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# R&D COOPERATION BETWEEN FIRMS AND UNIVERSITIES. SOME EVIDENCE IN FIVE EUROPEAN COUNTRIES

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# R&D cooperation between firms and universities. Some evidence in five European countries

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*Abstract*
This paper utilizes the Efige data (2007-2009) to identify the determinants of university-industry cooperation in five European countries (France, Germany, Italy, Spain, UK). We use a probit model for firm level data which incorporates variables of innovation activities and traditional determinants of R&D cooperation.The results of analysis support the view that the relationships between firms and universities have a high degree of heterogeneity. Traditionally evaluated firm variables, such as age, exporting, belonging to a sector, process innovation, are significant in only some countries. There are also common patterns: the probability of cooperating with universities increases for innovative firms and firms with R&D capacity in almost all countries. Policies in support of R&D and size are also an important factor.
*Keywords:* university-industry cooperation; European countries; R&D; manufacturing firms
*JEL Code:* O31; D21; C25

## 1. INTRODUCTION

In recent years the determinants of R&D cooperation have become an important research topic and theoretical and empirical literature has increasingly focused on R&D cooperation among firms. This literature assumes that cooperative R&D agreements involve relationships between organisations that aim to carry out R&D projects in order to enhance their innovation. One such relevant interaction is between firms and research institutions.

The Lisbon agenda and the EU Report Europe 2020 (European Commission,2010), which present the general context in which Europe will act in the next decade, stress the important role of active cooperation between firms and universities in maintaining Europe's economic competitiveness. Cooperation between businesses and universities encourages the transfer and sharing of knowledge, helps create long-term partnerships and opportunities and drives innovation. In the report "The State of European University - Business Cooperation", Davey et al (2011) revealed the marked variations in industry and university cooperation across European

countries and pointed out the necessity of a better understanding of differences and common patterns across European countries. Despite there being many reasons to analyse the factors affecting university-industry cooperation at European level, insufficient attention has been given to this area. An extensive body of empirical research focuses on specific countries (Tether, 2002 and Laursen and Salter, 2004 for the UK; Segarra-Blasco and Arauzo-Carod, 2008 and Busom and Fernàndez-Ribas, 2008 for Spain; Veugelers and Cassiman, 2005 for Belgium; Belderbos and al, 2004 for the Netherlands; Miotti and Sachwald 2003 for France; Schartinger et al, 2001 for Austria) and many of them on determinants of research partnerships (among others, Tether, 2002; Segarra-Blasco and Arauzo-Carod, 2008; Belderbos and al, 2004; Miotti and Sachwald 2003). This is probably because, apart from the Community Innovation Surveys (CIS), there are few databases that facilitate analysis of the links between universities and firms across countries. Only the studies by Fontana et al (2006) and Mohnen and Hoareau (2003) consider more than one country (the first Denmark, France, Germany, Greece, Italy, the Netherlands and the UK, and the second Germany, France, Ireland and Spain), but even they pool the data of the countries considered and, therefore, do not apply a comparative view to this phenomenon.

The aim of this paper is to fill this gap by investigating which firm characteristics are conducive to cooperation with universities and R&D centre. By analysing in detail, we provide empirical evidence on a sample of European manufacturing firms from the five largest European economies (France, Germany, Italy, Spain, the UK). The research questions were tested by using micro-based data which was harmonised across countries (EFIGE, 2007-2009). This allows firms to be compared in terms of their different modes of R&D cooperation and to analyse how these outcomes relate to other firm specific variables. We use a probit model, which incorporates variables of innovation activities such as firm size, internationalisation, public financing, firm sector, age, and the belonging to an enterprise group.

Our results indicate the central role of a firm's innovation activities as a precondition for cooperation with universities. The probability of cooperating with universities increases for innovative firms and when firms have R&D capacity in almost all of the countries. Policies in support of R&D and size are also an important factor, while belonging to an enterprise group has no influence. Another result shows that the traditionally evaluated firm characteristic variables of age, exporting, belonging to a sector, and process innovation are significant in only some countries.

The paper is organised as follows. In the second section, we review the literature on the determinants of industry-university cooperation. In the third section, we explain the data, variables and methodologies adopted for the empirical analysis. The estimation results are discussed in the fourth section. The final section concludes.

