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THE IMPORTANCE OF INTERMEDIARIES ORGANIZATIONS IN INTERNATIONAL R&D COOPERATION: AN EMPIRICAL MULTIVARIATE STUDY ACROSS EUROPE

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The importance of Intermediaries organizations in international R&D cooperation: an empirical multivariate study across Europe

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Abstract

Despite the large number of publications related to business cooperation in R&D and the wide perception of the importance of intermediary institutions in the R&D cooperation process, empirical studies on its role are scarce, scattered and fragmented. Moreover, the academic work developed in this area is basically of a theoretical nature, whereas the international perspective of R&D cooperation is seldom approached. Departing from a unique database that includes 473 R&D cooperation projects developed within the 6th Framework Programme, involving firms and intermediaries from all European Union countries, this paper gauges the determinants of the importance attached to Intermediaries, through a direct survey to the organizations involved. Based on an estimation of the multivariate model, this study demonstrates that the importance given to Intermediaries depends more on project features than on the characteristics of the participating organizations. In particular, the nationality of participating organizations and the promoter emerged with a strong explanatory power: *ceteris paribus*, projects with at least one participant from the United Kingdom tend to assign greater importance to intermediaries in international R&D cooperation. Unambiguously, results evidence that the innovating capacity of an organization emerges (both positively and significantly) associated with a greater importance attached to Intermediaries.

Keywords: R&D Cooperation; Intermediaries; International projects; Europe

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1. Introduction

In order to advance knowledge, research intensity and business expansion, firms need to cooperate in order to reduce the costs, time and risks associated with technology development and the process of market expansion (Tidd *et al.*, 2005). Empirical evidence shows that relationships between firms have a high failure rate since such processes usually encounter many obstacles which are difficult to overcome, namely loss of technical know-how, asymmetrical power relations, strategic differences and at the level of establishing objectives (Tidd *et al.*, 2005). The variety of ways in which organizations are connected is almost unlimited and includes strategic alliances, licensing, R&D cooperation agreements, joint ventures, consortia and networks, which in some cases are extremely complex and open systems (Teece, 1996).

This scenario of complexity has boosted the emergence of the intermediation phenomenon (Hoppe and Ozdenoren, 2005), giving rise to a group of actors generically called intermediaries, who perform an important set of functions within the innovation system as mediators or facilitators of the cooperation process (Howells, 2006). Intermediaries can provide the possibility to reduce the cost of knowledge acquisition, identify new inventions and separate profitable opportunities from non-profitable opportunities (Hoppe and Ozdenoren, 2005).

Over the past two decades, there has been a growing interest in the study of the role of the Intermediary. Howells (2006: 720) proposed the definition of Innovation Intermediary as "[a]n organization or body that acts as an agent or broker in any aspects of the innovation process between two or more parties". Thus, intermediary refers to a group of organizations, including brokers, third parties and other entities involved in innovation supporting activities.

In spite of the large number of empirical studies published on R&D cooperation, the same is not true when it comes to the study of the role of intermediaries, as well as their motivations, obstacles and outcomes within the context of international R&D cooperation. The few studies that do exist are basically of a theoretical nature, in which information emerges in a fragmented and disperse manner. Evidence also shows that there are very few empirical studies that test, from among the functions intermediaries perform, which are the ones that are profiled as the most relevant for firms. To the best of our knowledge, there is also a lack of empirical studies assessing the importance that intermediaries themselves attach to their functions. This gives our study the unique advantage of being a pioneering effort at this level.

In an attempt to bridge the gaps identified in the literature, this paper essentially aims to provide more empirical detail on the role and benefits created by intermediaries involved in R&D+I[1] cooperation projects and simultaneously highlight the main differences across countries at this level, as well as the motivations, obstacles and outcomes underlying these projects. To this end, a direct survey was conducted on organizations that participated in international R&D cooperation projects under the 6th Framework Programme of the European Union (EU). These projects constitute a fitting sample to test our research questions since they involve intermediary organizations that play a key role in boosting the innovation capacity of SMEs.

The paper is organized as follows. Section 2 presents a survey of the literature on R&D cooperation and discusses the role of intermediaries in this process. In Section 3, the methodology underlying the study is explained in detail. The empirical results are described in Section 4 and, finally, in Conclusions, the main findings of the study are summarized and some implications are drawn related to economic policy.

2. R&D cooperation and the role of Intermediaries. A brief review of the literature

Over the past 20 years, new trends have emerged in relation to the way R&D is conducted (Busom and Fernández-Ribas, 2008). One of them concerns the establishment of networks and partnerships between firms or between firms and public institutions. Moreover, the increased competition associated with the growing complexity of technologies prompt firms in general, but especially innovating firms, to cooperate with other firms and public knowledge institutes (Beers *et al.*, 2008), so as to promote and investment in R&D. Other reasons leading to cooperation include cost sharing, uncertainties inherent in the development of new technologies, and access to tacit knowledge (Hagedoorn, 1993).

Meanwhile, the growing interest in the study of topics such as innovation system analysis, scientific networks and dissemination of innovation, associated with the significant rise in collaborations and outsourcing, have raised renewed interest among academics to explore the nodes and links associated to cooperation in Research, Development and Innovation (R&D+I) (Howells, 2006). A new group of actors have emerged in this context, generally referred to as

[1] Despite the fact that the projects under empirical study explicitly refer to R&D+I, in line with the latest version of the Oslo Manual (OECD/European Communities, 2005) – which adds activities to R&D+I that are not directly related to research and development, but result in novelty with economic return (Innovation) for the firm and/or the surrounding context –, in this paper, for the sake of simplicity, we refer to R&D and R&D+I interchangeably. For a more in-depth discussion on the concepts of R&D and R&D+I, please refer to the R&D+I Activity Identification Manual issued by COTEC Portugal (COTEC, 2006).

"Intermediaries" and understood as a group of organizations and other entities involved in providing support to the innovation process (Howells, 2006).

Although some firms, especially larger ones, have the capacity to carry out research and development (R&D) and future implementations of technological innovations that would enable them to secure a competitive advantage, most still reveal an inability to do so (Rush *et al.*, 2004; Hamel, 2007), thus requiring, according to their needs, a certain type of joint cooperation (Dodgson, 1994; Duysters *et al.*, 1999, Becker and Dietz, 2004, Tidd *et al.*, 2005). Figueiredo (2003) (in Rush *et al.*, 2004) defined these technological capabilities as "[t]he resources needed to generate and manage improvements in processes and production organisation, products, equipment and engineering projects".

The literature shows the general trend towards growing collaboration between firms in the last few decades (Teece, 1992; Das and Teng, 1999; Duysters *et al.*, 1999; Tether, 2002; Becker and Dietz, 2004) and reflects its importance in the innovation process (Teece, 1992; Tether, 2002; Becker and Dietz, 2004). In fact, in light of increased competition and competitive pressures associated with the rising cost of research and development (R&D), as well as the shortened lifecycle of products which has characterized the last decades, firms have been increasingly resorting to R&D cooperation (Duysters *et al.*, 1999). In order to facilitate the development and commercialization of new technologies, there is a wide range of cooperation agreements that are characterized by a commitment between two or more partners towards achieving a common goal and involve the pooling of resources and activities (Teece, 1992; Dodgson, 1994). Innovation-based partnerships are relationships that involve, at least in part, a significant effort in R&D (Hagedoorn *et al.*, 2000).

