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INTERNATIONAL R&D COOPERATION WITHIN THE EU FRAMEWORK PROGRAMME: THE CASE OF SPANISH FIRMS

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STRUCTURE AND STRATEGY FOR CORPORATE R&D

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1 - Introduction

In order to understand international R&D cooperation, it is necessary to locate this phenomenon within the process of globalisation. Narula (2007) distinguishes two kinds of drivers of globalisation related, in one case, to political and economic factors and, in the other, to technological factors. Within the first category, financial liberalisation, supra-national institutions, economic integration and liberalisation of economic systems are pointed out, whereas the technological factors refer to rapid technological change, widespread use of information and communication technologies (ICT), the rising costs and risk of innovation and the increasing need for complementary technological capabilities within the firm.

The interaction of these social and technological trends fosters the interdependence of regions and firms and, as a consequence, the homogeneity of consumption patterns and the enlargement of the market. R&D cooperation appears in this context as a strategic answer to the global economy, allowing enterprises to seek partners who provide the best opportunities for learning and innovating, regardless of their location.

In fact, the evidence shows that R&D cooperation is increasing around the world, reaching an all-time peak in 2003, according to the most recent available data (National Science Board, 2006). Domestic alliances among U.S. companies lead the statistics, followed by alliances between U.S. and European companies. Cooperation carried out exclusively among European companies is about 12% of the total reported agreements. This percentage could be a figure of reference for understanding the scope of the present work.

R&D cooperation among European firms has been supported by the R&D Framework Programme (FP) since 1984. The FP offers public funding for cooperative R&D projects developed by private or public organisations, self-organised as transnational consortia.

Over the years, the FP has become a suitable source of data on international cooperation within the European Union, since research consortia meet all the requirements to be considered research joint ventures (RJV), as some authors have remarked (Caloghirou et al., 2004).

Prior literature concerned with RJVs (Hernán, Marín and Siotis, 2003) has found empirical evidence that explains why a firm decides to engage in research consortia. Nevertheless, these studies use data only from financed projects, without considering those applications that, after the evaluation process carried out under the auspices of the European Commission (EC), do not receive any financial aid.

The probability that a firm takes part in a consortium within the FP must be regarded as the result of a two-phase process. Firstly, the firm decides to engage in the consortia or not and, secondly, the project is approved or rejected.

From this dual perspective, the present work aims to explain which factors determine the participation of the Spanish firm in R&D consortia within the Framework Programme, distinguishing between the decision to apply and the agency selection. For that purpose, we analyse the participation of Spanish firms in the FP during the period 1995-2005, using a data base provided by the CDTI (the public organism in charge of monitoring the

participation of Spanish firms within the FP) that contains much relevant information about the projects and the participants. This information is available for both projects that, after the evaluation process, have received grants and those which have not received any financial aid. We also use data provided by the SABI database consisting of company accounts for over 1,000,000 Spanish firms.

Through this approach, this paper provides empirical evidence for policy makers interested in promoting Spanish participation within the FP and for all those people concerned with the strategic relevance of international R&D cooperation.

The second section of the paper summarizes theoretical and empirical works about R&D cooperation, stressing the international dimension of the process. After this, the third section focuses on the UE Framework Programme as analytical context and discusses the institutional factors that must be taken into account. Section 4 concerns the empirical model and the descriptive analysis of the data. The main results from the econometrical estimations are presented in Section 5 and, finally, relevant conclusions are drawn in Section 6.

2 - International R&D cooperation in the literature

International R&D cooperation is a complex research topic, involving many factors that, until now, have not been explained by a unique and common accepted model. Thus, theoretical approaches propose partial explanations of the process, whereas empirical works are limited by two obstacles: (i) the difficulty of identifying economic and technological indicators suitable for every type of collaboration and (ii) the lack of internationally normalised statistics (Archibugi and Iammarino, 2002).

Basically, theory about international R&D cooperation results from the confluence of two main trends: R&D internationalisation and R&D collaboration (Lundin, Frinking and Wagner, 2004). The first one, based originally on the FDI theory, has been very fruitful, proposing models that explain how and why multinational enterprises (MNEs) carry out their R&D activities abroad and progressively incorporating new perspectives from the evolutionary innovation theory (Niosi, 1999). Recent studies on international R&D investments stress the importance of the two-side perspective, regarding the knowledge flows between the host and the home countries and the strategic relevance of the spillovers generated in both economies (Veugelers, 2005).

Authors concerned with R&D cooperation have focused mainly on two questions: what the drivers of research partnerships are and what effects the cooperation has on both the individual partners and the industry. According to the transaction costs theory, knowledge is an intangible asset and thus market R&D contracts are incomplete, unable to capture all the value generated by this kind of activities. Through the cooperation, firms avoid the high cost of internalising R&D activities while minimising the cost of an incomplete transaction (Hagedorn, Link and Vonortas, 2002). In addition, industrial organisation researchers argue that knowledge is a public good, exposed to market failures and spillovers. Cooperation seems to be a suitable strategy for internalising these spillovers within formal consortia (Cassiman and Veugelers, 2002). The relationship between the firm's corporate strategy and the R&D cooperation process has also been stressed by some authors. Since

innovation is a knowledge-intensive activity, cooperation promotes learning from partners and incorporating complementary capacities (Teece et al., 1997). The dynamic of R&D has also been related to the competitive position of the firm, signaling that cooperation facilitates a rapid answer to market changes (Porter, 1986).

An attempt to joint disperse approaches — and one of the most cited works— is the taxonomy developed by Archibugi and Michi (1995). These authors identify three categories concerning the internationalisation of R&D activities: international exploitation of nationally produced innovations; global generation of innovation and global techno-scientific collaborations. The last category includes joint ventures for specific innovative projects and productive agreements with exchanges of technical information and/or equipment. This taxonomy explains, through a simple model, the alternatives that firms have for managing their R&D activities, assuming that the global economy is the context where decisions are taken.

Regarding empirical literature, the border between R&D cooperation and international R&D cooperation is quite diffuse. In fact, the main available data sources, such as the CATI-MERIT, the Financial Thomson Strategic Alliances or the NCRA-JRV databases, contain information from both domestic and cross-border joint ventures. Works concerning the drivers of international R&D cooperation add some specific arguments to the traditional set of advantages related to cooperation (shared cost and risk, access to complementary knowledge, learning opportunities and internalisation of spillovers). Thus, some authors remark that, when knowledge is a firm-specific or country-specific asset, i.e., an immobile and not marketable asset, international cooperation increases the probability of capturing knowledge wherever it is generated (Archibugi and Iammarino, 2002) as well as learning from the interaction between technology and foreign markets (Narula and Hagedoorn, 1998). Improvements in telecommunication and transport facilitate personal contact between geographically distant partners and reduce the coordination costs (Narula, 2003). These arguments, also gathered in the literature on firm internationalisation to explain the location of R&D activities abroad, reflect an important issue: in a global context, the strategic nature of R&D activities is reinforced when the activities are developed under international cooperation.