## 2. REVIEW OF THE LITERATURE

Since the late nineties, there has been a significant increase in studies evaluating the determinants of collaborations between university and industry (Etzkowitz, 1998). A variety of factors have been analysed to explain the development of such collaborations, be it from the perspective of universities (among others, Di Gregorio, Shane 2003; D'Este, Patel 2007; Abraham et al., 2011), the point of view of firms or both (Schartinger et al., 2001). In the literature which analyses the firm perspective, several variables have been identified as being important in affecting firms' decisions relating to R&D cooperation with external actors.

The first variable relates to R&D expenditures. Cohen and Levinthal (1990) assume that R&D plays an important role in increasing firm's absorptive capacity and, therefore, not only creates new knowledge, but helps the firm to exploit knowledge from external sources, for example universities. Therefore, it can be expected that the firm's level of R&D intensity will greatly

influence the likelihood that it will draw knowledge from universities. The positive link between intramural R&D and R&D cooperation has been demonstrated for several European countries (Fontana et al, 2006 for Denmark, France, Germany, Greece, Italy, the Netherlands and the UK.; Laursen ad Salter, 2004 for the UK; Segarra-Blasco and Arauzo-Carod, 2008 for Spain). However, there are studies that argue the opposite: that capable firms may want to try substituting in-house effort for external cooperation (Love and Roper, 1999). In this case, the smaller the R&D capacity, the more active the firm will be in cooperating with partners. Mohnen and Hoareau (2003) and Eom and Lee (2010) find that there is no significant relationship between R&D intensity and cooperation with universities.

Cooperation may be influenced by firm size. The role of firm size in influencing the probability of firms' collaborating with public research centres is one of the basic tenets of the literature on university-industry relationships, but the possible effect of size is *a priori* somewhat unclear. Larger firms are able to dedicate greater resources and time to building links with universities. On the other hand, smaller enterprises have fewer internal resources and need more external knowledge, which means more cooperation partners. Many studies based on European countries' data reveal that size is positively related to the probability of firms' cooperating with universities, e.g. Tether (2002) and Laursen and Salter (2004) for the UK, Mohnen and Hoareau (2003) for Germany, France, Ireland and Spain, Veugelers and Cassiman (2005) for Belgium, Miotti and Sachwald (2003) for France, Schartinger et al (2001) for Austria, Segarra-Blasco and Arauzo-Carod (2008) for Spain, Fontana et al (2006) for Denmark, France, Germany, Greece, Italy, the Netherlands and the UK.

The propensity to actively seek links with universities may be influenced by sectors, which are a proxy for technological opportunity. According to Pavitt (1984), some studies (Meyer-Krahmer and Schmoch, 1998; Santoro and Chakrabarti, 2002; Schartinger et al., 2002; Cohen et al.,

2002b) underline the importance of industry–university cooperation, arguing that science-based industries depend heavily on progress in science and technology. In line with previous studies, Laursen and Salter (2004),Veugelers and Cassiman (2005) confirm the marked industry effect in industry-science links, which tend to be agglomerated in specific science-based industries.

One of the most recurrent topics in R&D cooperation is the role of firm age in influencing the firm's propensity to cooperate with partners. Young firms depend on technological innovations and scientific progress and are therefore more inclined than others to engage in interaction with universities. Moreover, by creating new knowledge and training problem solvers, universities support the formation of start-ups. The issue is more controversial for older firms. On the one hand, older firms may have established a set of links with universities over time and, thus, have more experience in co-operation which may lead to a higher propensity to interact. On the other hand, older firms can be expected to be less dependent on external knowledge generated at universities, because these firms have been able to accumulate a stock of knowledge within the firm and, thus, have incorporated a large number of fields of knowledge. The empirical literature differs with regards this. Cohen et al (2002a) suggest that start-ups are more likely to draw from universities, while Laursen and Salter (2004) do not find support for the hypothesis that the propensity of a firm to draw knowledge from universities is influenced by the firm's age.