Several authors point out that SMEs have scarce resources and weak conditions to develop in-house R&D activities (Hausman, 2005), limited external contacts (Srinivasan *et al.*, 2002), inadequate training (Romano, 1990), and are unwilling to delegate authority or decision-making power to third parties (Dyer and Handler, 1994).

In order to overcome these obstacles to innovation, firms tend to establish collaborations with another group of actors commonly referred to as "Intermediaries", also known as "Research and Development (R&D) Supporting Institutions", which carry out a number of key tasks in the innovation process. Intermediary institutions represent an asset to their clients/partners in the sense that, in addition to the ability to play a mediating role between users and creators

(Ozdenoren and Hoppe, 2005; Kodama, 2008), they have the vital capacity to assess the potential of the technology and its licensing (Ozdenoren and Hoppe, 2005; Kodama, 2008).

Intermediaries also play a critical role in the context of innovation both as facilitators of information and technology transfer, essential to promote innovation, and as a linkage between research institutes and firms (Etzkowitz and Goktepe, 2005). Examples of research institutes include technology brokers, universities, regional technology centres, innovation agencies and transnational networks such as the TII (see The European Association for the Transfer of Technology, Innovation and Industrial Information) (Bessant and Rush, 1995). Such are the different designations presented for "R&D Supporting Institutions" and associated definitions, namely third parties firms, intermediary firms, bridgers, brokers, information intermediaries and superstructure organizations (Howells, 2006).

The diversity which marks the role intermediaries can play and their flexibility in terms of modes of operation and interaction, mean that they act as 'bridges' across a wide range of users (Bessant and Rush, 1995). Taking into account their competencies (e.g., highly experienced in assessing the value of new inventions; access to relevant data in a more timely manner), as well as the context of profitability uncertainty that characterizes investments in new technologies, intermediaries can also play an important role in providing decision-making support to potential investors by sharing useful information that can save costs and help reduce uncertainty (Ozdenoren and Hoppe, 2005).

Despite the recognized importance of intermediary/supporting organizations in R&D cooperation projects and some evidence as to the growth of the intermediation process in innovation over time (Howells, 2006), the literature pays very little attention to the assessment and estimation of its real value.

Although intermediary organizations tend to be focused on specific, so-called 'traditional', activities, evidence shows that the range of services provided seems to be increasing, with intermediaries taking on a more varied and holistic role than would be expected (Howells, 2006). Furthermore, it is also found that the range of functions performed by intermediaries is much wider than is commonly thought (see Table 1): consulting (Bessant and Rush, 1995; Hargadon and Sutton, 1997), technology assessment (Mantel and Rosegger, 1987), technology selection and articulation, finding new sources of knowledge, networking with external knowledge providers and development & implementation (Bessant and Rush, 1995), certification (Massa and Testa, 2008), information for potential partners, support to

organizations' participation in R&D funding schemes, organization of networking events, licensing and support in new business creation (Kodama, 2008).

Table 1: Functions of Intermediaries

Area	Function
Technology and Knowledge Transfer	Forecast of technological planning Support in the exchange of knowledge between partners Research and inside knowledge to support the consortium Diagnosis, testing, analysis and supervision Provider of facilities for pilot-scale trials Development of prototypes and scale-up Development of accreditation references Assessment of the products and technologies within the market
Decision support	Identification of market opportunities for the obtained product Support in the protection of results (Intellectual Property) Development of business plans
Networking	Identification and selection of potential partners
Moderation/ Intermediation	Facilitator of business contracts Support in legal regulation and moderation Support in the establishment of sales channels Support in raising funds for the development of proof of concept

3. Methodological considerations

Regardless of the amount (and quality) of papers on the subject of cooperation, including R&D cooperation, very few studies focus on R&D cooperation involving Small and Medium Enterprises (SMEs), and even fewer analyze the role that intermediaries play in these collaborations. There are two important aspects that should be mentioned here. The first is that, in general, empirical evidence regarding this subject – R&D cooperation – tends to be based on the perception of firms, neglecting the perception of intermediary institutions, such as R&D Institutes, Universities and Sectoral Associations. Additionally, the international dimension of R&D cooperation involving SMEs has not, to the best of our knowledge, been approached.

This paper provides evidence on which functions performed by intermediaries are the most relevant in R&D cooperation projects (according to firms *and* intermediaries). In addition, given the international dimension of our sample, this paper aims to explain/identify which of the variables associated with the characteristics of projects and respondent organizations may prove to be relevant and statistically significant (either positively or negatively) to explain both the high degree of importance attached to intermediaries and the results achieved in international R&D cooperation projects.

Based on the above aims and the fact that there are no databases publicly available with information on the subject analyzed at the microeconomic level (i.e., per firm, institution), in terms of methodology, data had to be collected by means of a direct survey to firms (particularly SMEs) and intermediaries involved in international R&D cooperation projects in a given period of time.

We drew up a questionnaire comprising five different parts, according to the issues/research aims mentioned above. The first part characterizes the respondent organization, particularly with regard to age, size, type of organization (SME, Other), human resources (number of workers, number of engineers, workers with more than 12 years of schooling) and performance measures (sales, exports, R&D investment, foreign capital). The remainder parts of the survey consist of questions about motivations (Part 2), obstacles (Part 3), the role of intermediaries (Part 4), and cooperation results (Part 5). A Likert scale of 1-7 was used to measure the degree of importance assigned to each item by respondents (1- not at all important/unfulfilled... 7- extremely important/completely fulfilled).

Our target population included a number of firms (SMEs) and other organizations (herein referred to as intermediaries) that participated in Co-operative and Collective Research[2] under the Sixth European Community Framework Programme (abbreviated FP6) for the years 2002-2006. This sample meets the requirements set out by our research questions: *international R&D* cooperation projects involving SMEs *and* Intermediaries.

The database underlying this study was built based on the European Union document – SME FP6 Project Catalogue – A Collection of Co-operative and Collective Research Projects[3], in which all R&D cooperation projects of the 'Co-operative' and 'Collective' type can be found.

The EU catalogue is a synopsis of 473 projects, indicating the promoter and contact details (e-mail, telephone and fax) for each project. This valuable information provided the possibility to quickly and efficiently send out the questionnaires. Moreover, each project also comprised a description, information regarding the characteristics of the contract, and the number, nationality and name of the organizations involved.

Upon treatment of the basic information provided in the Catalogue, a total of 473 survey questionnaires were sent initially by e-mail. Each questionnaire, written in English and

[2] Whereas in Co-operative Research projects R&D is assigned to organizations such as Universities, Technological Centres, etc., in Collective Research, external performers are basically Associations specific to each activity sector.