The Cooperative Agreements and Technology Indicators (CATI) database, developed by the Maastricht Economic Research Institute in Technology (MERIT), includes information about RJVs reported publicly in journals, books and company publications during the last decades. Authors working with the CATI-MERIT database (Hagedoorn, 2002; Hagedoorn, Link and Vonortas, 2002) indicate that technological alliances, which involve partners mainly from the Triad ─ North America, the European Union and Japan ─ have dramatically increased between 1970 and 1998, reaching a peak in 2003 (National Science Board, 2006). The share of international partnerships out of the total was about 55% during the 1990s, whereas a great number of domestic alliances are due to intra-U.S. collaboration in two main fields: information technology and biotechnology. It is also remarked that inter-firm research partnerships are mainly concentrated in a small number of high-technology industries. The increasing normalisation of intellectual property rules reinforces the election of contractual agreements and networks instead of equity joint ventures (Narula and Hagedoorn, 1998).

Recent studies based on the Thomson Financial Joint Venture database —which contains information from the Security and Exchange Commission (SEC) and its international counterparts— confirm many of the previously mentioned results (Moskalev and Swesen,

2007): joint ventures (JV) are more frequent within technologically intensive industries such as drugs, chemical, electronic and electrical equipment, telecommunications and communications equipment, due to the high risk associated to their activity. In fact, between 1990 and 2000, one of every three JVs registered by this database was a technological or R&D agreement. The international dimension of these agreements is also a remarkable feature, since 64% and 50% of all technological and R&D ventures, respectively, involved cross-border participants.

Other relevant data source comes from the U.S. National Cooperative Research Act, a legislative initiative enacted in 1984 to promote cooperation among U.S. firms. The most recent work carried out on the basis of these data conclude that R&D cost-sharing is an important incentive for the JRV formation. Moreover, variables such as firm-size differences, the number of members in the JRV, the activity branch of the firm and the impact on R&D investments are significant factors in determining technological cooperation (Röller, Siebart and Tombak, 2006).

3 - R&D cooperation within the EU Framework Programmes

The EU Framework Programme (FP) is the main political instrument supporting cooperative R&D within the European Union. It was born in 1984 with the aim of coordinating dispersed R&D activities funded by the European Commission. Since then, seven editions of the FP have been launched, evolving towards increasing budgets, new participation models and wider research priorities (Georghiou, 2001).

Projects carried out under the FP are representative of international R&D cooperation processes since partners from different nations formalise consortia and invest their own resources in cooperative research activities in order to obtain appropriable results.

Moreover, the operative scheme of the FP has retained some crucial aspects over the seven editions, making it possible to analyse homogeneous long data series (Roediger-Schula and Barber, 2006). These common aspects are the following:

- Promoters: all projects are promoted by self-organised consortia.
- Financial scheme: supported projects have a limited duration and their R&D activity is co-financed by grants coming from the European Commission and private funds coming from the consortia partners.
- Cooperation scheme: consortia are shaped by different kinds of partners located in different nations (usually, consortia are integrated by firms, public research centres, Universities and users).
- Evaluation scheme: selection criteria are based on scientific excellence and relevant socio-economic aspects. Evaluation is carried out by independent experts in each technological area from all the UE member countries.

Considering that micro-data on international R&D cooperation are scarce, it is obvious that information referring to firm participation in the FP is of great value for empirical studies. Moreover, the cooperation scheme, involving private and public organisations, has an additional value in contrast to other existing databases. In fact, some research trends have surged in the last years using this information.

One of them, supported by the IV FP through the TSER (Targeted Socio-economic Research) programme, is concerned with the study of RJVs defined as “cooperative agreements engaging companies, Universities and government agencies and laboratories to pool resources in pursuit of a shared R&D objective” (Caloghirou et al., 2004). For this purpose, researchers developed a complete database containing information about R&D projects supported by the FP and involving at least one firm.

Empirical works carried out under this initiative have analysed why firms decide to participate in RJVs, concluding that the probability of engaging in research consortia is positively related to the R&D intensity of the industry, the firm size and its past experience in research cooperation (Hernán, Marín and Siotis, 2003). These authors do not find any significant bias associated with the nationality of the firm, although they suggest that firms from larger countries are less likely to participate in cross-border RJVs.

A more recent line of research has worked with the EUPRO database, which contains all available information in the CORDIS project database. Some authors have analysed the structure of collaboration networks formalised under the FP, finding that these networks are shaped according to a stable path over the years in spite of operative and structural changes taking place within the FP (Roediger-Schluga and Barber, 2006). Moreover, they confirm that, throughout the consecutive editions of the programme, a central and stable core has emerged, shaped by the most participative organisations.

In general, authors working with data provided by the FP recognise that results of any analysis should be interpreted taking into account the formal context where R&D cooperation is carried out. In this respect, some aspects must be pointed out.

Over the seven editions of the programme, the budget allocated to the FP has increased. Moreover, the distribution of the total budget among the thematic priorities has changed according to specific economic and political goals. As such, in the first years, energy was the protagonist, whereas information technology led the latter editions. Regarding the technological distribution of budgets, some authors conclude that EU authorities have favored projects in R&D-intensive industries (Marín and Siotis, 2002).

From the origin of the FP, new instruments of participation have been incorporated, determining, in a non-residual way, the features of consortia partners and the dimension of R&D projects. In this respect, the most remarkable fact is the inclusion of the Integrated Projects and the Networks of Excellence in the VI FP, in order to co-finance more ambitious R&D initiatives.

Thirdly, the institutional context and administrative requirements of the FP should be taken into account in order to explain firm participation. In this sense, recent studies (Siune, Schmidt and Aagaard, 2006) stress the following factors:

- Access to information about opportunities and formal requirements determines both the decision to participate in the FP and the success of a proposal. The diffusion of information is managed by the EC – mainly through the web page of CORDIS[1] – and also by the National Contact Points (NCPs), offices in charge of providing individual assistance and promoting national participation in the FP. In this respect, one relevant contribution of the Commission and the NCPs is the assessment in finding partners, which could be considered one of the obstacles to carrying out cooperative R&D projects.

- A high degree of administrative formalisation facilitates the evaluation of proposals, but could discourage firms from applying, especially those without previous experience within the FP. Otherwise, expert and independent evaluators guarantee the fair selections of proposals, but this procedure requires them to constantly update their knowledge of specific objectives of the FP (Marimón, 2004).

- Before receiving the approved financial aid, the consortium coordinator and the Commission should sign a contract in order to formalise concrete aspects. Some authors (Siune, Schmidt and Aagaard, 2006) have reported that firms, especially SMEs, perceive this negotiation phase as a resource-consuming requirement that could delay the timing of the R&D project.

- Intellectual property rights are regulated by the aforementioned contract. By requiring this agreement among partners, the Commission tries to promote good practices within the cooperation project. Nevertheless, a too strict regulation could discourage firm participation (Caloghirou and Vonortas, 2000).

From all these factors, it could be pointed out that the FP is a more favourable scenario for firms that already perform R&D activities, especially within the FP, and thus could allocate resources and knowledge to apply and to elaborate proposals according to the administrative and technological requirements. Moreover, firm size, as an indicator of resources and information availability, and the technological area, as an indicator of funding opportunity, seem to be relevant variables to explain why a firm applies within the FP. But, otherwise, the lack of experience and resources could be neutralized by the existence of public mechanisms aimed at promoting the participation of firms, assessing them, or even financing the elaboration of proposals[2].