Some studies include access to public funds for R&D activities among the determinants of R&D cooperation (Belderbos et al, 2004; Busom and Fernàndez-Ribas, 2008; Miotti and Sachwald, 2003; Mohnen and Hoareau, 2003; Segarra-Blasco and Araunzo Carod, 2008). According to these studies, firms with access to public subsidies aimed at promoting R&D activities tend to cooperate more. The availability of R&D subsidies may make a great difference in motivating firms to establish R&D partnership. This result has been found for several European countries:

Miotti and Sachwald (2003) for France, Mohnen and Hoareau (2003), for France and Spain, Busom and Fernàndez-Ribas (2008) for Spain and Belderbos et al (2004) for the Netherlands.

The propensity for firms to cooperate with universities may be influenced by the type of innovative activities the firms carry out. Some investigations provide mixed results concerning the direction of the relationship. Mohnen and Hoareau (2003) find a positive relationship between the introduction of radical innovation and the extent of reliance on universities and research centres. Laursen and Salter (2004) only find partial support for the hypothesis that the firms which are more active in terms of product innovations are those that rely most on public sources. Fontana et al (2006) maintain that companies involved in process innovation are more likely to cooperate with public research organisations, while there is no evidence of a significant correlation between product innovation and engagement in collaboration with universities.

Exporting is used in a few of studies as an additional determinant of cooperation. Given that they operate in more competitive environments, exporting firms are more inclined to invest in research and to improve R&D strategies. However, Tether (2002) and Carboni (2013) find that being export oriented is insignificant in the case of cooperating with public research organisations.

Finally, belonging to an enterprise group is considered to make cooperation with universities more likely. The reasoning behind this is the same as that mentioned above for larger firms: they have more knowledge about the capabilities of universities (Tether 2002) and it is easier for them to access information and establish contacts (Mohnen and Hoareau 2003). At the same time, they have more internal resources, which, on one hand, give more opportunities for finding a partner outside the firm, but, on the other hand, might mean that they do not need universities as knowledge sources because they can use knowledge from within their group (Tether 2002). However, empirical results are ambiguous. Tether (2002), and Segarra-Blasco and Araunzo

Carod (2008) find a positive relationship[1] whereas Mohnen and Hoareau (2003) and Miotti and Sachwald (2003) find a negative relationship. Belderbos et al (2004) confirm that belonging to a group increases R&D cooperation with customers and suppliers, but not with universities or research institutions, while Eom and Lee (2010) find this relationship to be insignificant.

## 3. DATA AND VARIABLES

The empirical analysis is based on the EU-EFIGE dataset[2] which contains data from a survey and from balance-sheets. Data was collected in 2010 and covers the years from 2007 to 2009. The EFIGE survey was conducted on a representative sample of manufacturing firms with more than ten employees in seven European countries (Italy, France, Spain, the United Kingdom, Germany, Hungary and Austria). Our analysis focuses on the five EU countries with the highest number of firms in the sample. Our sample consists of over 13 thousand firms with almost about 3,000 firms for each of Germany, France, Italy and Spain, and around 2,000 firms for the United Kingdom (precise figures are reported in Table 1). The dataset combines measures of firms' international activities (eg exports, outsourcing, FDI and imports) with quantitative and qualitative information ranging from R&D and innovation, labour organisation, financing and organisational activities, and pricing behaviour.[3] Since firms originally reporting a number of

[1] In greater detail, Tether (2002) find that groups of firms from the other countries are more likely to have at least one R&D relationship, especially with customers and universities, while according to Segarra-Blasco and Araunzo Carod (2008), firms belonging to domestic groups are more predisposed to cooperating with domestic universities.

[2] The EU-EFIGE data is a database which has recently been collected from within the EFIGE "European Firms in a Global Economy: internal policies for external competitiveness" project. This is supported by the Directorate General Research of the European Commission through its 7th Framework Programme and coordinated by Bruegel. For details on the EFIGE dataset, see Altomonte and Aquilante (2012).

[3] The EFIGE data has its limitations. It is worth mentioning that one important determinant of R&D collaboration, the distance between University and each firm, is missing in our estimations since, in order to preserve anonymity, the EFIGE database just includes randomised regional and industry identifiers. This means that users know that a given firm in a given country is in an 'industry 2' or/and in 'region 3', but they do not know what 'industry 2' or 'region 3' correspond to. Hence, region and industry variation are allowed for in the data, but variables based on geographical measures, such as the distance between each firm and University, are not allowed for in the analysis.

employees equal or larger than 500 in the EFIGE dataset are capped at 500 employees, we have restricted our sample to firms with a number of employees between 10 and 499.[4]

The evidence from the EFIGE data shows that a only small fraction of enterprises (around 5%) use universities and public research laboratories as an information source for their innovation process. Firms located in Germany have the highest shares of reference to universities and public research laboratories (6% and 5% respectively), while French and Italian firms have the lowest shares (3 and 4%, respectively). In the UK and Spain, the percentage of firms that acquire R&D from universities is similarly to the EU average (around 5%) (Table 1).

