Cooperation with universities and technological centres: Is it really effective in improving firms' innovative performance?

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Abstract

This paper aims to analyse the role of cooperation with scientific and technological agents (universities, public research organizations, and technological centres) in industrial innovation, using a large-scale cross-industry sample of innovative manufacturing firms located in a technology follower country (Spain). The paper develops an integrated framework to examine: a) the factors that shape the propensity of firms to cooperate with universities and technological centres in their innovative activities; and b) the efficiency of cooperation with these agents on firms' innovative performance. The results reveal that in the Spanish context the cooperation with scientific agents is motivated more by access to funds through participation in government sponsored programmes than by improving innovative capacities based on the integration of complementary knowledge from external agents. Thus, although Spanish firms tend to cooperate more with universities relative to other external agents, this cooperation does not seem to be oriented towards the development of key activities for their innovation processes.

Keywords: Cooperation, innovation, universities, firms, technological centres

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1. Introduction

Many current economic theories on and approaches to innovation, to a greater or lesser extent, hold that individual firms are seldom capable of innovating independently and that a firm's internal technical capabilities are insufficient to cope with the challenges of the global market. Likewise, studies in the field of business management indicate that the search for new product ideas, new forms of organization and/or solutions to existing problems go beyond the firm's boundaries in exploring available capacities in other firms or institutions. In theory, a wider and more diverse search strategy will provide access to new opportunities and enable the firm to build new organizational competences based on the integration of complementary knowledge sets from external agents (Teece, 1986; March, 1991).

These approaches emphasise cooperation as an important knowledge-transfer mechanism, which allows the firm to learn from other organisations, thereby increasing its innovation capabilities. In this line, cooperation with universities and research centres has received special attention, becoming one of the main objectives of the innovation policies introduced by many OECD countries. This government interest in university-industry collaboration also has been supported by a large body of economic research that highlights the benefits of the so-called "science-industry relationship," and describes university research as one of the engines of industrial innovation (Henderson et al., 1998; Mansfield, 1998). However, many if not most of these studies, although valuable, are hindered by a focus on a limited number of technological environments and industrial sectors (such as in biotechnology in developed countries), and rarely address the broader matrix of university-industry relationships that span a broad range of industrial sectors (Laursen and Salter, 2004).

This paper aims to analyse the role of cooperation with scientific and technological agents (universities, public research organizations, and technological centres) in industrial innovation, using a large-scale cross-industry sample of innovative manufacturing firms located in Spain. Spain is a technology follower country, demonstrated by its science and technology indicator scores, which are among the lowest in the EU. Another feature of the Spanish innovation system that is distinctive, is the great importance of the public sector, which constitutes the principal source of knowledge. In 2004, this sector, comprised of universities and public research organizations, accounted for 45% of total national expenditure on R&D and employed more than 76% of the researchers in Spain. This is atypical for Europe as a whole; in other European countries almost half of all researchers are employed by private firms. In addition, cooperation between firms and research centres in Spain is lower than the European average according to the 4th Community Innovation Survey (CIS-4). Bearing in mind these features of the Spanish innovation system, it is hoped that the results provided in this paper will facilitate comparison and establish differences in innovation patterns with the technologically leading countries, which traditionally have been the focus of this type of analysis. Also, given that one of the priorities of Spanish innovation policy is to intensify the relationships between firms and public research institutions (European Commission, 2001), the results of the present study, which examines the effects of cooperation and other external knowledge sourcing strategies on firms' innovative performance, should have important implications for public policy.

The remainder of this paper is organized as follows. The next section explains the empirical model used and describes the dataset. Section 3 presents the results and Section 4 concludes.

2. Data and methodology

The data used in the empirical analysis come from the 2004 Technological Innovation in Companies Survey (TICS) conducted by Spain's National Statistical Institute. This survey is based on the Oslo Manual, and provides information on the innovative behaviour of Spanish firms during the period 2002-2004. It is designed to collect detailed information on innovation activities in Spanish firms in all sectors of the economy. In the TICS survey, firms are asked whether they have introduced a new product or process, or whether they had ongoing or abandoned innovation activities during the period 2002-2004. A positive answer to one of these questions classifies them as *innovators*. We used this selection criterion to restrict our analysis to the subsample of *innovator* firms. This decision is mainly driven by the design of the questionnaire itself, because only the *innovator* firms have to answer the full questionnaire, including those questions related to cooperation with external agents. After deleting observations with missing values, we were left with a sample of 3,311 manufacturing firms.