[1] http://cordis.europa.eu/

[2] In the case of Spain, the NCP (Centre for the Development of Industrial Technology, CDTI) offers financial support to elaborate a proposal.

4 - Empirical model and data

The aim of this paper is to describe the factors that determine the firm's participation in a R&D consortium financed by the FP. Most of the empirical studies that try to explain the participation in national or international aid programmes have information only about financed projects, and therefore are not able to distinguish between the firm's decision to apply for the aid and the agency selection among the proposals (see, for example, Blanes and Busom, 2004, which refers to the participation in R&D subsidy programs). The main disadvantage of this lack of information is that the selectivity problem is not considered. However, in our database, we also have data about rejected applications. Taking this into account, we can express the probability of participation in a financed cooperative R&D project as the following joint probability:

$$\begin{aligned}\Pr(participation = 1) &= \Pr(application = 1, award = 1 \mid x) \\ &= \Pr(award = 1 \mid application = 1, x) \cdot \Pr(application = 1 \mid x)\end{aligned}$$

To estimate both probabilities, the empirical model consists of two equations. The first one describes the decision of applying for a FP cooperation project involving at least one Spanish firm. The equation to be estimated takes the form:

$$y_{1i} = \begin{cases} 1 & \text{if } y_{1i}^{*} = f(x_{1i}\beta_1 + u_i) > 0 \\ 0 & \text{otherwise} \end{cases} \qquad \textbf{(1)}$$

where y_{1i}^{*} is a latent dependent variable, x_{1i} is the set of explanatory variables, β_1 is the vector of coefficients and u_i is the error term. The firm *i* applies within the FP if y_{1i}^{*} is positive. Following the existing literature, and given the data availability, the following variables have been included in the model:

x_1 = *(prior experience in FP proposals, granted/rejected project in previous year, firm size, exporter, region, liquidity ratio, intangible fixed assets, stock market, industry activity, year)*

The second equation refers to the agency selection. Again, the decision of awarding or denying is formalized in terms of a binary model:

$$y_{2i} = \begin{cases} 1 & \text{if } y_{2i}^{*} = f(x_{2i}\beta_2 + e_i) > 0 \\ 0 & \text{otherwise} \end{cases} \qquad \textbf{(2)}$$

where y_{2i}^{*} is the latent dependent variable, x_{2i} is the set of explanatory variables, β_2 the vector of coefficients and e_i is the error term. The proposal in which the Spanish firm *i* participates is approved if y_{2i}^{*} is positive[3]. Although most of the explanatory variables in

[3] Notice that more than one Spanish firm can participate in the same proposal. The relevant variable in this case is the proposal.

the first equation have firm dimension, the variables in this second equation have group dimension, as the agency decision about the cooperative proposal refers to all members in the consortium:

x_2 = *(leader nationality, size of the consortium, participation of public organisms, technological area, FP budget allocated to the specific programme, year of the application, prior experience in FP projects, granted/rejected project in previous year, geographical dispersion)*

These variables are assumed to be strictly exogenous or predetermined longer in advance.

4.1 Database

Our analysis is based on integrated data from two sources: the CDTI-PM database and the SABI database. Since the VI FP went into effect, the CDTI (*Centro para el Desarrollo Tecnológico Industrial*) has been the organism in charge of the maintenance and management of the information related to the Spanish participation in the FP. As a consequence, the CDTI-PM database includes information about all the proposals[4], eventually granted or not, in which at least one Spanish firm participates between 1995 and 2005. During this period, 3,492 Spanish companies applied for cooperative FP projects, with the number of proposals reaching 8,178 (1,888 were ultimately financed).

The information from the CDTI-PM database has been completed with the one from the SABI database that contains the company accounts of more than 1,000,000 Spanish firms between 1995 and 2005. From these, we have selected a control sample that takes into account the availability of data about the relevant variables for each firm. We have chosen all companies employing more than 200 employees. Firms employing between 10 and 200 employees are selected by a random sampling scheme for each NACE class (two-digit) level, and represent around 4% with respect to the Spanish *Central Companies Directory* (CCD), which gathers in just one information system all Spanish companies and their local units located in the country. This makes our control sample representative of the Spanish economy. Coverage of the data is basically restricted to firms which have at least 10 employees (annual average), but we have also included 615 micro-companies (0.5% with respect to the CCD, chosen again by means of a random sampling scheme) given that 219 applicants of cooperative FP projects belong to this category. Although we have information since 1995, the sample used in the empirical analysis refers only to the period 1999 to 2005, given that the V FP started in 1999 and we want to take into account the experience, if it exists, in the previous programme.

Overall, the final sample consists of an unbalanced panel of 55,981 observations, 10,423 companies, and 3,251 proposals. The information from the SABI database is used mainly to estimate the firm's decision to engage in the cooperative project, while the CDTI-PM database allows us to analyse the determinants of the agency selection.

[4] To guarantee the homogeneity of the sample, only Specific Targeted Research Projects (STREPs) and Integrated Projects are considered. The present work does not consider the specific instruments designed for SMEs (CRAFT). Nevertheless, it should be noted that the STREPs and the Integrated Projects accounted for 74% of the total aid received by Spanish SMEs in the VI FP.

4.2 Descriptive analysis

According to prior empirical evidence on international R&D cooperation, the econometric model includes three groups of possible determinants: 1) variables characterising the financial and technological situation of the Spanish applicant; 2) variables reflecting the features of the consortium and 3) indicators of the previous experience in international R&D collaboration. In what follows, we describe the variables that we have considered in each set of determinants.

4.2.1 Firm characteristics

As we have seen in previous sections, empirical works about the advantages of cooperation point out the importance of shared cost and risk, access to complementary knowledge, learning opportunities and the internalisation of spillovers, and also suggest that inter-firm research partnerships are mainly concentrated in a small number of high-tech industries. Specific evidence about participation in the FP (Hernán, Marín and Siotis, 2003) confirms these regularities, concluding that the probability to participate in a JRV is positively related to the firm's size and the R&D intensity of the industry.

Besides the firm's size, our database includes a large set of financial indicators. However, there is not information about R&D intensity or other measures of the company's technological performance, such as innovations or patents. Given the intangible character of R&D, we instead use the proportion of intangible fixed assets over total fixed assets. The difference of means test confirms that the average of this variable in the sample is higher for the applicants within the FP than for the non-applicants (see Table 1). We also take into account whether the firm's activity corresponds to a high-tech service sector or a high or medium-tech manufacturing sector according to the OCDE classification[5]. The frequencies in Table 1 reflect a high presence of these activities among the proponents, especially in the high-tech services. In addition, we consider a set of geographical dummies to be explanatory variables, given that the more technological Spanish firms tend to locate in specific regions[6].

Another fact to consider is that the importance of sharing costs through cooperative agreement can be superior if the company is financially restricted. The liquidity ratio is included in the specification to capture the own financial capacity, under the hypothesis that firms with a lower proportion of shareholders funds over non-current liabilities are more likely to be interested in the aid provided by the EC. In fact, the mean of the liquidity ratio of applicants in the sample is statistically lower than the mean of non-applicants (see again Table 1).

[5] See the correspondence with the NACE-2-digit classification in Table A1 of Appendix 1.

[6] Find the exact definitions of the variables in Appendix 2.