[3] At http://ec.europa.eu/research/sme-techweb/index_en.cfm?pg=publications, accessed on 15th September 2008.

customized with the identification of the organization responsible for the project, as well as the project name and designation, was sent in attachment together with a text message, also customized with the name of the organization responsible for each project. The questionnaires were sent in Word format with insertion of form fields to facilitate completion by respondents. Since some surveyed organizations were involved in more than one research project, we were careful to attach the different questionnaires accordingly. This was done three times in the span of three weeks, so, during this period, it was necessary to update the file so as to not send any questionnaire that had already been answered, which required additional effort and focus. For the 43 projects that we were not able to contact by e-mail, the relevant organizations were contacted (twice) by fax.

There was a response rate of 37%, which is quite satisfactory considering its non-mandatory nature. From our final sample (174 projects), 84 questionnaires were completed by firms and 90 by intermediary organizations.

Table 2 presents the main features of some of the relevant variables of international R&D cooperation projects (area, duration, cost, funding, type of contract, organizations per project, countries per project and promoting countries), establishing a parallel between the initial population and our final sample. The nonparametric method (Kruskal Wallis test) shows that, for variables considered critical, there are no statistically significant differences between our final sample and unanswered projects.

As to the initial population of projects and the set of variables related to the area of project development, only the sample of respondents from Agri-Food & Aquaculture is under-represented, though hardly noticeable. The same is true for the promoting country's nationality variable regarding the United Kingdom. In light of the evidence presented, we can say that the set of data collected through our survey (sample) is clearly representative of the population.

The average cost of each project corresponds to 1,700,642 Euros, which represents a reimbursement from the EU amounting to 60%, has a duration of approximately 28 months and involves 12 organizations from 6 different countries. The type of contract that dominates is Co-operative Research (81%).

The main areas which these projects fall under are, in descending order of importance: Materials & Processes, ICT & Electronics and Agri-Food & Aquaculture. Together, all three areas represent, in percentage terms, an average of 66.6% of the final sample, thus indicating

its strong technological component. The least represented areas are: Transport (3.4%), Construction and Forestry (both 1.2%) and Management Sciences (unconfirmed records, albeit its representativeness in the initial population is also minimal). We identified 22 different nationalities regarding promoting countries, where this responsibility is shared among the majority (62.4%) by four countries: the United Kingdom, Germany, Spain and Italy. Curiously, although having no major representativeness in terms of promoting organization, Portugal displays a weight of 1.7%, ranking alongside countries such as Denmark and Hungary and above the so-called emerging economies such as Poland, Lithuania and Iceland.

Table 2: Statistical summary of international R&D cooperation project features – population versus sample

	Average		**Kruskal Wallis Test**	
Variables	*Population (n=473)*	*Sample (n=174)*	*Chi-Square*	*Asymp. Sig.*
Project cost (€)	1,670,761.8	1,700,641.7	0.670	(0.413)
Funding (€)	1,000,868.1	1,024,259.5	0.403	(0.525)
Number of participating organizations	11.4	11.8	0.881	(0.348)
Type of Contract (%)				
Co-operative Research	82.5	81.0	0.382	(0.537)
Collective Research	17.5	19.0		
Number of countries involved	5.4	5.6	1.550	(0.213)
Duration (months)	27.7	27.9	0.820	(0.365)
Project areas (%)				
Agri-food & Aquaculture	18.0	14.9		
Environment	9.1	10.9		
Biotechnology & Health	10.6	8.6		
Management Sciences	0.2	0.0		
Construction	1.9	1.2		
Energy	7.8	8.1		
Materials & Processes	36.4	36.8		
Forestry	0.8	1.2		
ICT & Electronics	13.1	14.9		
Transport	2.1	3.4		
Promoters per country (%)				
Germany	18.0	18.4		
Austria	4.4	5.2		
Belgium	1.9	2.9		
Cyprus	0.2	0.0		
Denmark	2.3	1.7		
Spain	13.7	14.4		
Finland	1.9	2.3		
France	3.2	2.3		
Greece	2.1	3.4		

Variables	Average		Kruskal Wallis Test	
	Population (n=473)	*Sample (n=174)*	*Chi-Square*	*Asymp. Sig.*
Holland	6.6	5.7		
Hungary	1.1	1.7		
Ireland	0.4	0.0		
Iceland	0.4	0.6		
Israel	0.8	0.0		
Italy	11.0	10.3		
Lithuania	0.2	0.6		
Norway	4.7	5.2		
Poland	0.6	0.6		
Portugal	1.3	1.7		
United Kingdom	21.8	19.5		
Sweden	3.0	2.9		
Switzerland	0.4	0.6		

Source: Authors based on publication by the European Union – *SME FP6 Project Catalogue*.

On analyzing the average weight of each country per project (Figure 1), regarding the country of origin of the respondent organization (firm and intermediary), we can see that there is greater diversity of the nationalities involved (37). However, except for Italy, although its weight decreased in percentage terms (albeit not very significantly), the Top 4 ranking still includes the four countries identified as the most representative analyzed in terms of country of origin of the respondent organizations.

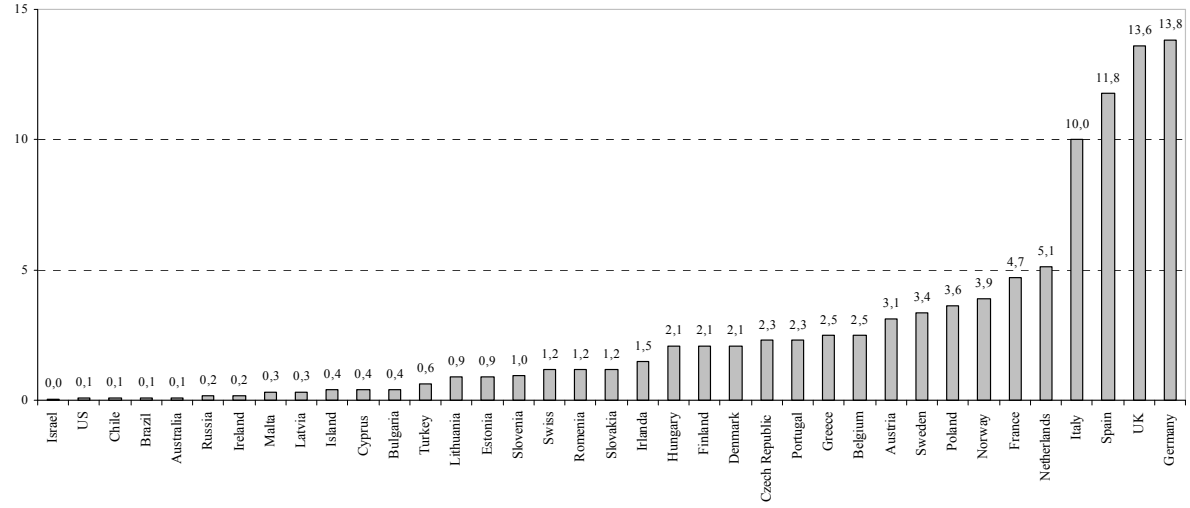

Figure 1: Average weight of each country per project (n=174)

The analysis of correlations of the average weight of each country per project (Table 3), allows us to extract information regarding the degree of involvement amongst the most representative countries in our sample (the United Kingdom, Germany, Spain and Italy). In this type of project, if the promoting organization is in the United Kingdom, this country

tends to represent a greater number of organizations in the United Kingdom in each project. In addition, in projects involving organizations from the United Kingdom, they tend to involve a smaller number of organizations of German, Spanish and Italian nationality (statistically significant and negative correlation).