Table 2 summarises the variables used in the analysis and provides information on their description, while table 3 reports the main statistics of the variables used.

As shown in table 3, there is great heterogeneity in the indicators analysed for the five EU countries. To be more precise, Germany and the UK have the highest percentage of firms which collaborate with university in R&D activities, while the lowest is found in France.

The highest share of innovative firms is observed in Spain, the UK and Italy; while size, R&D intensity and the share of science based firms are greatest in Germany.

The highest percentage of exporting firms are Italian and, of the five EU countries, Italy also has the highest percentage of firms which benefit from tax allowances and financial incentives for R&D activities.

[4]The number of observations which we lost, that is the number of firms with a number of employees greater or equal to 500, was 367 out of the 13,828.

Table 1: Distribution of firms by country in the dataset

| Country | N. firms | N. Industry-university cooperation |
|---|---|---|
| France | 2886 | 90 |
| Germany | 2815 | 164 |
| Italy | 2958 | 121 |
| Spain | 2781 | 125 |
| UK | 2021 | 107 |
| Total | 13461 | 607 |

R&D collaboration: R&D acquired from universities over the 2007-2009 years.

Table 2 - Description of variables used in the empirical investigation

| **VARIABLE** | **DESCRIPTION** |
|---|---|
| COLL | dummy equal to one when a firm has undertaken R&D investments acquired from universities and R&D centres in 2007-2009 and zero otherwise |
| INNO | dummy equal to one when a firm reports introducing at least one innovation (product or process innovation) during the 2007-2009 |
| Product innovation | dummy equal to one when a firm reports introducing at least one product innovation during the 2007-2009 |
| Process innovation | dummy equal to one when a firm reports introducing at least one process innovation during the 2007-2009 |
| RD | average 2007-2009 R&D intensity (R&D expenditures as a share of sales) of firms |
| Size | number of employees in 2008 (in log) |
| Science Based | dummy equal to one if a firm is in the "High-tech industry" according to the Pavitt taxonomy and zero otherwise |
| Young | dummy equal to one in the case of a firm which is less than 6 years, and zero otherwise |
| GovSupport | dummy equal to one if the firm benefitted from tax allowances and financial incentives for R&D activities made in the period 2007-2009 and zero otherwise |
| Export | dummy equal to one if the firm is direct exporter in 2008 or has been actively exporting in years before 2008 |
| Group | dummy equal to one if the firm belongs to a national or foreign group and zero otherwise |
| Family | dummy taking the value 1 if the share of executives (including middle management) who are related to the family that owns the company is higher than the national average of the family-owned firms in the sample |

Table 3: Main descriptive statistics by country

| Variable | France | | Germany | | Italy | | Spain | | UK | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | *Std. Dev.* | Mean | *Std. Dev.* | Mean | *Std. Dev.* | Mean | *Std. Dev.* | Mean | *Std. Dev.* |
| COLL | 0,031 | *0,174* | 0,058 | *0,234* | 0,041 | *0,198* | 0,046 | *0,209* | 0,053 | *0,224* |
| INNO | 0,557 | *0,497* | 0,642 | *0,480* | 0,673 | *0,469* | 0,692 | *0,462* | 0,667 | *0,471* |
| RD | 3,057 | *7,479* | 4,201 | *7,811* | 3,951 | *7,358* | 3,250 | *7,233* | 3,687 | *8,762* |
| Size | 3,495 | *0,886* | 3,689 | *0,955* | 3,369 | *0,751* | 3,357 | *0,801* | 3,496 | *0,863* |
| Science based | 0,037 | *0,190* | 0,067 | *0,250* | 0,032 | *0,177* | 0,033 | *0,179* | 0,048 | *0,214* |
| Gov support | 0,177 | *0,382* | 0,092 | *0,290* | 0,186 | *0,389* | 0,179 | *0,383* | 0,147 | *0,355* |
| Export | 0,619 | *0,486* | 0,641 | *0,480* | 0,734 | *0,442* | 0,629 | *0,483* | 0,662 | *0,473* |
| Obs. (max n°) | 2886 | | 2815 | | 2958 | | 2781 | | 2021 | |

