in R&D cooperation with universities during the first stage of the survey process in 2011, and 0 otherwise (INTCOLLU). Particularly, the data showed that 246 of 375 firms (approximately 65%) were interested in collaborating with universities.

Given that the dummy nature of the dependent variable, we applied *probit* models and proposed the following relation:

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

The dependent variable (Y_i) quantifies the firm's probability of showing interest in collaborating with academic groups, i is the index of firms, and ϕ denotes the standard normal distribution function. Different empirical models were estimated (Table 3). While the models 1 to 2 consider INN_D variable as the proxy of the innovative activities developed by firms, the model 3 adds the different types of innovative activities carried out by firms.

Table 3. Firms' interest in collaborating with universities (Average partial effects)

	Model 1	Model 2	Model 3
LN_SALES	0.014		
	(0.009)		
LN_EMPLOYEES		0.018	0.020
		(0.018)	(0.016)
LN_AGE	-0.036	-0.021	-0.015
	(0.026)	(0.023)	(0.021)
INDEP	-0.052	-0.058	-0.049
	(0.048)	(0.044)	(0.049)
HIGHTECH	-0.093*	-0.100*	-0.051
	(0.044)	(0.040)	(0.034)
INN_D	0.743***	0.677***	
	(0.042)	(0.035)	
PRODINN			0.407***
			(0.080)
PROCINN			0.253***
			(0.065)
COMINN			0.090
			(0.065)
ORGINN			0.063
			(0.046)
SINV_D	-0.084	-0.133**	-0.162***
	(0.047)	(0.041)	(0.039)
SPROB_D	0.004	0.000	-0.032
	(0.046)	(0.044)	(0.033)
SPAIN	-0.208***	-0.289***	-0.268***
	(0.052)	(0.047)	(0.047)
PORTUGAL	-0.222*	-0.305***	-0.411***
	(0.102)	(0.086)	(0.071)
Obs	267	334	334
Wald χ^2(d.f.)	118.30*** (9)	116.12*** (9)	117.25*** (12)
R^2 mcfadden	0.52	0.53	0.65
Pseudolikelihood	-85.32	-103.50	-79.97
Akaike criterion (d.f.)	190.6(10)	207.0(10)	179.9(13)
Hosmer-Lemeshow χ^2 (8 d.f.)	5.87	15.39	4.61

Notes: Table shows the average partial effects (APE) which provide a more realistic interpretation of the estimation results and more consistent estimates than marginal effects at the mean (Bartus, 2005). 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 (H1a). This result could be considered consistent with those of Eom and Lee (2010) and Fernández-López et al. (2015). In this sense, Okamuro et al. (2011) advice that the effect of firm size on U-I cooperation is negligible in small and medium firms, which it is the case of most of our sample firms.

Contrary to expected, firm age (H2a) and the independence of the firm (H3a) were also not significant in any of the estimated models.

Belonging to high-tech industries (H4a) showed a negative effect on firms' interest in R&D cooperation with universities. However, this effect disappeared after controlling by the type of

innovative activities carried out by firms, which leaded us to conclude that it is innovation what matters in firms' intention to cooperate, rather than operating in a high-tech industry.

In contrast, carrying out innovative activities positively impacted the firm's intention of cooperating with research groups (H5a). Indeed, the interest for a firm that performs innovative activities was approximately 70% higher than for those who did not. This result supports the argument of that previous innovative activities provide firms with a higher absorptive capacity which, in turn, allows them to do a better identification of external knowledge. Similarly to Fernández-López et al. (2015) and Segarra-Blasco and Arauzo-Carod (2008), the results also showed that firms that had developed product or process innovation are more likely to be interested in cooperating (H5a1 and H5a2).

As expected, the firms that foresee investments in short-term relied less on U-I cooperation (H6a1). This finding is consistent with those of Fernández-López et al. (2015) who suggests that collaborative agreements with universities are regarded by firms as a financial consuming process. Then, when a firm needs to invest, it might decide to concentrate financial efforts on those investments and discard cooperating with universities.