Similarly, projects involving German organizations tend to involve a smaller number of organizations in Italy and the United Kingdom, and fewer organizations from Germany and the United Kingdom participate in projects involving Italian organizations.

Table 3: Descriptive statistics and correlation matrix of the average weight of each country per project

	Mean	SD	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)
(1) Promotor country	0,262	0,130	0	0,64	1	0,026	0,159*	0,030	0,068	0,092
(2) Germany	0,138	0,150	0	0,57		1	-0,181*	-0,137	-0,210**	-0,116
(3) UK	0,136	0,166	0	0,67			1	-0,209**	-0,182*	-0,004
(4) Spain	0,118	0,148	0	0,56				1	-0,082	-0,004
(5) Italy	0,100	0,146	0	0,60					1	-0,070
(6) France	0,470	0,096	0	0,71						1

Caption: *** significant at 1%; ** significant at 5%; * significant at 10%

Table 4 shows some descriptive statistics that allow us to characterize the respondent organizations that, as previously mentioned, are responsible for the promotion of each one of the projects.

Based on the previous table, it is possible to say that in relation to the variables regarding the human component, and the average number of workers in intermediaries is significantly higher compared to firms, although in both cases, this number differs a great deal from the average observed for the entire sample (398.3). One can also note that the ratio of engineers in total workers presents a very high value (50.7%).

In relation to the variables measuring the performance index (on average) of respondent organizations: the R&D ratio in total sales represents more than half of the total investment of respondent organizations (53.1%), whereas in the case of intermediary institutions, the ratio is 66.4%; the percentage of exports in total sales is higher for firms (35.3% versus 21.5% in the case of intermediary institutions), though the value is significant in both cases; while the percentage of foreign capital presents a minute value (8.9% in the case of firms and 1.7% for intermediary organizations).

Table 4: Some descriptive statistics of respondent organizations

Variables	Mean		
	71 Firms (n=84)	61 Intermediaries (n=90)	Total Sample (n=174)
Number of employees	49,8	746,7	398,3
Engineers in total employees (%)	54,5	46,6	50,7
R&D in total sales (%)	41,1	66,4	53,1
Exports in total sales (%)	35,3	21,5	29,3
Foreign capital (%)	8,9	1,7	5,6

Note: Average for the 2005-2007 period
Source: Authors based on a direct survey to organizations involved in international R&D cooperation projects.

By adopting the grouping criteria recommended by the European Union (2003) regarding the definition of micro, small and medium enterprises, the sample is decomposed into five different categories (Figure 2). The crossing of our variables – number of workers with the type of entity – shows that the weight of large firms is null and small and medium-sized (small and large) firms is nearly 77%. With regard to intermediary organizations, it can be noted that these fall under the five categories defined, where 33.3% had more than 500 workers and almost 45% present between 50 and 499 workers, which indicates that such organizations represent a high degree of employability.

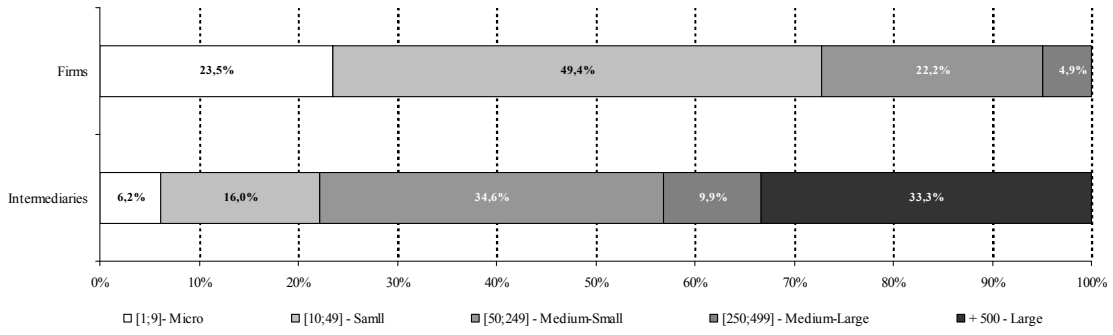

Figure 2: Number of workers by type of respondent organization (n=174)
Note: Average for the 2005-2007 period
Source: Authors based on a direct survey to the organizations involved in international R&D cooperation projects.

In general and on average, respondent firms have a slightly higher ratio of engineers in relation to the total number of workers in intermediary organizations: 54.5% versus 46.6% (Figure 5). Nevertheless, 83.5% of the surveyed intermediaries stated their staff included between 20 and 100 engineers, showing a higher ratio in this category compared to that of firms, which still remains surprisingly high (77.5%). Based on an overall analysis, it can be noted that 81% of the surveyed organizations include 81% of engineers on their staff

compared to the total number of staff members, which denotes a high qualification component in relation to total workers (Wood and Ridao-Cano, 1999; Noorbaksh *et al.*, 2001).

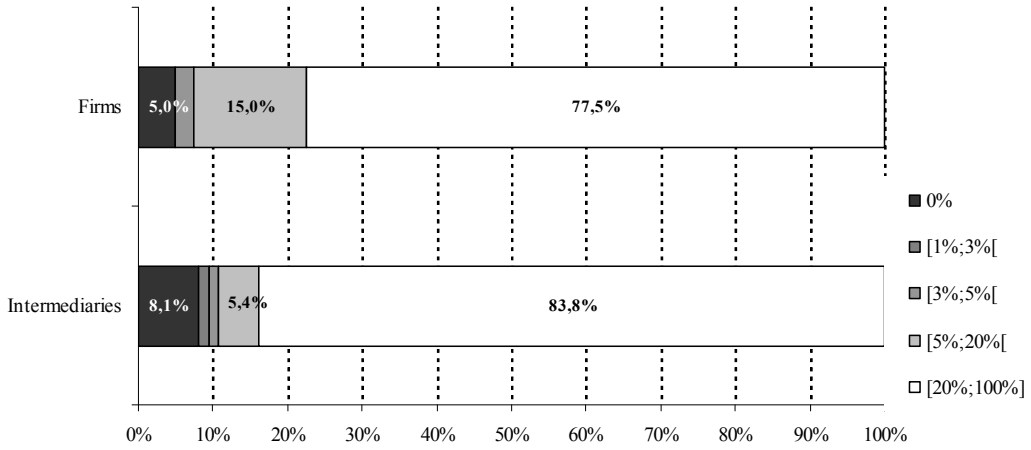

Figure 3: Number of engineers in total workers by type of respondent organization (%) (n=174)
Note: Average for the 2005-2007 period
Source: Authors based on a direct survey to the organizations involved in international R&D cooperation projects.