Cooperation can take several forms depending on the characteristics of the partners, the organizational structure of the relationship, the scope of the project, the time horizon, etc. (Howells et al, 2003). This has resulted in a number of taxonomies for different modes of inter-firm relationships. We can make a basic distinction between equity-based joint ventures (JV) and contractual partnerships, such as joint R&D and joint development agreements. In this study, we focus on contractual cooperation, for which we have information from TICS. We drew specifically on the responses to the questions about cooperation with external agents for R&D and innovation activities during the period 2002-2004. We consider heterogeneity in R&D and innovation cooperation differentiating between four types of cooperation: with competitors (horizontal), with suppliers or customers (vertical), with universities and research institutes (scientific cooperation) and with technological centres (technological cooperation). This distinction is important as knowledge from these types of agents tends to be different in nature and therefore may not only serve different purposes but may also relate differently to a firm's motivations.

Since it is our main interest to explore the role of cooperation with scientific agents on industrial innovation we develop an integrated framework to examine: a) the factors that shape the propensity of firms to cooperate with universities and technological centres in their innovative activities; and b) the efficiency of cooperation with these agents on firms' innovative performance. In this sense, we have defined two econometrics models aim to analyse each of this aspects.

The dependent variables of the first model are two dummy variables equal to one if the firm was engaged over the period 2002-2004 in an active R&D and innovation partnership with universities and/or research institutes (s*cientific cooperation*) and technological centres (*technological cooperation*), respectively. This model includes a range of explanatory variables supported by our review on the determinants of R&D cooperation. Specifically, we include four sets of explanatory variables in the analysis related to firms' characteristics, sectoral characteristics, public funding and obstacles to innovation. The inclusion of this last set of variable mainly follows the perspective of management literature on determinants of firms' decisions to establish R&D alliances. This literature has typically analyzed cooperation from a transaction costs and resource-based framework, stressing the cost minimizing and the access to complementary know-how as the main firms' motivations to engage in cooperation.

Later, in the second model, we analyse the influence of these types of cooperation on innovation, employing 'new or significantly improved product introduction' (*Product*) and 'new or significantly improved process introduction' (*Process*) as dependent variables. In addition, this models includes as explanatory variables the other types of cooperation (*vertical cooperation* and *horizontal cooperation*) and variables relates to the different external and internal knowledge sourcing strategies. The econometric specification of these models are as follow:

$$\begin{aligned} Coop_i^d &= \alpha_0 + \alpha_1 Size_i + \alpha_2 Grouponal_i + \alpha_3 Groupo\,\text{int}er_i + \alpha_4 Hightec_i \\ &+ \alpha_5 Medtec_i + \alpha_6 Lowtec_i + \alpha_7 Cost1_i + \alpha_8 Org_i \\ &+ \alpha_9 Market_i + \alpha_{10} Fina1_i + \alpha_{11} Fina2_i + \alpha_{12} Fina3_i \end{aligned} \qquad \textbf{(Model 1)}$$

$$\begin{aligned} Innov_i^e &= \alpha_0 + \alpha_1 Sciencoop_i + \alpha_2 Techcoop_i + \alpha_3 Vertcoop_i + \\ &\alpha_4 Horcop_i + \alpha_5 Size_i + \alpha_6 ERD_i + \alpha_7 EQ_i + \alpha_8 Tecno_i + \\ &+ \alpha_9 Training_i + \alpha_{10} IRD_i \end{aligned} \qquad \textbf{(Model 2)}$$

where *i* = 1,...,N (number of occurrences); d = *Sciencoop, Techcoop*; e = *Product, Process*

A rich and heterogeneous tradition of studies in industrial economy shows that innovation differs across sectors in terms of characteristics, sources, actors, links and relationships among actors, and the boundaries of the process (Malerba, 2005). To control for these potential variations, here we adopt the traditional distinction between low and high R&D-intensity sectors (widely used in OECD and EU international studies).