Table 1
Firm characteristics in the sample: descriptive statistics

Means of quantitative variables:	All firms	Applicants	Non-Applicants	t-test[a]
Liquidity ratio	0.717	0.690	0.718	3.31 (0.0009)
Intangible fixed assets	0.153	0.201	0.150	-10.80 (0.0000)
Frequencies of binary variables (%):	**All firms**	**Applicants**	**Non-Applicants**	
Exporter	48.01	57.20	47.46	
Stock-market	1.33	4.84	1.12	
Region				
Andalusia	7.47	6.01	7.57	
Catalonia	24.08	23.35	24.12	
Galicia	3.72	3.84	1.71	
Madrid	24.21	34.36	23.60	
Basque Country	7.81	15.53	7.35	
Valencia	9.49	7.02	9.63	
High-tech services	7.01	24.17	5.99	
Post and telecommunications	1.16	4.40	0.97	
Computer and related activities	4.84	14.71	4.25	
Research and development	1.01	5.06	0.77	
High and medium-tech manufacturing	16.50	19.84	16.30	
Chemicals and chemical products	5.03	4.78	5.04	
Machinery and equipment n.e.c.	4.33	4.27	4.33	
Office machinery and computers	0.21	0.57	0.19	
Electrical machinery and apparatus n.e.c.	1.94	1.90	1.94	
Radio, television and communication	1.08	2.37	1.00	
Medical, precision and optical instruments	0.82	1.33	0.79	
Motor vehicles, trailers and semi-trailers	2.23	1.55	2.27	
Other transport equipment	0.87	3.07	0.74	
Number of observations:	55,981	3,161	55,820	

[a]: t-test=two-sample difference of means test. P-value in parenthesis.

To complete the set of explanatory variables, we include two additional indicators. The first one is presence in international markets through exports. The proportion of exporters among the proponents is supposed to be higher for two reasons. First, exports and international cooperation can be part of the same firm's internationalisation strategy. Second, due to their superior knowledge of the international context, exporters could more easily find partners for their R&D agreements.

The second indicator reflects whether the firm is listed on the stock-market. This kind of company is usually financially more consolidated and international funds could be less attractive to it. However, firms on the stock market tend to show more formalised quality procedures and therefore could find the formal requirements of the FP easier, as

mentioned in section 3. In our sample, both export and stock market activities are less frequent among the non-applicants.

4.2.2 Features of the consortium

As remarked in previous sections, any analysis of consortia created within the FP must take into account the specific features of this programme regarding barriers to and opportunities for company cooperation.

Cooperation processes could be hindered by two main factors: 1) access to information channels in a broad sense and 2) the relevance of the coordination cost related to both formal procedures and the transfer of knowledge between public and private organizations, which, at the end of the process, will allow for the right management of intellectual property rights.

Access to information channels should be considered as a process that includes the selection of partners. Thus, the firm's capability to find the best partners increases the probability of receiving funds. We could approximate this capability by considering the identity of the coordinator, who plays the main role within the consortium. Since some authors have identified a central core of frequent participants in projects supported by the FP (Roediger-Schluga and Barber, 2006), it is supposed that, when the coordinator of the consortia belongs to the more active countries, there will be fewer obstacles to cooperation.

Literature shows that, by means of cooperative projects, firms try to share high costs and risk associated with their technological activity. Nevertheless, according to the transaction-cost theory, cooperation is only an efficient alternative if coordination costs are lower than both, market and internal corporate costs. In the case of the FP, costs are increased by means of the administrative requirements and the delay in receiving funds, that is, by a wider time-to-market period. Moreover, due to the tacit nature of R&D (Santos, *et al.* 2006), coordination cost is supposed to be related to the transfer of knowledge among partners.

In this respect, our model will analyse three specific cost factors: the size of the consortium, the geographical distance between members and the type of organisations engaged in the cooperative agreement. In order to get an initial impression of the relevance of the selected variables, in Table 2 we distinguish between supported proposals and non-supported proposals.

The size of the consortium is a determinant factor not only in coordinating the partnerships, but also in reaching the technological objectives of the project. Coordination costs are supposed to be positively related to the number of partners, although a low number of members may not be enough to form multidisciplinary research teams.

Table 2
Features of the consortium and the project: Descriptive statistics

Means of quantitative variables:	Proposals	Supported proposals	Non-supported proposals	t-test[a]
Size of consortium	12.21	14.12	11.67	-5.15 (0.0000)
FP budget for the specific programme	21.16	20.01	21.50	3.55 (0.0004)
Participation of organisms (%)	49.14	45.37	50.21	5.20 (0.0000)
Geographical distance	0.32	0.18	0.36	7.20 (0.0000)
Frequencies of binary variables:	**Proposals**	**Supported proposals**	**Non-supported proposals**	
Leader nationality				
Spanish	31.13	32.41	30.77	
Italian	10.52	9.04	10.94	
German	11.04	13.91	10.23	
Dutch	2.83	4.31	2.41	
French	8.74	10.57	8.21	
British	9.97	10.71	9.76	
Technological area				
Information and communication	44.54	36.02	46.96	
New materials	6.18	6.26	6.16	
Environment and energy	8.95	8.93	9.04	
Transports	18.95	26.98	16.67	
Agro-food	2.09	1.81	2.17	
Aeronautic and aerospace	3.01	6.26	2.09	
Innovation programmes	3.48	4.27	3.08	
Number of observations	3,251	719	2,532	

(*): t-test=two-sample difference of means test. P-value in parenthesis.

Regarding geographical distance, some authors (Narula, 2003) have remarked that information technologies and transports have contributed to reducing the specific cost related to knowledge transfer. Nevertheless, a broader concept of geographical distance, which also considers cultural and operational aspects, reveals that a higher “cooperative distance” is perceived by firms as an obstacle to cooperating (Nagle *et al.*, 2007).

In order to analyse this fact, we have introduced in the model a geographical-distance index, calculated as the percentage of partners from Northern Europe, Eastern Europe and non-European countries over the total number of members for each consortium. The percentage is multiplied by 2 or 3 if the partners are, respectively, from 2 or 3 of the geographical areas mentioned. This index allows us to measure the relative presence of geographically distant partners (taking Spain as the point of reference) as well as the geographical heterogeneity within the consortium (notice that the presence of at least one Spanish firm in the sample is guaranteed by definition). As a first approximation, Table 2 shows that the geographical-distance index is lower for those proposals that received funds.

The number of public organisms participating in the project is supposed to be positively related to the coordination costs and the transfer of knowledge, due to the different objectives and working procedures that characterized both firms and public organisations. The statistics in Table 2 confirm that the presence of public organisms is lower for those proposals that are eventually supported.

Incentives to cooperate under the FP should be understood from a dual perspective: first the financial aid, and second, the possibility to harmonize corporate R&D strategy with the institutional objectives pursued by the EC. Although financial incentives are always welcome, any R&D project supported by the FP should be related with the technological priorities included in each call for proposals.

In order to capture the opportunities perceived by firms which decide to participate in a cooperative project, we use two variables. First, financial opportunity is measured through the budget allocated by the EC to the specific programme to which the firm applies (in percentage of the total budget of each edition of the FP). Second, technological opportunity is represented in the model by a set of variables that identify the main technological area of the project. The descriptive statistics of these variables are shown in Table 2.