## 4 EMPIRICAL ANALYSIS

### *Econometric specification and results*

This section sets up the models used in the empirical analysis. In order to analyse the relationship between industry and university, we estimate the following probit model for each country:

$$P(COLL = 1/x_i) = \Phi(\alpha_0 + \alpha_1 INNO_i + \alpha_2 RD_i + \alpha_3 Size_i + \alpha_4 ScienceBased_i + \alpha_5 Young_i + \alpha_6 GovSupport_i + a_7 Export) \quad [1]$$

Where COLL is equal to 1 when a firm undertook purchased from universities and R&D centres in 2007-2009 and zero otherwise. We include as independent variables the typical factors shown in previous literature to affect the decision to cooperate. INNO is 0/1 variable which takes a value of 1 when a firm introduced at least one innovation (product and/or process) during the 2007-2009 period; *RD* is the average percentage of total turnover that the firm invested in R&D over the 2007-2009 period; *Size* indicates firm size as measured by (a logarithm of) its number of employees in 2008; *Science Based* is a dummy equal to one if the firm is in the "High-tech industry", while *young* assumes the value of one in the case of a firm which is less than 6 years old, and zero otherwise; *Gov Support* is a dummy equal to one if the firm benefitted from tax allowances and financial incentives for R&D activities carried out in the 2007-2009 period and

zero otherwise*; Export* assumes the value of one if the firm was a direct exporter in 2008 or had been actively exporting in the years before 2008.

To shed additional light on the university-industry relationship, we also evaluate whether additional variables, i.e. belonging to a group or family management, affect University-firm collaboration (see table 2).

Results on the probability of collaborating with universities and research centres in each country are reported in table 4.

As expected, estimates show that the probability of collaborating is positively correlated with R&D investments (*RD*): firms whose R&D capacities are large enough to absorb external knowledge usually seek such links. The only exception is for university-firm collaboration in the UK which does not seem to be affected by R&D intensity. These results are in line with those of Fontana et al (2006), Laursen and Salter (2004), Segarra-Blasco and Arauzo-Carod (2008), who found the same results for several European countries.

With respect to firm *size*, measured as (a logarithm of) the number of employees, results show that, in all countries but France, large firms cooperate with partners more effectively than small firms, thereby benefiting more from such cooperation and confirming the results found for the UK, Germany and France (Tether, 2002, and Laursen and Salter, 2004; Mohnen and Hoareau, 2003; Mohnen and Hoareau, 2003, and Segarra-Blasco and Arauzo-Carod, 2008).

The findings concerning *sector* show that, in the case of Italy only, firms in the high tech sector exhibit a significantly higher probability of collaborating with universities than do other firms. This confirms the results obtained by Carboni (2013), which indicate that science based firms tend to have a stronger propensity to invest in research, while firms operating in other sectors are likely to rely more on innovative strategies based on the acquisition of the innovation embodied in capital goods developed by external suppliers. However, this result is not significant for the

other countries considered and, therefore, the idea that universities and public research centres are important sources of open science and R&D cooperative activities in high-tech sectors is not empirically verified for all countries.[5]

Moreover, the dummy *young* has a not significant effect on the probability of R&D cooperation of French, Spanish and UK firms, so confirming the results of Laursen and Salter (2004). The only exception is for Italian and German firms where younger firms have a lower probability of cooperating with universities than older ones.

Innovative firms (*INNO*) and firms which have benefitted from tax allowances and financial incentives for R&D activities (*Gov Support*) are more likely to collaborate with universities and R&D centres. According to these results, firms with access to public incentives aimed at promoting R&D activities are likely to cooperate more in all the five EU countries here analysed, so confirming the results from previous empirical works that report this for France and Spain (Miotti and Sachwald, 2003 for French firms; Mohnen and Hoareau, 2003 for French and Spanish firms; Busom and Fernàndez-Ribas , 2008 for Spanish firms).[6]

Exporting firms have a higher probability of collaborating with universities than other firms in the cases of France and Germany and the UK, but not Italy and Spain. This determinant of cooperation is used in a few of the previous studies and the results for the UK (Tether, 2002) and Italy (Carboni, 2013) show that being export oriented is insignificant when it comes to cooperating with public research organisations.