3. Results

Table 1presents the basic statistics for the main variables in the regression analysis. First of all, we note that those firms that belong to more technologically advanced sectors tend to cooperate more with external agents. Thus, cooperation is more widespread in sectors of higher technological intensity, as suggested by Hagedoorn (1993). In partnerships, vertical cooperation

is the most frequent form of collaboration, even for firms in high technological intensity sectors. However, If we look at the individual categories, we can see that low technological intensity firms mainly cooperate with suppliers of machinery and equipment, while high R&D intensity firms mainly cooperate with universities.

Table 1. Descriptive statistics

Variables	Low technological intensity sectors		High technological intensity sectors	
	Mean	S.D.	Mean	S.D.
Scientific Cooperation	0,14	0,35	0,22	0,41
Universities	0,12	0,32	0,19	0,40
Research centres	0,06	0,24	0,09	0,29
Technological Cooperation	0,14	0,34	0,15	0,35
Vertical Cooperation	0,23	0,42	0,27	0,44
Clients	0,08	0,27	0,14	0,34
Suppliers	0,17	0,38	0,17	0,37
Horizontal Cooperation	0,06	0,23	0,08	0,27
IRD	0,77	0,42	0,90	0,30
ERD	0,13	0,50	0,49	0,50
EQ	0,51	0,50	0,47	0,50
Tecno	0,14	0,35	0,16	0,37
Training	0,45	0,50	0,52	0,50

If we consider knowledge acquisition as a market transaction, firms that belong to sectors with a high technological intensity tend towards R&D outsourcing, while low technological intensity firms tend to draw on the 'embodied' purchase of machinery and equipment. These results largely coincide with the expected patterns. Other differences across the sectoral categories analysed relate to the development of in-house R&D activities. Our findings show that 90% of firms in high technological intensity sectors conduct in-house R&D, and nearly 80% of them continuously, while the proportions for low technological intensity sectors are 77% and 58% respectively.

Table 2 presents the results of regression model related to the determinants of firms' cooperation (Model 1). This model proves that the cooperation with scientific agents is more frequent in sectors with a high technological complexity than in sectors with a low technological complexity (*lowtech* is the reference variable in the model). Likewise, Firm's size has a positive and significant effect on the two types of cooperation analysed.

Table 2. Determinants of firm's decision to cooperate

Independent variables	Scientific cooperation (sciencoop)	Technological cooperation (techcoop)
Size	0,21*** (0,04)	0,17*** (0,04)
Groupnal	0,19 (0,13)	0,46*** (0,13)
Groupinter	0,05 (0,16)	0,11 (0,18)
Hightec	0,87*** (0,14)	-0,14 (0,17)
Medtec	0,39*** (0,11)	0,09 (0,12)
Cost	0,03 (0,07)	0,10 (0,07)
Org	0,10 (0,08)	0,37*** (0,09)
Market	0,09 (0,07)	0,06 (0,07)
Fina1	0,64*** (0,11)	1,01*** (0,11)
Fina2	0,83*** (0,11)	0,67*** (0,12)
Fina3	1,08*** (0,16)	1,13*** (0,16)
Intercept	-6,54*** (0,64)	-6,85*** (0,70)
Chi-squared (d,f)	399,58 (11)	394,34(11)
Pseudo R2	0,19	0,20
Observations	3311	3311

Data inside parenthesis are the corresponding standard errors

** P< 0,1*

*** P< 0,05*

**** P< 0,01*

In addition to industrial and firm's characteristics, cooperation with scientific and technological agents can be motivated by the reduction of costs and uncertainty associated to innovative activities or by the access to complementary knowledge or abilities of the partner. The importance of these motivations is evaluated in the model by means the *Cost, market and Org* variables. *Cost* captures bottlenecks caused by lack of financial resources or high costs of innovation activities. *Market* variable captures bottlenecks caused by uncertain market conditions (market dominated by established firms, uncertainty about the demand for innovative products and services). Finally, *Org* variable captures bottlenecks relate to the firm's lack of qualified personnel, lack of information about technology and lack of information about markets. In general, none of these variables were found to have significant impact on firm's decision to cooperate with scientific agents. However, the variables related to public funding (Fina1, Fina2, Fina3) have a significant and positive impact on scientific and technological cooperation, which suggests that these types of cooperation are mainly used as solutions to the problems of sharing cost and of obtaining finance.