By including a set of dummy variables related to the year of application, the model considers the effect of the formal changes taking place within the FP. As mentioned in the literature (Sinue, Schmidt and Aagaard, 2006), during the last year of each edition, the number of calls decreases; consequently, the number of supported proposals also decreases. Moreover, these time variables also take into account the inclusion of new financial instruments, such as the integrated projects within the VI FP.

4.2.3 Prior experience in international collaboration

Hernán, Marín and Siotis (2003) found that the firm's past experience in research cooperation increases its probability of participation. This can be explained by at least three motives. Firstly, the preparation of an application usually entails a high degree of administrative formalisation, which could discourage firms from applying, especially in the case of those without previous experience within the FP. Secondly, the firm that has previously engaged in a research consortium has less trouble finding suitable partners for the new alliance. Finally, past participation in a financed cooperative programme implies that the evaluator has acknowledged the company's technological capacity at that moment. In general, possessing broader experience in R&D cooperation is supposed to reduce the coordination costs and facilitate access to information.

To capture these effects, we use three measures of prior experience. All of them are dummy variables that take the value 1 when the Spanish firm: 1) has applied for or achieved aid in the immediately previous edition of the FP; 2) has participated in a project granted in the previous year or 3) has presented a proposal rejected during the last year. As can be seen in Table 3, the proportion of firms with prior experience in proposals is clearly superior in applicants compared to non-applicants in the sample. In addition, the presence of firms with past experience in granted FP projects (whether in the previous edition of the FP or in the last year) is higher in the supported proposals than in the non-

supported ones. It must be remarked that at least one Spanish firm with proposals rejected in the previous year is involved in 44.36% of the supported projects.

Table 3
Prior experience in FP: Descriptive statistics

Frequency:	All firms	Applicants	Non-Applicants
Prior experience in FP proposals	8.54	45.97	6.30
Granted project in previous year	1.25	13.35	0.53
Rejected proposal in previous year	3.99	43.59	1.62
Frequency:	Proposals	Supported proposals	Non-supported proposals
Prior experience in FP granted projects	23.07	26.30	22.12
Granted project in previous year	13.60	16.83	12.68
Rejected proposal in previous year	44.36	44.65	44.27

5 - Results

In this section we present the results of the estimation of the model depicted in Section 3. As equations (1) and (2) indicate, we decompose the probability of participation in a cooperative project financed by the EC into two different decisions. In the first stage, the firm decides to engage or not in the proposal. In the second stage, the European agency decides to finance or not the cooperative project.

5.1 Determinants of the firm's decision to apply

Table 4 summarises the estimates of the model that represents the determinants of the firm's decision to engage in a research consortium. Given the binary character of the dependent variables, and taking into account the panel structure of the data, the specification has been estimated as a random effects probit model. The majority of variables are statistically significant, although marginal effects are small, except for those variables measuring previous experience in the FP. This fact points out the requirement to complete the group of explanatory variables with explicit indicators of the firm's technological profile.

In column (1) of Table 4, the first coefficient corresponds to a dummy that stands for years 2003 to 2005, corresponding to the VI FP. This variable achieves a negative effect, although it is not significant. When we substitute this dummy for the whole set of time dummies -see column (2)- we observe that the specific features of the sixth edition (years 2003 to 2005), in comparison with the fifth one, were less favorable to the technological objectives of Spanish firms, which consequently applied in a smaller proportion. In addition, it is confirmed that firms tend to submit a smaller percentage of proposals the last year of an edition of the FP (year 2002), likely due to the lower number of calls.

As we have supposed, prior experience in FP proposals increases the probability of applying in the next edition, and to a greater extent when the prior experience took place during the last year. The last-year experience effect is slightly higher if the previous proposal was rejected instead of being approved. Obviously, since the application process within the FP is very costly, companies will try to profit from the accumulated knowledge by means of applying to the following calls for proposals.

The rest of the explanatory variables generally exhibit the expected effect. Companies that export, are on the stock market and maintain a higher proportion of intangible fixed assets are also more likely to apply, while the liquidity ratio is negatively associated with the probability of engaging in the cooperative project.

Table 4
Determinants of the firm's decision to apply within the FP
Probit estimates

	(1)		(2)		(3)	
	dy/dx	Std. E.	*dy/dx*	Std. E.	*dy/dx*	Std. E.
VI FP	-0.001	0.001				
Time dummies						
Year 2000			-0.001	0.002	-0.001	0.002
Year 2001			-0.002	0.002	-0.002	0.002
Year 2002			-0.008 ***	0.001	-0.008 ***	0.001
Year 2003			0.002	0.002	0.002	0.002
Year 2004			-0.007 ***	0.001	-0.008 ***	0.001
Year 2005			-0.007 ***	0.001	-0.007 ***	0.001
Prior experience in FP proposals	0.031 ***	0.005	0.026 ***	0.004	0.026 ***	0.004
Granted project in previous year	0.207 ***	0.027	0.191 ***	0.026	0.191 ***	0.026
Rejected proposal in previous year	0.216 ***	0.023	0.201 ***	0.023	0.203 ***	0.023
Exporter	0.005 ***	0.001	0.005 ***	0.001	0.005 ***	0.001
Liquidity ratio	-0.003 ***	0.001	-0.002 ***	0.001	-0.002 **	0.001
Intangible fixed assets	0.005 ***	0.002	0.005 ***	0.002	0.006 ***	0.002
Stock market	0.038 ***	0.010	0.037 ***	0.010	0.037 ***	0.010
Firm's size dummies (no. of workers)						
From 10 to 49	-0.008 ***	0.001	-0.007 ***	0.001	-0.007 ***	0.001
From 50 to 99	-0.011 ***	0.001	-0.010 ***	0.001	-0.010 ***	0.001
From 100 to 199	-0.013 ***	0.001	-0.011 ***	0.001	-0.011 ***	0.001
More than 200	-0.016 ***	0.002	-0.014 ***	0.002	-0.014 ***	0.002
Region						
Andalusia	0.003	0.003	0.003	0.002	0.002	0.002
Basque Country	0.024 ***	0.004	0.023 ***	0.004	0.023 ***	0.004
Catalonia	0.007 ***	0.002	0.006 ***	0.002	0.007 ***	0.002
Galicia	-0.002	0.003	-0.002	0.003	-0.003	0.003
Madrid	0.009 ***	0.002	0.009 ***	0.002	0.008 ***	0.002
Valencia	0.007 **	0.003	0.006 **	0.003	0.006 **	0.003
Sigma_u	0.600	0.046	0.646	0.049	0.636	0.048
Rho	0.265	0.030	0.294	0.031	0.288	0.031
Log of likelihood function	-7,697.51		-7,624.33		-7,605.72	
Number of observations	55,981		55,981		55,981	

Std. E.: Estimated standard error. Coefficients significant at: 1%***, 5%**, 10%*. All regressions include the constant. Dummies excluded for firms with less than 10 employees and the year 1999. Marginal effects (*dy/dx*) are computed at sample means. For dummy variables, the marginal effect corresponds to the change from 0 to 1.