We did not find a significant relationship between a strategy focused on overcoming problems related to innovative activities and firms' interest in R&D cooperation (H6a2). This lack of significance involves that U-I cooperation is not completely understood by firms as a source of knowledge that could be used to face their innovative needs.

Finally, apart from the firm's innovative activities and strategy, institutional country factors also affect the firm's interest in U-I collaboration. Thus, compared to the French companies (omitted group), the Spanish and the Portuguese were about 20-30% less likely to be interested in collaborating with universities. Therefore, the H7a was largely satisfied and further research is required to know whether the existence of some institutional reasons might explain different firm's attitudes towards collaborating with universities.

To sum up, the firm´s interest in R&D cooperation with universities is positively related to carrying out innovative activities and both product and process innovation, and negatively related to foreseeing significant investments in short-term. Finally, institutional country factors also affect firm's intention of collaborating with universities.

The second step: Engagement in collaborating

To analyse the determinants of firms' cooperation with universities (second research question), we only took into account those firms which had shown interest in R&D cooperation with universities (246 firms) at the end of 2011. In this analysis, we used two alternative measures of the dependent variable: 1) a dummy variable coded as 1 if the firm signed at least one ACA, and 0 otherwise (ACA_D), and 2) the number of ACAs signed by the firm (ACA_N). Then, we re-run the models in Table 4 by applying probit models in the former case and regression models for count data (i.e. Poisson and negative binomial models) in the latter.

After several meetings whit academic groups, 40 of 246 interested firms (approximately 16%) signed one or more ACAs. As a result, a total of 72 ACAs had been signed. Table 4 shows the estimated models following these different approaches.

Table 4. Firms' decision to collaborate with universities (Average partial/marginal effects)

	PROBIT: Dependent variable ACA_D			POISSON (QML): Dependent variable ACA_N			NEGBIN: Dependent variable ACA_N		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
LN_SALES	-0.012			-0.028			-0.033		
	(0.014)			(0.023)			(0.032)		
LN_EMPLOYEES		-0.052*	-0.056*		-0.098*	-0.123*		-0.115*	-0.131*
		(0.024)	(0.023)		(0.047)	(0.052)		(0.051)	(0.054)
LN_AGE	-0.003	0.027	0.024	0.114	0.117	0.116	0.093	0.101	0.098
	(0.040)	(0.031)	(0.032)	(0.094)	(0.074)	(0.087)	(0.079)	(0.061)	(0.069)
INDEP	0.036	0.065	0.060	0.232*	0.240**	0.229**	0.219*	0.244**	0.242**
	(0.107)	(0.070)	(0.070)	(0.108)	(0.080)	(0.083)	(0.111)	(0.076)	(0.082)
HIGHTECH	-0.001	-0.017	-0.049	-0.012	-0.017	-0.076	-0.026	-0.018	-0.104
	(0.068)	(0.054)	(0.051)	(0.142)	(0.110)	(0.095)	(0.133)	(0.107)	(0.101)
INN_D	0.052	0.078		0.239	0.241*		0.193	0.232*	
	(0.135)	(0.077)		(0.155)	(0.099)		(0.204)	(0.100)	
PRODINN			0.065			0.197			0.191
			(0.067)			(0.124)			(0.127)
PROCINN			0.109			0.191			0.236
			(0.084)			(0.219)			(0.172)
COMINN			-0.251**			-0.579			-0.64
			(0.091)			(0.305)			(0.350)
ORGINN			-0.005			0.063			-0.009
			(0.075)			(0.125)			(0.133)
SINV_D	0.065	0.090	0.153*	0.252*	0.241**	0.284**	0.176	0.171	0.277**
	(0.094)	(0.075)	(0.070)	(0.117)	(0.086)	(0.107)	(0.124)	(0.102)	(0.106)
SPROB_D	0.121	0.085	0.100	0.392*	0.332*	0.292	0.341*	0.272	0.282*
	(0.084)	(0.078)	(0.081)	(0.163)	(0.153)	(0.152)	(0.150)	(0.147)	(0.141)
SPAIN	-0.119	-0.121	-0.102	-0.804	-0.923	-0.679	-0.429	-0.551	-0.482
	(0.135)	(0.116)	(0.111)	(0.545)	(0.592)	(0.541)	(0.404)	(0.488)	(0.469)
PORTUGAL	-0.142	-0.133	-0.121	-0.525**	-0.479**	-0.410**	-0.410**	-0.377**	-0.377**
	(0.091)	(0.071)	(0.076)	(0.176)	(0.163)	(0.152)	(0.145)	(0.133)	(0.138)
Obs.	160	208	208	160	208	208	160	208	208
Wald χ^2(d.f.)	4.65(9)	15.25(9)	28.47**(12)	14.33(9)	23.08**(9)	45.75**(12)	11.72(9)	23.07**(9)	39.36***(12)
R^2 Mcfadden	0.04	0.08	0.13	0.10	0.12	0.16			
Pseudolikelihood	-75.72	-86.89	-81.84	-125.15	-142.71	-137.03	-111.66	-127.66	-124.37
H-L χ^2 (8 d.f.)	12.02	4.85	8.09						
LR test							26.98***	30.10***	25.31***
Wald test							2.97**	3.00**	2.78**
Regression-based test				3.54**	3.35**	2.48**			