[5]In the case of the UK, Laursen and Salter (2004) find that the machinery and the chemical industries are the sectors that most use universities as a source for their innovative activities. Firms from the paper and printing and food industries appear to use universities less. Veugelers and Cassiman (2005) confirm this result for Belgian firms and show that the firms are more likely to be actively involved in industry science links in the chemical and pharmaceutical industry.

[6]Miotti and Sachwald (2003) find that R&D subsidies encourage public/private and also horizontal cooperation among French firms. Mohnen and Hoareau (2003), who use a sample of mostly French and Spanish firms, show that receiving subsidies is the factor which has most influence on the probability that a firm will set up a public–private partnership. Busom and Fernàndez-Ribas (2008) point out that public support significantly increases the chances that a Spanish firm will cooperate with a public research organisation.

To shed additional light on the direction of the relationship between the type of innovative activity of the firm and the firm's propensity to collaborate with universities, we decide to replace the dummy *INNO* with two dummy variables: one to capture whether the firm has introduced process innovation (*Process*) and one focusing on product innovation (*Product*). Table 4 reports the results obtained. While the effects of the other variables do not substantially vary,[7] we find different results on the basis of the type of innovation considered. When we consider firms which have introduced a product innovation, the results indicate that they have a higher probability of acquiring R&D from universities and R&D centres in all of the countries. There are, though, some important differences. In the UK for example, the propensity of firms to collaborate with universities is three times that of French firms.

With respect to process innovation, the results show a higher probability of firms' enjoying R&D cooperation with universities in Germany and Italy only, while it is insignificant in other countries.

We also include other variables in the model, but, almost always, they do not exert a significant effect in the five EU countries under scrutiny. To be more precise, we have included among regressors a dummy *group* equal to one if the firm belongs to a group and zero otherwise and a dummy to take into account the role of families in the management of companies (value 1 if the share of managers who are related to the controlling family is higher than the each national average). Results, reported in table 5, show that there is no significant difference in the probability of cooperating with a university in R&D activities between firms belonging to a group and firms which do not belong to a group and that there is no significant difference between family and non-family managed firms in terms of collaboration with universities.

[7]However, the *young* coefficient now becomes not significant in the case of Italian firms.