Table 4bis
Determinants of the firm's decision to apply within the FP

	(1)		(2)		(3)	
	dy/dx	Std. E.	*dy/dx*	Std. E.	*dy/dx*	Std. E.
High-tech services	0.038 ***	0.005	0.037 ***	0.005		
Post and telecommunications					0.054 ***	0.013
Computer and related activities					0.030 ***	0.005
Research and development					0.068 ***	0.015
High and medium-tech manufacturing	0.003 *	0.002	0.003 *	0.001		
Chemicals and chemical products					0.000	0.002
Machinery and equipment n.e.c.					-0.001	0.002
Office machinery and computers					0.027	0.021
Electrical machinery and apparatus n.e.c.					0.001	0.004
Radio, television and communication…					0.012 *	0.007
Medical, precision and optical instruments					0.009	0.007
Motor vehicles, trailers and semi-trailers					-0.001	0.003
Other transport equipment					0.036 ***	0.012
Sigma_u	0.600	0.046	0.646	0.049	0.636	0.048
Rho	0.265	0.030	0.294	0.031	0.288	0.031
Log of likelihood function	-7,697.51		-7,624.33		-7,605.72	
Number of observations	55,981		55,981		55,981	

With respect to the geographical indicators, firms located in the Basque Country, Catalonia, Madrid and Valencia show higher probabilities of submitting an application, which is coherent with the major concentration of technological firms in these regions. Firms that carry out high or medium-tech activities are also more prone to become proponents, mainly in the case of high-tech services, confirming what we have observed through the descriptive analysis. The estimates in column (3) of Table 4bis show that the presence of proponents is especially important in ICT activities. The probability of engaging in a FP project increases 5.4% for companies in the Post and telecommunications service sector, and 1.2% for firms in the Radio, television and communication manufacturing sector. Also, affiliation to the transport equipment industry increases the probability of applying by 3.6%.

The effect of the firm's size requires further explanation. The coefficients of the set of size dummies indicate a negative impact of size on the probability of applying. However, this may be reflecting the fact that our control sample is biased towards large firms, which are chosen on the basis of a census, while firms employing between 10 and 200 employees are selected by a random sampling scheme. To study this question, estimates in Tables 5 and 5bis split the sample into two sub-samples, one for small and medium-sized firms (SMEs) and one for firms with more than 200 employees (large firms). According to this criterion, the results let us establish that size in fact has a negative effect on SMEs, while the impact is the opposite in the case of large firms. This non-linear relationship between the firm's size and the probability of applying within the FP could be reflecting the special effort that the Spanish organism CDTI has made to stimulate the participation of small firms in this programme.

The results in Tables 5 and 5bis provide additional evidence about the dissimilarities in firm behavior according to size. Notice that the liquidity ratio is significant only in the case of large firms, while the proportion of intangible fixed assets increases the SMEs' probability of being a proponent, but not the large firms'. This evidence could confirm that intangible assets allow SMEs to internalise the profits of cooperation, improving their absorptive capacity, whereas large firms could obtain these profits by means of a stronger financial position. Moreover, presence on the stock market is irrelevant in the case of small and medium firms. This effect is coherent with the fact that in the Spanish economy, the majority of companies that are listed on the stock market are large firms.

Table 5
Determinants of the firm's decision by size
Probit estimates

	Small and medium -sized firms		Large firms	
	dy/dx	Std. E.	*dy/dx*	Std. E.
Time dummies				
Year 2000	-0.003	0.002	0.002	0.003
Year 2001	-0.002	0.002	0.0004	0.003
Year 2002	-0.008 ***	0.002	-0.006 ***	0.002
Year 2003	0.001	0.002	0.003	0.003
Year 2004	-0.007 ***	0.002	-0.006 ***	0.002
Year 2005	-0.006 ***	0.002	-0.006 ***	0.002
Prior experience in FP proposals	0.010 ***	0.004	0.041 ***	0.007
Granted project in previous year	0.207 ***	0.042	0.125 ***	0.026
Rejected proposal in previous year	0.191 ***	0.036	0.158 ***	0.025
Exporter	0.001	0.001	0.009 ***	0.002
Liquidity ratio	-0.001	0.001	-0.003 **	0.001
Intangible fixed assets	0.008 ***	0.002	0.001	0.003
Stock market	0.004	0.009	0.024 ***	0.008
Firm's size	-0.004 ***	0.001	0.006 ***	0.001
Region				
Andalusia	0.003	0.003	-0.002	0.003
Basque Country	0.028 ***	0.006	0.010 **	0.005
Catalonia	0.007 ***	0.002	0.002	0.002
Galicia	-0.002	0.003	-0.003	0.003
Madrid	0.007 ***	0.003	0.004	0.002
Valencia	0.007 **	0.003	0.005	0.004
Sigma_u	0.790	0.084	0.510	0.052
Rho	0.384	0.051	0.206	0.034
Log of likelihood function	-4,869.53		-2,625.76	
Number of observations	33,953		22,028	

Std. E.: Estimated standard error. Coefficients significant at: 1%***, 5%**, 10%*. All regressions include the constant. Dummy excluded for the year 1999. Marginal effects (*dy/dx*) are computed at sample means. For dummy variables, the marginal effect corresponds to the change from 0 to 1.

Table 5bis
Determinants of the firm's decision by size
Probit estimates

	Small and medium -sized firms		Large firms	
	dy/dx	Std. E.	*dy/dx*	Std. E.
High-tech services				
Post and telecommunications	0.030 **	0.013	0.068 ***	0.019
Computer and related activities	0.022 ***	0.005	0.042 ***	0.011
Research and development	0.057 ***	0.016	0.112 *	0.063
High and medium-tech manufacturing				
Chemicals and chemical products	-0.002	0.002	0.006	0.004
Machinery and equipment n.e.c.	-0.002	0.002	0.009	0.006
Office machinery and computers	0.010	0.017	0.081	0.065
Electrical machinery and apparatus n.e.c.	-0.002	0.004	0.003	0.005
Radio, television and communication…	0.004	0.006	0.028 **	0.014
Medical, precision and optical instruments	0.007	0.008	0.008	0.015
Motor vehicles, trailers and semi-trailers	-0.005 *	0.003	-0.001	0.003
Other transport equipment	0.022	0.014	0.034 **	0.015
Sigma_u	0.790	0.084	0.510	0.052
Rho	0.384	0.051	0.206	0.034
Log of likelihood function	-4,869.53		-2,625.76	
Number of observations	33,953		22,028	

Although previous experience is significant for both samples, it must be stressed that long-term experience, measured by participation in the last edition of the FP, has a stronger effect on large firms, whereas short-term experience, referring only to the last year, further reinforces the probability of the SME collective applying.

With respect to the activity branch (Table 5bis), the participation of SMEs is mainly limited to high-tech services. As for large firms, some manufacturing industries also accumulate a major proportion of proponents. In particular, firms in Radio, television and communication and Other transport equipment are more likely to apply than the average. The rest of the explanatory variables keep their impacts with respect to Table 4 and exhibit similar effects in both groups of firms.

5.2 Determinants of awarding the proposal

Table 6 shows the results obtained from the estimation of the model in which the dependent variable is the probability of awarding the proposal and the information being treated as a pool[7]. The sample consists of 3,251 proposals for the period 1999 to 2005.

The econometric analysis shows that the probability of a proposal being supported is higher when it is led by an organization from Spain, The Netherlands or Germany. According to these results, we can conclude that the partners' selection (especially the coordinator partner) is a relevant variable for firms deciding to cooperate.