Notes: Table shows the average partial effects (APEs) for the probit models and average marginal effects (AMEs) for Poisson and negative binomial models. The Stata *margeff* command was used to calculate the APEs and the AMEs. ***, **, * denotes significance at the 0.001, 0.01 and 0.05, respectively. Robust standard errors are in parentheses. d.f. denotes degrees of freedom. LR test is distributed as χ^2_{1-s} under H_0 (null hypothesis of no overdispersion) (Cameron and Trivedi, 1998). Wald test and regression-based test are distributed as z_{1-s} under H_0 (null hypothesis of no overdispersion).

Firm size, measured as LN_EMPLOYEES, has a negative and significant effect on R&D cooperation (H1b). This finding consistent with the argument of Eom and Lee's (2010), suggesting that the lack of internal resources, which tend to be found in a greater extent in the small firms, could act as an important driving force of university-industry collaboration.

As it happened when we previously analyzed firms' intention of collaborating with universities, firm age (H2b) and belonging to high-tech industries (H4b) were not significant. Contrary to expected, independent firms showed to be more likely to engage in R&D cooperation with universities in the count regression models (H3b). This result is consistent with those of Eom and Lee (2010). Given that independent firms lack a corporate group which acts as a source of cooperation, they would feel a higher need for cooperative agreements with external partners.

We were unable to demonstrate a clear relationship between the prior innovative activities carried out by firms, regardless the type of innovative activity, and the formal decision to engage in R&D cooperation with universities (H5b, H5b1 to H5b4). These findings could be expected since innovative activities became the main determinant of the firms' interest in R&D cooperation (first step), and they acted to some extent as a filter in this second step of the analysis (formal decision to cooperate).

In contrast, firms´ strategies were significant in the count regression models. Contrary to the results obtained when we previously analyzed a firm's interest in collaborating with universities, the companies that foresee investments in short-term (H6b1) are more likely to engage in R&D cooperation with universities. Similarly, firms whose strategy is focused on overcoming problems related to innovative activities are more likely to cooperate with university research group (H6b2).

Again, country mattered in the propensity to engage in R&D cooperation with universities. Thus, compared to the French companies (omitted group) the Portuguese were about 6% less likely to engage in R&D cooperation agreements with universities (H7b).