Related to the efficiency of cooperation with scientific agents, we found that S*ciencoop* variable has no significant effect on product and process innovation, even in technology intensive sectors (table 3). This result suggests that universities and research rarely act as direct source of knowledge for the firm's innovative activities, at least in the context analysed by this research. In contrast, cooperation with suppliers and customers (vertical cooperation) seems to be an important strategy to develop new products and processes, especially in low technological intensity sectors.

Table 3 also shows that product and process innovations are largely driven by the acquisition of knowledge 'embodied' in machinery and equipment (*EQ*) and that R&D contracting (*ERD*) has no significant effect. In addition, we found that in-house R&D activity (*IRD*) represents a strategic asset in the development of new products and that developing and implementing these activities is significantly more important than employing strategies involving scientific partners.

These results are consistent with the findings from other studies that show that the value of external factors to innovation may have been overestimated, and strongly indicate the importance of cooperation in conditional terms. As Freel (2003, p. 762.) puts it: 'certain types of cooperation are associated with specific types of innovation, involving certain firms, in certain sectors'.

Table 3. Determinants of firm's innovation performance

Independent variables	Product Innovation		Process Innovation	
	Low technological intensity sectors	High technological intensity sectors	Low technological intensity sectors	High technological intensity sectors
Size	0,04 (0,06)	-0,02 (0,06)	0,00 (0,06)	0,20*** (0,06)
ERD	0,01 (0,06)	0,06 (0,07)	-0,11* (0,06)	0,06 (0,06)
EQ	0,13** (0,06)	0,20*** (0,07)	0,51*** (0,07)	0,40*** (0,06)
Tecno	0,10 (0,06)	0,04 (0,07)	0,07 (0,08)	0,06 (0,06)
Training	0,18*** (0,06)	0,06 (0,07)	0,21*** (0,07)	0,33*** (0,06)
IRD	0,36*** (0,05)	0,51*** (0,07)	-0,12** (0,06)	-0,04 (0,06)
Vertcoop	0,19*** (0,07)	0,15** (0,08)	0,31*** (0,08)	0,03 (0,06)
Horcoop	-0,02 (0,07)	0,01 (0,08)	0,17* (0,10)	0,07 (0,06)
Sciencoop	-0,02 (0,07)	0,02 (0,08)	-0,05 (0,08)	-0,04 (0,06)
Techcoop	0,04 (0,07)	0,28*** (0,09)	0,22** (0,09)	0,06 (0,07)
Intercept	0,81*** (0,06)	1,30*** (0,07)	1,30*** (0,07)	0,77*** (0,06)
Chi-squared (d,f)	120,43 (10)	125,52 (10)	167,80 (10)	171,14 (10)
Pseudo R2	0,10	0,11	0,14	0,13
Observations	1644	1667	1644	1667

Data inside parenthesis are the corresponding standard errors

* P< 0,1

** P< 0,05

*** P< 0,01

4. Conclusions

The results reveal that in the Spanish context the cooperation with scientific agents is motivated more by access to funds through participation in government sponsored programmes than by improving innovative capacities based on the integration of complementary knowledge from external agents. Thus, although Spanish firms tend to cooperate more with universities relative to other external agents, this cooperation does not seem to be oriented towards the development of key activities for their innovation processes. These results do not imply that the contribution of universities to industrial innovation is irrelevant, rather they suggests that we must pay more attention to the role of indirect mechanisms such as training of qualified personnel or mobility of researchers from university to industry.

In Spain, those responsible for innovation policy have traditionally been guided by a linear vision of innovation, focusing in particular on strengthening the public research system. Recently, encouraging closer relations between firms and public institutions has become an objective of innovation policy, which could explain the relative importance of universities and research centres as cooperation partners. However, in the light of our results, it would appear that policy makers should concentrate on strengthening the technological capabilities of firms as it is these features that have the greatest influence on innovation. Also, in order to promote the transfer and exploitation of the knowledge generated by public research centres and universities, innovation policy should go beyond simple support for these relationships and establish mechanisms to enhance firms' reliance on the research conducted by these agents in order to promote cooperation in activities with a higher impact on innovation. These policies should be integrated with university and research centre policies, which, rather than indiscriminately promoting the commercialization of their knowledge and technological capabilities, should take account of the requirements of the sectors and firms being targeted.

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