As shown in Figure 4, by crossing the strategic variable 'type of organization' with 'type of activity developed', some interesting patterns surface. Areas associated with consulting, technical and scientific activities prevail in both cases (firms and intermediaries). Apart from this area which represents 40% of the answers provided by firms, manufacturing industries also carry a significant weight, corresponding to nearly ¼ of the total weight. In the case of intermediaries, the collected data show that they fall under two other statistically significant areas, with 14% of the total falling under education-related areas (Universities and Institutes), and 8% under other activities in the services sector (Associations). The evidence presented supports the literature in the sense that it confirms that intermediation activities are mainly performed by organizations associated with Universities, Institutes and Associations, as well as other bodies, such as, for example, consultants.

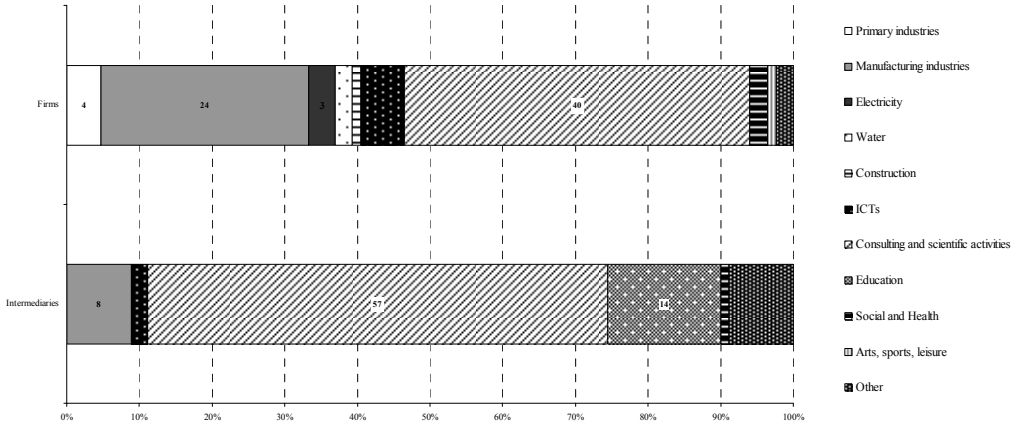

Figure 4: Distribution of respondent organizations by type of activity

At a first sight, R&D initiatives are much lower in firms than in intermediary organizations (Figure 5). As mentioned earlier, on average, firms spend 41.1% of their turnover on R&D activities, whereas intermediaries invest 66.4%. These figures, however, are still quite significant as they demonstrate the importance that R&D carries in their development strategies. About 62% of the surveyed firms reported investing between 20% and 100% of their total turnover on R&D expenditure. For the same investment category, intermediaries invest 86%. These figures indicate the high degree of importance attached to activities related to research and development.

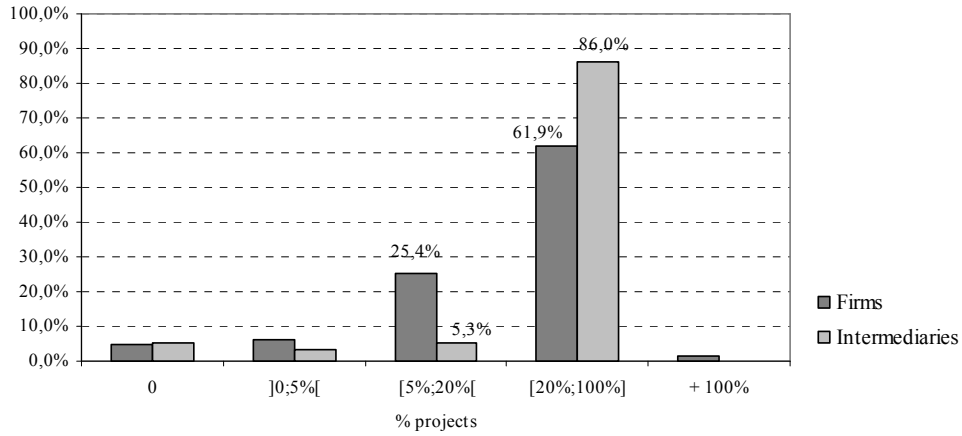

Figure 5: Type of organization by R&D intensity (R&D-to-sales ratio)
Note: Average for the 2005-2007 period

Figure 6 shows a weak inclination of the promoting organizations towards export activities. This result may indicate that the main motivations underlying these projects may have little to do with their commercial component, but for some other reason.

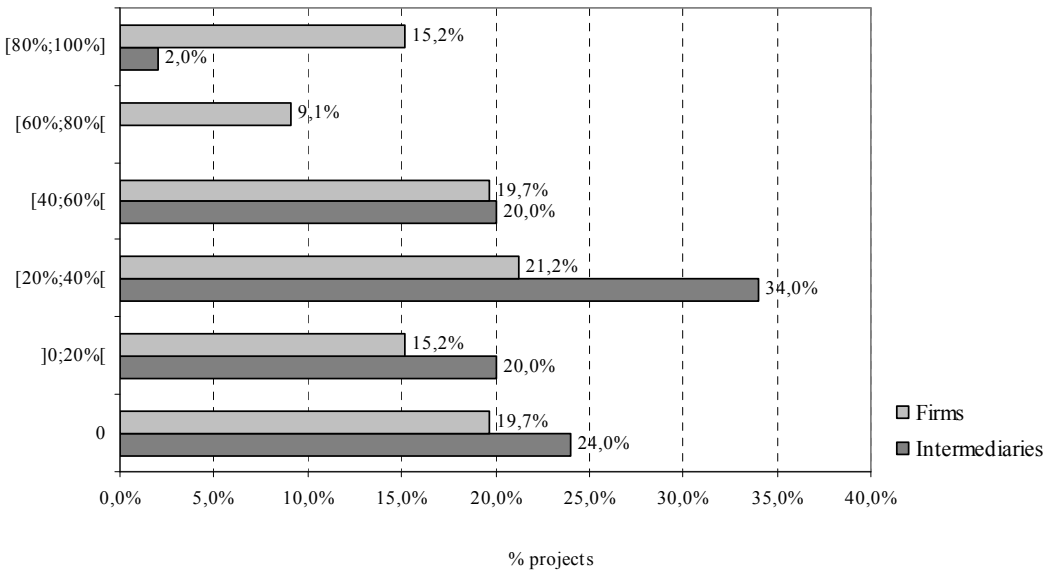

Figure 6: Type of organization by ratio of exports to sales (n = 174)
Note: Average for the 2005-2007 period

With regard to the percentage of foreign capital for each organization (Figure 7), it should be noted that a substantial percentage of respondent organizations fall completely under domestic capital (77.3% in the case of firms and 92.6 % for intermediaries).