Taken together, previous results indicated that 65% of the firms had interest in collaborating with research groups, but only 16% of the interested firms, i.e. 10% of the sample firms, ended up cooperating with them, suggesting that the U-I cooperation process shows a funnel-

shaped behavior. In the first step, the firms that develop innovative activities tend to be more interested in R&D collaboration, unless they are planning investments in the short-term. Nevertheless, after seeing the potential solutions proposed by research groups to their innovative needs (second step), the firms really engaged are the small and independent firms whose strategies are focused on overcoming problems related to innovative activities. Finally, institutional country factors also affect firms' propensity to cooperate with universities.

Conclusions and policy implications

This paper explores the determinants of firms' attitudes towards R&D cooperation with research groups. Our findings firstly indicate that firms that carried out innovative activities tend to be more interested in collaborating, suggesting that these companies show a more proactive attitude to collaboration.

Secondly, within the group of firms interested in R&D collaboration, the firms really involved are the independent or small firms. Similarly, the propensity to engage in R&D cooperation agreements with universities is positively related to firms' strategies of investing in short-term and overcoming problems related to innovative activities.

Finally, we also provide evidence that country factors affect firms' attitudes towards R&D cooperation with universities. Spanish and Portuguese companies are less likely to be interested in cooperating than French firms. Moreover, Portuguese firms are also less likely to sign collaborative projects with research groups.

Previous findings have some important policy implications. Firstly, because companies that develop innovative activities are more open to collaboration, university decision-makers should consider them as the 'target audience' in the U-I collaborative projects. Different authors define the absorptive capacity from a dynamic or process-oriented perspective (Lane et al., 2006; Zahra and George, 2002) and divide in four dimensions this process: acquisition, assimilation, transformation and application. Universities should focus in the first step since

the acquisition capacity allows firm to identify value and acquire external knowledge that is critical to its operations (Camisón and Forés, 2010). Therefore, identifying the best companies in terms of absorptive capacity is a relevant issue for the development of effective strategies that optimize the universities' technology transfer.

Secondly, when companies consider investing in the short-term, they are reluctant to collaborate with universities, perhaps because they usually associate it with waste of money. Nevertheless, after seeing the potential solutions proposed by university groups to their innovative needs, we found that the forecasted investment is not an obstacle for collaboration. Similarly, at the beginning of U-I collaboration process, companies do not consider universities as an instrument to overcome their R&D problems. However, after several meetings with the research groups this perception changes. Hence, from our point of view, it is necessary to design institutional strategies geared toward publicizing the R&D services offered by higher education institutions. In this sense, universities should hardly effort to change firm´s perception of the existing policies of collaboration with them, introducing their selves as institutions able to solve problems. A good practice could be to give greater visibility to the research results that have been utilized as solutions for companies near of the local scope of the university. Another good practice may be to promote research based on firm´s demand (market push). In other words, it is needed a previous analysis of the client's needs aimed at providing it with solution proposals. A reasonable approach to tackle this issue could be enable professional and industrial doctorates.

Thirdly, since the firms that cooperate with universities tend to be small and independent companies, the contacts between firms and research groups should be favoured and funded by offering either public funds or higher tax deductions for small and medium firms. In any case, showing successful previous experiences could be the less costing way to get a change of firms' perception of the utility of U-I collaboration.

The aforementioned policies should be implemented especially in countries as Spain and Portugal where companies tend to be less interested in collaborating with universities in R&D.

This study makes several noteworthy contributions to the literature on U-I cooperation. Firstly, unlike most of the empirical literature, which only focused on the determinants of R&D collaboration agreements engaged by the firm, we understand U-I cooperation as a sequential process. Moreover, this paper analyses firms' attitudes towards R&D cooperation with universities by assuming and outside/in perspective. In contrast, most previous studies have adopted an inside/out approach, i.e. from the university perspective. Secondly, we study two countries with fewer R&D activities than other European countries, while most research has 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. Professionals and researchers might benefit of the conclusions founded in this study.

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.

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