Firms that participate in consortia led by an organization from The Netherlands or Germany, which are very active countries within the FP, earn greater experience, and enjoy better access to information, have a greater probability of being supported by the EC. The Spanish leadership is overestimated because we only consider proposals in which Spanish firms participate, but, in any case, it could be confirmed that proposals coordinated by Spanish organizations (private or public) have a greater probability of receiving financial support than those coordinated by a foreign one. That could indicate that the geographical proximity to the leader reduces the coordination costs for Spanish firms.

Coordination costs due to the size of consortia seem to be mitigated by the required technological diversity of the research equipment. The number of partners engaged in a proposal has a positive effect on the probability of being supported. This fact could also be a consequence of the more ambitious goals pursued by the sixth edition of the FP, giving priority to bigger projects developed by large consortia.

The presence of public organisms within a consortium is a significant variable in our model, although with a negative effect on the viability of the proposal. That could indicate that coordination costs among private and public partners are perceived as an obstacle to cooperating.

It could also be pointed out that cooperation with geographically and probably also culturally distant partners increases the coordination costs and decreases the likelihood of being supported.

The negative effect of inadequate information and high coordination costs could be reduced in part by previous experience in cooperative projects. Our model confirms that the probability of being involved in a supported proposal is higher when the firm has already participated in a proposal during the last year, even if it was rejected. It seems clear that both the "learning-by-doing" and the "learning-by-failing" processes are relevant factors in explaining the firm's performance within international R&D consortia, especially within the FP.

[7] Alternatively, we have estimated the specification as a random effects probit model, which takes into account that the same Spanish firm can participate in different proposals during the period. The assumption behind this second estimation is that the composition of the consortia in which the same Spanish firm participates is also likely to be more constant. Therefore, we would be controlling for the presence of consortium effects. However, in both estimates, the results are nearly identical, suggesting that this correction is not very important in our sample.

Table 6
Determinants of awarding the proposal
Probit estimates

	dy/dx		Std. E.
Year of the application			
Year 2000	-0.003		0.024
Year 2001	0.013		0.025
Year 2002	0.016		0.028
Year 2003	-0.112	***	0.032
Year 2004	-0.085	**	0.036
Year 2005	-0.033		0.040
Participation of organisms	-0.137	***	0.037
Size (of consortium)	0.157	**	0.075
Size squared	0.005		0.015
FP budget for the specific programme	-0.005		0.004
Leader nationality			
British	0.024		0.028
Dutch	0.117	**	0.053
French	0.026		0.029
German	0.075	***	0.029
Italian	-0.023		0.025
Spanish	0.075	***	0.021
Technological area			
Aeronautic and aerospace	0.203	***	0.074
Agro-food	-0.013		0.066
Environment and energy	0.021		0.053
Information and communication	0.076	*	0.046
Innovation programmes	0.113		0.089
New materials	0.049		0.051
Transports	0.115	***	0.034
Geographical distance	-0.245	***	0.024
Prior experience in granted FP projects	0.018		0.017
Granted project in previous year	0.045	*	0.025
Rejected proposal in previous year	0.034	**	0.016
Pseudo-R2	0.11		
Log of likelihood function	-1,536.64		
Number of observations	3,251		

Std. E.: Estimated standard error. Coefficients significant at: 1%***, 5%**, 10%*. All regressions include the constant. Dummies excluded for firms with less than 10 employees and the year 1999. Marginal effects (*dy/dx*) are computed at sample means. For dummy variables, the marginal effect corresponds to the change from 0 to 1.

Beside variables explaining obstacles to cooperation, firms would take into account that participation in the FP entails technological and financial opportunities. According to some authors mentioned in Section 3 (Marín and Siotis, 2002), the FP would give priority to some technological areas like information and communication technologies (the greater

part of the total budget is allocated to this field). The empirical analysis allows us to confirm this fact for the case of the Spanish firms, since variables related to some technological areas, such as ICT, transports and aeronautic technologies are significant. Nevertheless, the "FP budget for the specific programme" variable is not significant, reflecting that the probability of being supported is not affected by the highest budgets allocated to specific programmes. These two pieces of evidence could indicate that the firms´ response capacity regarding the financial opportunities of the FP is more conditioned by the necessary concordance of corporate R&D strategies and EC goals than by the availability of public funds. As a consequence, it could be remarked that those Spanish firms affiliated to the aforementioned industries (TIC, aeronautics and transports) have a greater capacity to fit their innovation strategies with the goals pursued by the EC.

This response capacity could be also analysed from a dynamic perspective with regard to the introduction of new instruments and technological goals within the FP. As confirmed in previous sections (see Table 4), the more ambitious objectives pursued by the VI FP had a negative effect on Spanish participation. In Table 6, the dummy variables which indicate the year in which the firm applied are significant with a negative sign for 2003 and 2004, the first years of the VI FP. Thus, it seems clear that, during the sixth edition of the FP, Spanish firms had greater difficulty adapting their R&D lines and strategies to the technological priorities of the EC. This fact had a negative effect on both probabilities of a Spanish firm applying and being supported.

6 - Conclusions

The objective of this paper is to analyse which factors determine the participation of Spanish firms in R&D consortia within the Framework Programme. For that purpose, we take into account that this phenomenon is the result of two decisions. Firstly, the firm decides to engage or not in the consortia. Secondly, the project is evaluated by the agency that approves or rejects it.

Therefore, the empirical model consists of two equations to reflect each of the decisions, in whose specification we consider three types of potential determinants: 1) variables characterising the financial and technological situation of the Spanish applicant; 2) variables reflecting the features of the consortium and 3) indicators of previous experience in international R&D collaboration. These variables have been constructed with data from two sources that we linked together: The CDTI-PM database and the SABI database. The first one includes information about all the proposals, eventually approved or not, in which at least one Spanish firm participated since 1995. The second contains the company accounts of more than 1,000,000 Spanish firms from 1995 to 2005. From these, using a random sampling scheme, we have selected an unbalanced panel of more than 10,000 firms for the period 1999 to 2005.

The estimation of the firm's probability of applying within the FP, taking into account the panel structure of the data, lets us confirm that, as expected, the company's technological capacity, captured through its proportion of intangible fixed assets, its belonging to a high or mid-high technological sector, and its location in a high-tech region, increases the propensity to become a proponent within the FP.

The empirical evidence also shows that exporters apply more, which is coherent with the idea that exports and international cooperation are part of the same internationalisation strategy, and also that exporters can more easily find partners for their R&D agreements.

The firm's size has a non-linear impact on the probability of applying. It reduces this probability in the case of SMEs and has the opposite effect on large firms. The role of the Spanish National Contact Point, the CDTI, can be behind this regularity. This organism encourages the participation of firms (especially SMEs), by facilitating access to information, the search for appropriate partners and the fulfillment of administrative documents.

Regarding large firms, presence on the stock market has a positive effect on their probability of applying. This can be explained by the more formalised quality procedures of companies listed on the stock market, which makes them easier to overcome the administrative costs implied by the formal scheme of the cooperation process.

With respect to the proposal award, empirical evidence shows that variables capturing access to information and the coordination cost effect have a significant influence on the probability of receiving funds from the EC.