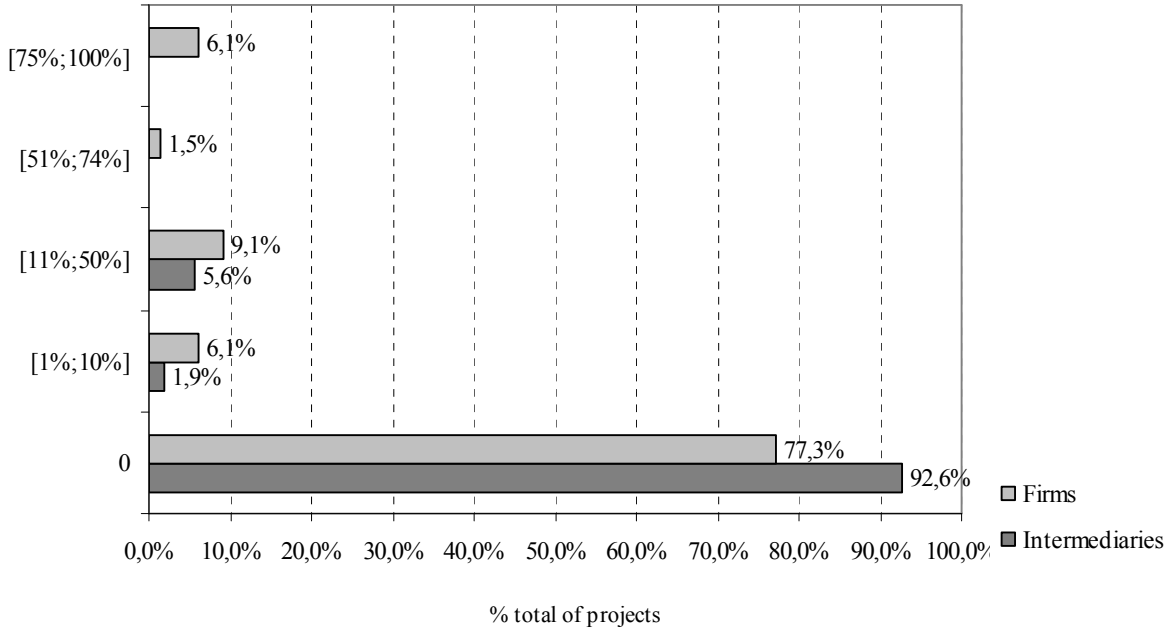

Figure 7: Type of organization by foreign capital ratio (n=174)

In light of the evidence gathered, and given the size and international nature of the sample, we shall proceed with comparative analyses which, upon proper statistical treatment, will allow us to draw up political considerations in the field of technological cooperation.

4. Relevance of R&D supporting institutions in business R&D cooperation. An empirical application at international level

Among the potential roles played by intermediaries, the surveyed organizations referred to "Research and inside knowledge to support the consortium" as the most commonly performed intermediary function. The most cited reason for business cooperation was "Promotion of knowledge sharing/learning", which seems to indicate that respondents perceive intermediaries as key players in the promotion and exchange of knowledge and know-how. "Diagnosis, testing, analysis and supervision", comprised in the "Testing and validation" group, is another highly rated function by the surveyed organizations. Functions pointed out in the literature as relevant, such as "Support in legal regulation and moderation" (Hoppe and Ozdenoren, 2005), and those associated with commercial activities, as discussed by Kodama (2008) and Howells (2006), are not considered that relevant in the type of projects under study.

In cases in which respondent organizations are firms, the tasks that are considered most important are "Research and inside knowledge to support the consortium", "Support in the exchange of knowledge between partners" and "Identification and selection of potential partners". Then follow the functions considered less traditional (Howells, 2006), such as "Diagnosis, testing, analysis and supervision", "Provider of facilities for pilot-scale trials", "Development of prototypes and scale-up". Not surprisingly, the items "Identification of market opportunities for the obtained product", "Development of business plans", "Support in the establishment of sales channels" and "Support in raising funds for the development of proof of concept" are functions with the lowest rating by firms since the empirical evidence shows that the reasons (for cooperation) associated with commercialization and marketing are comparatively less referenced by respondents.

Regarding the perception of the role of intermediaries, the ranking by intermediary organizations is practically the same, except for the function "Development of accreditation references", for which there is a great disparity, ranking ninth when the respondent was a firm and fourteenth when an intermediary organization.

These results seem to confirm the study developed by Howells (2006) insofar as there is another type of function beyond the more traditional roles perceived as highly important in this type of cooperation projects by the organizations involved (firms and intermediaries).

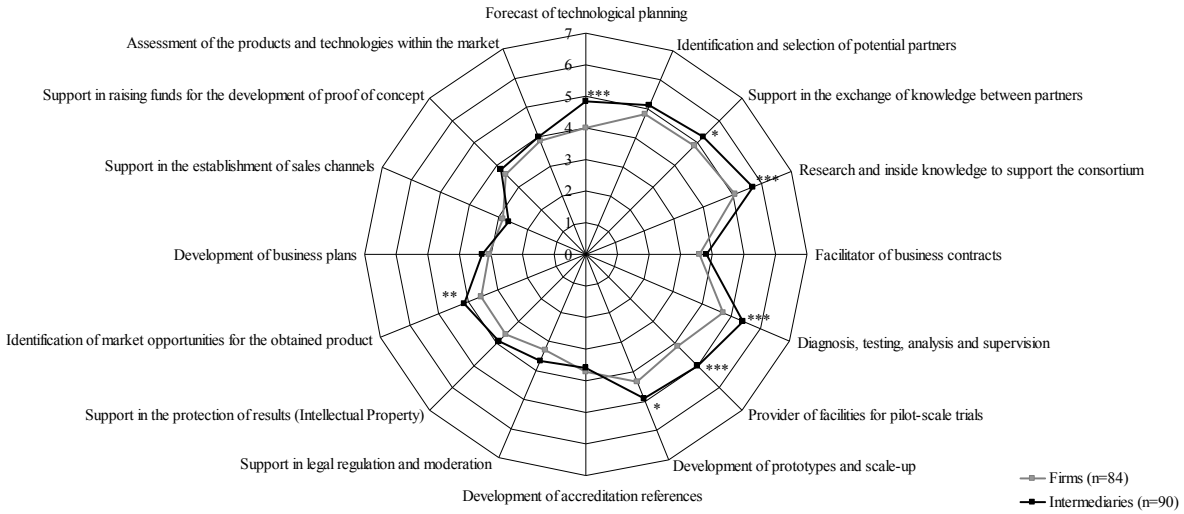

Figure 8: The role of intermediaries in the process of international R&D cooperation, by type of respondent organization

Notes: Average values; 1: not relevante at all, …, 7: extremely relevant; Kruskal-Wallis test to the differences in means regarding the importance attributed to intermediaries by firms and intermediaries

Legend: *** Significant at 1%; ** Significant at 5%; * Significant at 10%

In order to complement the exploratory statistical analysis previously carried out, we find it important to empirically assess the determinants of the importance assigned to intermediaries by organizations participating in international R&D projects, based on a multivariate model. Hence, the dependent or explanatory variable is the importance (above average) given to intermediaries by organizations participating in projects.