Table 4 - Estimation results on the probability to collaborate with universities

| | Innovation | | | | | Product and Process innovation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | France | Germany | Italy | Spain | UK | France | Germany | Italy | Spain | UK |
| INNO | 0.0207*** | 0.0492*** | 0.0296*** | 0.0262*** | 0.0546*** | | | | | |
| | (0.0063) | (0.0078) | (0.0069) | (0.0083) | (0.0084) | | | | | |
| Product | | | | | | 0.0180*** | 0.0258*** | 0.0251*** | 0.0193** | 0.0577*** |
| | | | | | | (0.0068) | (0.0086) | (0.0071) | (0.0078) | (0.0093) |
| Process | | | | | | 0.0086 | 0.0507*** | 0.0229*** | 0.0059 | 0.0050 |
| | | | | | | (0.0066) | (0.0087) | (0.0070) | (0.0078) | (0.0103) |
| RD | 0.0009*** | 0.0011*** | 0.0009** | 0.0009** | 0.0006 | 0.0009*** | 0.0010** | 0.0008** | 0.0009** | 0.0005 |
| | (0.0002) | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0002) | (0.0004) | (0.0004) | (0.0004) | (0.0004) |
| Size | 0.0049 | 0.0085** | 0.0163*** | 0.0080* | 0.0129** | 0.0048 | 0.0076* | 0.0147*** | 0.0076* | 0.0124** |
| | (0.0034) | (0.0043) | (0.0042) | (0.0043) | (0.0054) | (0.0034) | (0.0043) | (0.0042) | (0.0043) | (0.0054) |
| Science based | -0.0082 | 0.0154 | 0.0551** | 0.0126 | 0.0312 | -0.0082 | 0.0183 | 0.0528** | 0.0110 | 0.0301 |
| | (0.0106) | (0.0173) | (0.0255) | (0.0200) | (0.0243) | (0.0106) | (0.0176) | (0.0248) | (0.0196) | (0.0240) |
| Young | -0.0088 | -0.0222* | -0.0178* | 0.0068 | -0.0060 | -0.0086 | -0.0228* | -0.0173 | 0.0068 | -0.0070 |
| | (0.0117) | (0.0134) | (0.0107) | (0.0181) | (0.0159) | (0.0117) | (0.0129) | (0.0108) | (0.0180) | (0.0155) |
| Gov Support | 0.0501*** | 0.1263*** | 0.0696*** | 0.1177*** | 0.0392*** | 0.0482*** | 0.1248*** | 0.0676*** | 0.1182*** | 0.0361** |
| | (0.0113) | (0.0211) | (0.0121) | (0.0176) | (0.0150) | (0.0112) | (0.0210) | (0.0119) | (0.0179) | (0.0147) |
| Export | 0.0154** | 0.0433*** | 0.0026 | 0.0126 | 0.0234** | 0.0151** | 0.0423*** | 0.0009 | 0.0126 | 0.0203* |
| | (0.0067) | (0.0081) | (0.0092) | (0.0084) | (0.0105) | (0.0067) | (0.0082) | (0.0095) | (0.0084) | (0.0108) |
| Observations | 2,874 | 2,812 | 2,957 | 2,717 | 2,021 | 2,874 | 2,812 | 2,957 | 2,717 | 2,021 |
| log likelihood | -338.6 | -523.0 | -424.2 | -400.3 | -374.7 | -337.6 | -512.5 | -418.6 | -400.8 | -370.8 |
| pseudo-R2 | 0.154 | 0.163 | 0.160 | 0.210 | 0.105 | 0.157 | 0.180 | 0.171 | 0.209 | 0.114 |
| Wald chi2 | 123.5 | 204.3 | 162.1 | 213.3 | 87.72 | 125.4 | 225.3 | 173.2 | 212.3 | 95.47 |
| p-value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Note: average partial effects are reported. Standard errors clustered at provincial level in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5 - Estimation results on the probability to collaborate with universities including *group* and *family* in the specification.

| VARIABLES | France | Germany | Italy | Spain | UK | France | Germany | Italy | Spain | UK |
|---|---|---|---|---|---|---|---|---|---|---|
| INNO | 0.0207*** | 0.0491*** | 0.0298*** | 0.0263*** | 0.0546*** | 0.0206*** | 0.0492*** | 0.0296*** | 0.0263*** | 0.0545*** |
| | (0.0063) | (0.0078) | (0.0069) | (0.0083) | (0.0084) | (0.0063) | (0.0077) | (0.0069) | (0.0083) | (0.0084) |
| RD | 0.0009*** | 0.0011*** | 0.0009** | 0.0008** | 0.0007 | 0.0010*** | 0.0011*** | 0.0009** | 0.0009** | 0.0006 |
| | (0.0002) | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0002) | (0.0004) | (0.0004) | (0.0004) | (0.0004) |
| Size | 0.0048 | 0.0088* | 0.0139*** | 0.0068 | 0.0107* | 0.0061* | 0.0097** | 0.0163*** | 0.0078* | 0.0122** |
| | (0.0038) | (0.0045) | (0.0046) | (0.0046) | (0.0058) | (0.0036) | (0.0049) | (0.0046) | (0.0046) | (0.0056) |
| Science based | -0.0082 | 0.0157 | 0.0516** | 0.0124 | 0.0297 | -0.0078 | 0.0153 | 0.0551** | 0.0127 | 0.0308 |
| | (0.0106) | (0.0173) | (0.0249) | (0.0200) | (0.0240) | (0.0106) | (0.0172) | (0.0255) | (0.0200) | (0.0243) |
| Young | -0.0089 | -0.0219 | -0.0193* | 0.0056 | -0.0076 | -0.0079 | -0.0219 | -0.0178* | 0.0067 | -0.0065 |
| | (0.0117) | (0.0135) | (0.0104) | (0.0178) | (0.0157) | (0.0120) | (0.0135) | (0.0107) | (0.0180) | (0.0158) |
| Gov Support | 0.0501*** | 0.1261*** | 0.0700*** | 0.1173*** | 0.0392*** | 0.0507*** | 0.1267*** | 0.0696*** | 0.1178*** | 0.0393*** |
| | (0.0113) | (0.0211) | (0.0121) | (0.0175) | (0.0150) | (0.0114) | (0.0211) | (0.0121) | (0.0176) | (0.0150) |
| Export | 0.0154** | 0.0434*** | 0.0028 | 0.0125 | 0.0224** | 0.0154** | 0.0436*** | 0.0026 | 0.0126 | 0.0233** |
| | (0.0067) | (0.0081) | (0.0092) | (0.0084) | (0.0106) | (0.0067) | (0.0081) | (0.0092) | (0.0084) | (0.0105) |
| Group | 0.0003 | -0.0029 | 0.0122 | 0.0069 | 0.0112 | | | | | |
| | (0.0072) | (0.0111) | (0.0101) | (0.0101) | (0.0118) | | | | | |
| Family | | | | | | 0.0105 | 0.0063 | -0.0000 | -0.0010 | -0.0064 |
| | | | | | | (0.0108) | (0.0124) | (0.0082) | (0.0094) | (0.0159) |
| Observations | 2,874 | 2,812 | 2,957 | 2,717 | 2,021 | 2,874 | 2,812 | 2,957 | 2,717 | 2,021 |
| log likelihood | -338.6 | -523.0 | -423.3 | -400.0 | -374.2 | -338.0 | -522.9 | -424.2 | -400.3 | -374.6 |
| pseudo-R2 | 0.154 | 0.163 | 0.162 | 0.211 | 0.106 | 0.156 | 0.164 | 0.160 | 0.210 | 0.105 |
| Wald chi2 | 123.5 | 204.3 | 163.8 | 213.8 | 88.67 | 124.6 | 204.5 | 162.1 | 213.3 | 87.87 |
| p-value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Note: average partial effects are reported. Standard errors clustered at provincial level in parentheses; *** p<0.01, ** p<0.05, * p<0.1