As part of the relevant information a firm uses to decide whether to participate in the FP, the selection of the appropriate coordinator is a significant variable. Thus, when proposals are led by partners from active countries such as The Netherlands and Germany, Spanish firms have a greater probability of being supported. This probability also increases when the coordinator is Spanish (private or public entities), likely due to the lower coordination costs that exist among organisations from the same country.

In fact, geographical distance with respect to those partners located in Northern Europe, Eastern Europe and non-European countries seems to increase coordination costs and reduce the probability of Spanish firms receiving grants as well.

The rest of the variables capturing the cost of coordination, such as size of the consortium and presence of public organisations, are significant but with a different sign. Whereas the size of the consortia has a positive effect on the viability of the proposal, the presence of public centers reduces the probability of receiving financial aid.

Thus, the negative impact of coordination costs due to the size of the consortia seems to be mitigated by the positive outcome of the higher technological diversity associated with the research equipment. This fact could be a consequence of the more ambitious goals pursued by the sixth edition of the FP.

The negative effect of inadequate information and high coordination costs could be reduced in part by previous experience in cooperative projects. Our model confirms that the probability of being involved in a supported proposal is higher when the firm has already participated in a proposal during the last year, even if it was rejected. It seems clear that both the "learning-by-doing" and the "learning-by-failing" processes are relevant factors in explaining the firm's performance within international R&D consortia, especially within the FP.

Empirical evidence also suggests that international R&D cooperation has an important strategic component. The firms' response capacity to increasing financial opportunities

within the FP seems to depend more on their ability to fit corporate R&D strategies with EC priorities than on the amount of available public funds.

Regarding the aforementioned results, it could be considered that this first approach to international R&D cooperation adds some evidence to the existing knowledge of such a complex process. Those results allow us to draw some conclusions regarding the interest of policymakers in increasing the participation of European firms in cooperative R&D projects.

One of the most significant facts is the need to reinforce the technological capacity of firms regardless of their size, taking into account that international cooperation is more frequent in: 1) those sectors more intensive in R&D and 2) in those technological areas which are considered a priority within the international context (in our case, the context of the European Union). In this sense, it seems obvious that national R&D priorities should fit international trends.

Considering that success in R&D cooperation is highly related to previous experience, measures focused on fostering the involvement of national firms in the FP should not penalize the rejected projects. On the contrary, participants must be encouraged to apply again and, if possible, to lead a consortium.

Public support in the search for partners and during the formalisation of the consortium seems to be necessary in order to facilitate access to information and to reduce the coordination costs that hinder R&D cooperation. In this respect, those measures which facilitate the transfer and protection of knowledge, especially between public and private entities, could increase the quality of cooperative projects.

Although the database used for this research has proved to be a valid instrument, it should be completed with some additional data referring, overall, to the R&D capacity of firms and their strategy concerning intellectual property protection. Moreover, the significance of the results obtained reinforces the convenience of integrating databases from others countries, in order to broaden our knowledge on international R&D cooperation within the European Union. Future lines of research would take into account these topics.

7 - Annex 1: Classification of high-tech sectors

Table A1
Classification of high and mid-high technology sectors

NACE-Rev.1	Sectors
	High and mid-high technology manufacturing sectors
24	Chemicals and chemical products
29	Machinery and equipment n.e.c.
30	Office machinery and computers
31	Electrical machinery and apparatus n.e.c.
32	Radio, television and communication equipment…
33	Medical, precision and optical instruments…
34	Motor vehicles, trailers and semi-trailers
35	Other transport equipment
	High technology services
64	Post and telecommunications
72	Computer and related activities
73	Research and development

8 - Annex 2: Definition of variables

Exporter: Dummy variable, which takes the value 1 if the company has exported during the period.

Firm's size: Number of employees in the current year (in log.).

FP budget for the specific programme: Percentage of the total FP budget allocated to each specific programme

Geographical distance: Percentage of partners from Northern Europe, Eastern Europe and non-European countries over the total number of partners. The percentage is multiplied by 2 or 3 if the partners are, respectively, from 2 or 3 of the aforementioned geographical areas.

Granted project in the previous year: Dummy variable, which takes the value 1 when~~,~~ at least one of the Spanish firms involved in the consortium has participated in a granted project during the previous year.

High-tech services: Dummy variable, which takes the value 1 if the company belongs to the high-tech services (NACE2 codes 64, 72, 73)

High and medium-tech manufacturing: Dummy variable, which takes the value 1 if the company belongs to any high or medium-tech manufacturing sectors (NACE2 codes 24, 29, 30, 31, 32, 33, 34, 35)

Intangible fixed assets: Intangible fixed assets over total fixed assets in the current year.

Leader nationality:

- **British leader**: Dummy variable, which takes the value 1 if the leader of the consortium is from the United Kingdom.
- **Dutch leader**: Dummy variable, which takes the value 1 if the leader of the consortium is Dutch.
- **French leader**: Dummy variable, which takes the value 1 if the leader of the consortium is French.
- **German leader**: Dummy variable, which takes the value 1 if the leader of the consortium is German.
- **Italian leader**: Dummy variable, which takes the value 1 if the leader of the consortium is Italian.
- **Spanish leader**: Dummy variable, which takes the value 1 if the leader of the consortium is Spanish.

Liquidity ratio: Shareholders' funds over non-current liabilities in the current year.

Participation of organisms: Number of non-entrepreneurial organisms over the total number of consortium members.

Prior experience in FP proposals: Dummy variable, which takes the value 1 if the Spanish firm applied to the FP in the edition previous to the current one.

Prior experience in FP granted projects: Dummy variable, which takes the value 1 if at least one of the Spanish firms involved in the consortium has participated in a cooperative project financed during the FP edition previous to the current one.

Region:

Andalusia: Dummy variable, which takes the value 1 if the firm is located in Andalusia.

Basque Country: Dummy variable, which takes the value 1 if the firm is located in the Basque Country.

Catalonia: Dummy variable, which takes the value 1 if the firm is located in Catalonia.

Galicia: Dummy variable, which takes the value 1 if the firm is located in Galicia.

Madrid: Dummy variable, which takes the value 1 if the firm is located in Madrid.

Valencia: Dummy variable, which takes the value 1 if the firm is located in Valencia.

Rejected proposal in the previous year: Dummy variable, which takes the value 1 when at least one of the Spanish firms involved in the consortium has participated in a rejected project during the previous year.

Size of the consortium: Total number of members (firms, public organisms or other institutions) in the consortium (in log.).

Stock market: Dummy variable, which takes the value 1 if the firm is on the stock market.

Technological area:

Information and communication: Dummy variable, which takes the value 1 if the project is related to information and communication technologies

New materials: Dummy variable, which takes the value 1 if the project is related to new materials technologies

Environment and energy: Dummy variable, which takes the value 1 if the project is related to environment and energy technologies

Transports: Dummy variable, which takes the value 1 if the project is related to transport technologies

Agro-food: Dummy variable, which takes the value 1 if the project is related to agro-food technologies

Aeronautic and aerospace: Dummy variable, which takes the value 1 if the project is related to aeronautic and aerospace technologies

Innovation programmes: Dummy variable, which takes the value 1 if the project is related to innovation programmes

Year of the application: Set of time dummy variables, which take the value 1 when the proposal has been presented this year.

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