The binary nature of the observed data related to the dependent variable [importance rated above average? (1) Yes; (2) No] limits the choice of the estimation model. Moreover, the assumptions required to test hypotheses in a conventional regression analysis are necessarily violated (for example, it does not seem feasible to assume that the error distribution is normal). Expected values in a multiple regression model cannot be interpreted as probabilities because they do not confine to the interval between 0 and 1. Therefore, conventional estimation techniques in the context of a discrete dependent variable are not a valid option. Based on the above limitations, the analysis in this study will be carried out within the context of the general framework for probabilistic models.

Prob (event j occurs) = Prob (Y= j) = F [relevant effects: parameters].

The **X** vector (explanatory variables) includes a number of factors which may influence the importance rated and the perception that participating organizations have on the results of cooperation. This combination of factors is divided into two groups: one related to project features and the other with the characteristics of firms. The former group – *project features* – includes the following set of variables: Project cost; Number of organizations, firms and intermediaries participating in the project; Project status (completed=1; in progress=0); Proportion of financial support (funding/cost); Type of contract/instrument (*SMEs-Co-operative research contracts*=1; *Collective*=0); Type of participating organization (SME=1, Other=0); Diversity of countries participating in each project (number of different countries); Number of countries of the same nationality as the promoter, among other variables; Country of the participating organization and promoter; Scientific field. The variables comprised in the group *characteristics of organizations* participating in the projects are as follows: Size (number of workers); Human Resources (total number of engineers); R&D intensity (R&D-to-sales ratio); Export intensity (export-to-sales ratio); Foreign capital (foreign ownership equal to or greater than 10%=1, other=0).

Nonetheless, it is important to emphasize that the model herein proposed is based on the literature review carried out in Section 2. It is not intended to be a model of hypotheses testing

as there is (still) no theoretical body strong enough to propose predefined assumptions between the importance assigned to intermediaries by participants in R&D and variables such as project cost, number of partners, etc.. Thus, the proposed econometric specification does not aim to test the 'theory', but rather to grasp an 'empirical' understanding of the relations between project features and the characteristics of firms (explanatory variables of the model) and the importance of intermediaries rated by participants in R&D projects.

The set of β parameters reflects the impact of **X** changes on the probability of organizations associated with the project rating an above average importance to intermediaries. The general logistic regression model is applied with the following specifications:

$$P(\textit{above average impor}\tan ce) = \frac{1}{1+e^{-Z}};$$

$$\textit{with } Z = \beta_0 + \underbrace{\beta_1 \ln\cos t + \beta_2 \ln no\_org + \beta_3 proj\_status + \beta_4 Support\_prob + \beta_5 Type\_contract + \beta_6 Type\_organization +}_{\textit{project features}}$$
$$\underbrace{\beta_7 Div\_countries + \beta_8 No\_countries\_nat\_promoter + \beta_9 Participating\_country + \beta_{10}\Pr omoting\_country + \beta_{11} Subject\_area +}_{\textit{project features}}$$
$$+ \underbrace{\beta_{12} Size + \beta_{13} Human\_\mathrm{Re}sources + \beta_{14} R\&D\_Intensity + \beta_{15} X\_Intensity + \beta_{16} Foreign\_Capital}_{\textit{characteristics of organizations}} + \varepsilon_i$$

We decided to adjust the equation of the logistic model to a rewritten model in terms of the odds of an event occurring, which facilitates a clear and direct interpretation of the coefficients of the logistic function.

In that case, the logit model is achieved by:

$$\log\left(\frac{\textit{Above average prob}}{\textit{Same or below average prob}}\right) = \beta_0 + \underbrace{\beta_1 \ln\cos t + \beta_2 \ln no\_org + \beta_3 proj\_status + \beta_4 Support\_prob + \beta_5 Type\_contract + \beta_6 Type\_organization +}_{\textit{project features}}$$
$$\underbrace{\beta_7 Div\_countries + \beta_8 No\_countries\_nat\_promoter + \beta_9 Participating\_country + \beta_{10}\Pr omoting\_country + \beta_{11} Subject\_area +}_{\textit{project features}}$$
$$+ \underbrace{\beta_{12} Size + \beta_{13} Human\_\mathrm{Re}sources + \beta_{14} R\&DIntensity + \beta_{15} X\_Intensity + \beta_{16} Foreign\_Capital}_{\textit{characteristics of organizations}} + \varepsilon_i$$

One way of interpreting the logistic coefficient would be to change the ratio of odds associated to a unitary change in the independent variable:

$$\frac{\textit{Above average prob}}{\textit{Same or below average prob}} = e^{\begin{array}{l}\beta_0 + \underbrace{\beta_1 \ln\cos t + \beta_2 \ln no\_org + \beta_3 proj\_status + \beta_4 Support\_prob + \beta_5 Type\_contract + \beta_6 Type\_organization +}_{\textit{project features}} \\ \underbrace{\beta_7 Div\_countries + \beta_8 No\_countries\_nat\_promoter + \beta_9 Participating\_country + \beta_{10}\Pr omoting\_country + \beta_{11} Subject\_area +}_{\textit{project features}} \\ + \underbrace{\beta_{12} Size + \beta_{13} Human\_\mathrm{Re}sources + \beta_{14} R\&D\_Intensity + \beta_{15} X\_Intensity + \beta_{16} Foreign\_Capital}_{\textit{characteristics of organizations}} + \varepsilon_i\end{array}}$$

In this case, e elevated to β_i is the factor by which the odds change when the independent variable i^{th} increases by a unit. Where β_i is positive, this factor is greater than 1, which means the odds increases and the factor positively influences the perception of organizations participating in projects regarding the importance of intermediaries; if β_i is negative, this

factor is less than 1, which means the odds decrease, thus the factor negatively influences the perception of organizations participating in projects regarding the importance and results of cooperation; where β_i is equal to 0, the factor is equal to 1, meaning that the odds remain unchanged, therefore, the factor has no impact on the perception organizations participating in projects regarding the importance and results of cooperation.

For example, if the calculation of β6 is positive and statistically significant, this means a project in which the promoting organization is a Small and Medium Enterprise (SME) (versus another type of organization, such as, for instance, a University or R&D Institute) is associated with an above-average rating of the importance attached to intermediaries.

Table 5 presents the estimation results in relation to the determinants of the odds log of importance (above average) assigned to intermediaries. Three models are presented in this study. Model 1 is a more restricted model that is not taken into account with the number of participating organizations from the same country as the promoting organization (which could be considered a 'cultural proximity' index), nor the specific nationality of the promoter (German, British, Spanish or Italian versus other countries). Model 3 is more comprehensive, including all the variables considered in Model 1 plus those previously mentioned. Model 2 is similar to Model 1, except that it excludes the variable 'Type of organization' (SME versus other organizations).