## 5. CONCLUDING REMARKS

The aim of this paper is to identify the differences and the common characteristics of university-industry cooperation across European countries (France, Germany, Italy, Spain and the UK), by using a sample of over 13 thousand small and medium-sized enterprises. We use the Efige data (2007-2009) and apply a probit estimation.

Our main findings can be summarised as follows.

First, we find that some determinants of R&D cooperation differ across countries. This supports the view that there is a high degree of heterogeneity in the relationships between firms and universities. Firm age and the innovation process only have positive impacts in Germany and Italy, while, if firms are exporting firms, this affects R&D cooperation in the case of France, Germany and the UK, but not in Italy and Spain. On the other hand, only in Italy do firms in the high tech sector tend to have a high propensity than firms in other sectors to collaborate with universities .

Second, the results of the analysis underline the central role that firms' research and innovation capability has regarding collaboration. R&D-intensive firms and product innovators are more likely to cooperate with universities. These results are consistent with the absorption hypothesis: only firms with important internal R&D activities are able to extract knowledge from universities and research centres.

Third, these results provide evidence that public policies have a key role in promoting collaboration between universities and firms by offering public funds to encourage private R&D. This is very much in line with the orientation of public R&D funding in the area of this type of activity and the promoting of technology transfer.

Fourth, in line with previous studies, we also find that larger firms are, in almost all cases, more likely to cooperate with science institutions than smaller ones.

These results have some policy implications, but we should be aware of the limitations of the data used. Our estimates are based on a cross-section of firms and this limits our ability to take unobservable heterogeneity into account.

The results seem to suggest that some firm characteristics which might explain university-industry cooperation are country specific. Therefore, a great deal of caution is required when developing policies that generalise university-industry relationships.

However, we also find some common results for European countries, for instance that firms with no existing R&D capability or public support, firms which are not heavily R&D oriented and small firms are significant barriers to industry-university interaction. We believe that public policies can stimulate R&D cooperation by offering public funds to innovative firms, especially large firms with important internal R&D activity. However, medium- and long-term policies that increase firm's absorptive capacity are also needed in order to exploit knowledge from universities.

In Europe, policies have, over recent years, mainly been directed at creating incentives for universities to interact with firms. These results, though, indicate that there may not be an appropriate level of demand from firms in certain economic contexts because these may not have the requisite features to be able to absorb external knowledge.

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