Except for Model 1, the other estimated models show a reasonable quality of adjustment, with the chi-square statistic associated with the Hosmer and Lemeshow test showing a level of significance above 10%, which means the non rejection of the null hypothesis that the estimated models adequately represent reality.[4] Moreover, the percentage of properly estimated 'predictions' falls between 63% and 67%.

A fact that becomes quite clear following these inferences is that it is mostly project features that 'explain' the importance (above average) assigned to intermediaries. In fact, less onerous projects (i.e., lower cost) and those involving a greater number of organizations tend, on average, to be associated with a higher rating for the role of intermediaries. In addition, *ceteris paribus*, for projects with at least one participant from the U.K., the importance given to intermediaries tends to be rated above average. In contrast, if the project has at least one Spanish participant or if the promoter is German (see Model 3), the importance assigned to intermediaries is lower.

[4] Since the Hosmer and Lameshow test rejects the null hypothesis that reality is well represented in Model 1, our comments apply only to Models 2 and 3.

As regards the characteristics of the organizations involved, only R&D intensity is shown as positively and significantly related to the importance assigned to intermediaries (Model 2). This suggests that projects in which the promoting organization has a greater innovation capacity (measured by the value of R&D expenditure in their turnover) are associated with a higher rating for intermediaries.

It is interesting to note that being an SME or another type of organization (e.g., University, R&D Institute) does not seem to have any impact on the importance given to intermediaries. Given that they tend to be organizations within the scientific and technological system (Howells, 2006), including universities, technology centres or associations, it could *a priori* be expected that the latter organizations assign an above-average importance to intermediaries (i.e., one could expected the estimation of β_6 to be negative and statistically significant), which is not the case.

Based on the sample and calculations made, the subject areas of the projects were not found to differ (statistically) in relation to the importance given to intermediaries.

In short, by controlling for a broad set of factors that could potentially 'explain' the different ratings of importance assigned to intermediaries in international R&D cooperation projects, namely, the size of firms, human resources, export intensity and foreign capital, among others, this study concludes that, on average, the importance assigned to intermediaries in a given project is greater when: the lower the costs; the greater the number of participating organizations; participants from the United Kingdom are included; participants from Spain are not included; promoters from Germany are not included; and the more innovative the promoting organizations.

Thus, despite the fact that the diversity of countries participating in each project and the 'cultural proximity' index do not 'explain' the higher importance given to intermediaries, the type of country which the participating organizations and promoters are from emerges as a relevant explanatory variable.

Table 5: Explaining the odds log of the above-average importance of intermediaries in international R&D cooperation projects as rated by organizations

			Model 1	Model 2	Model 3
Project features	(1) Project cost (ln)		-1.487*	-1.548*	-2.471*
	(2) Number of organizations, firms and intermediaries participating in the project (ln)		2.058*	2.077*	2.377
	(3) Project status (completed=1; in progress=0)		0.199	0.267	-0.153
	(4) Proportion of financial support (funding/cost)		-1.333	-1.366	-2.455
	(5) Type of contract/instrument (SMEs-Co-operative research contracts=1; Collective=0)		-0.417	-0.553	-0.421
	(6) Type of promoting organization (SME=1; Other=0)		-0.329	-	-0.003
	(7) Diversity of countries participating in each project (number of different countries in ln)		-0.946	-0.966	0.019
	(8) Number of countries with the same nationality as the promoter (ln)		-	-	0.865
	(9) At least one participant is from the country of... (yes=1; no=0)	Germany	-0.518	-0.498	-0.133
		United Kingdom	1.144*	1.128*	2.643***
		Spain	-0.757	-0.743	-2.152***
		Italy	0.125	0.124	0.281
		France	-0.272	-0.239	-0.255
	(10) The promoter of the project is from the country of... (yes=1; other=0)	Germany	-	-	-3.010***
		United Kingdom	-	-	-0.848
		Spain	-	-	1.631
		Italy	-	-	-0.073
	(11) The subject area of the project is... (yes=1; no=0)	Agri-food & Aquaculture	0.580	0.528	-0.402
		Environment	0.047	0.013	-0.767
		Biotechnology & Health	0.317	0.180	-0.033
		Energy	1.747	1.643	1.563
		Materials & Processes	1.098	1.014	0.768
		ICT & Electronics	1.593	1.531	1.748
Characteristics of promoting organizations	(12) Size – number of workers (ln)		0.039	0.088	0.118
	(13) Human resources (total proportion of engineers)		0.518	0.390	-0.211
	(14) R&D intensity (R&D-to-sales ratio)		1.118	1.266*	1.226
	(15) Export intensity (export-to-sales ratio)		-0.143	-0.189	-1.754
	(16) Foreign capital (ownership equal to or greater than 10%=1; other=0)		0.307	0.243	-0.001
Constant			17.352	17.955	29.547
N			108	108	108
Above-average importance assigned to intermediaries			56	56	56
Other			52	52	52
Adjustment quality					
% correct			62.9	63.0	66.7
Hosmer and Lameshow test (signif)			18.190 (0.019)	10.547 (0.229)	6.09 (0.637)

Caption: *** significant at 1%; ** significant at 5%; * significant at 10%

5. Conclusion

The empirical results gathered in this study partially confirm the work developed by Howells (2006). In fact, we found that, in addition to the fact that respondent organizations identify as important the most traditional functions that intermediaries usually take on – "Support in the exchange of knowledge between partners" and "Research and inside knowledge to support the consortium" – there are new functions emerging and recognized as highly important in international cooperation projects – e.g., "Forecast and technological planning" – albeit in a fragmented and scattered manner.

Among the functions carried out by intermediaries, those which are rated as the most important according to the perception of respondent organizations are: "Research and inside knowledge to support the consortium", which makes us believe that respondents view intermediaries as organizations that play an essential role in the "Promotion and exchange of knowledge and know-how" and "Diagnosis, testing, analysis and supervision". Functions pointed out in the literature as relevant, such as "Support in the establishment of sales channels", and, again, those linked to a commercial nature, as discussed by Kodama (2008) and Howells (2006), are not considered relevant for international projects. Regarding the perception of intermediary functions/roles as rated by both firms and intermediaries, it appears that, except for "Development of accreditation references" and "Support in the establishment of sales channels", all other functions are perceived in a more significant manner by intermediary organizations.

Based on the empirical evaluation of the determinants underlying the importance assigned to intermediaries, and taking into account the (above average) importance assigned to intermediaries by the organizations participating in projects, this study concludes that, on average, projects are associated to an importance assigned to intermediaries which is all the higher when: the lower the costs; the greater the number of participating organizations; participants from the UK are included; participants from Spain are not included; promoters from Germany are not included; and the more innovative the promoting organizations.

Given that the importance of intermediaries achieves more relevance in projects with more innovative promoters, it seems to be pertinent for the political authorities in each country to implement measures leading to the promotion of the innovation capacity of their intermediary organizations, namely those within the scientific and technological domain (e.g., R&D Institutes and Universities).

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