UNIVERSIDAD COMPLUTENSE DE MADRID

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COOPERATION IN INNOVATIVE ACTIVITIES, ORGANIZATIONAL INNOVATION AND PRODUCTIVITY: THREE ESSAYS ON ECONOMIC OF INNOVATION

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

PRESENTADA POR

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Bajo la dirección del doctor
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Madrid, 2008

- **ISBN: 978-84-692-2927-9**

ACKNOWLEDGEMENTS

I would like to thank my advisor, José Carlos Fariñas, whose guidance and support has been essential in completing this dissertation. I am also indebted to Jordi Jaumandreu for his valuable suggestions and to Elena Huergo for all her help through this process.

I am grateful for comments from the members of the IEEF research project. In particular, the second chapter of this dissertation has benefitted from joint work with Laura Abramovsky, Elisabeth Kremp, Tobias Schmidt and Helen Simpson.

I also acknowledge insightful comments by Pedro Albarrán, Manuel Arellano, Andrés Barge, Bronwyn Hall, Aija Leiponen, Georg Licht, Ramón Marimón, Stephen Martin, Manuel Trajtenberg, Reinhilde Veugelers, several anonymous referees and the audiences at several conferences and seminars.

Thanks is due to the INE and FUNEP for access to the data.

I am also grateful for support from projects IHPSE-CT-2001-00047 (IEEF project), SEJ2004-02525/ECON, SEJ2007-66520/ECON and from Fundación Banco Herrero.

Last, I thank my family and friends. Thanks, Ana, for being there for me through everything.

INTRODUCTION

Innovation activities performed by firms and their economic impacts are of central interest to economists and policy-makers. Analysis of these issues requires both knowledge of the factors that affect firms' ability to innovate and knowledge of the impact of innovation activities on firm performance through changes in both demand and costs.

This dissertation studies two of the most relevant research issues on Economics of Innovation: (i) cooperation in innovative activities, and (ii) the relationship between innovation and productivity. In doing this, I use data at the firm level from the Third Community Innovation Survey (CIS3) and from the Encuesta sobre Estrategias Empresariales (ESEE). The Community Innovation Surveys take place every 4 years in European countries to investigate innovation activities performed by firms. In 2001, the third wave was conducted and covered the period 1998 to 2000. The ESEE is an unbalanced panel survey of Spanish manufacturing firms with 10 or more workers, starting in 1990 and sponsored by the Ministry of Industry. A detailed description of these surveys can be found in each chapter.

This introduction is organized in three parts. Firstly, I introduce the two issues at stake: cooperation in innovative activities and the relationship between innovation and productivity. I focus on contextualizing both topics in the current development of literature on innovation, as well as on specifying my contributions to this literature. Secondly, I present the structure of the dissertation, summarizing the contents of each chapter. Finally, the last part of this introduction is concerned with the main policy implications of the issues covered by this dissertation.

Issues at stake

Cooperation in innovative activities

The innovative activities of a firm partly depend on the variety and structure of its links to sources of information, knowledge, technologies, and human and financial resources. Each of these links connects the innovating firm with other actors in the innovation system: commercial laboratories, universities, policy departments, regulators, public research institutes, competitors, suppliers, and customers. These flows of knowledge between firms and other organisations have an important role in both the development and diffusion of innovations.

The Oslo Manual (OECD, 2005) identifies three types of external linkages: (i) open information sources, (ii) acquisition of knowledge and technology, and (iii) cooperation in innovative activities. Firstly, open information sources provide openly available information that does not require the purchase of technology or intellectual property rights, or interaction with the source. Secondly, acquisition of knowledge and technology are purchases of external knowledge and capital goods (machinery, equipment, software) and services embodied with new knowledge or technology that do not involve interaction with the source. Thirdly, cooperation in innovative activities is active cooperation with other actors in the innovation system (for example, universities, firms or public research institutes) with the objective of performing innovation activities. These activities constitute agreements by which firms share the costs and returns of innovative projects, sometimes with other firms and sometimes with research institutions. In what follows, I focus on this type of external linkage.

With the ultimate interest of stimulating innovation, a lot of attention has recently been paid to the subject of cooperative innovative activities among firms (see, among others, Dodgson (1994), Hagedoorn et al. (2000), Hagedoorn (2002), and Tyler and Steensma (1995)).

Moreover, an important feature of this kind of cooperative activity is its interactions with competition policy. Since the seminal work by Schumpeter (1943), the relationship between market competition and innovation has been a question of interest for economists and policy-makers. Competition heavily influences the way technology and innovation are started and diffused, and the analysis of the dynamics of technology is one of the most important parts of this broad area of interest.

Economic analysis suggests the existence of several difficulties for the innovative activities to be carried out at an optimal level in a fully competitive environment[1]. The character of

[1]See Martin (2002, Chapter 14). This author ,after reviewing the literature, observes that a market

the input "knowledge" (freely usable when displayed), the presence of important fixed -and often sunk- costs associated with innovative activity investments, and the uncertainty associated with the results coming out of these activities are likely to provide few incentives to firms to allocate enough resources to an activity that shows important positive externalities towards other firms and consumers. But, at the same time, as many empirical studies have shown[2], competitive pressure seems in many circumstances to strongly stimulate innovative activities and the introduction of innovations by firms[3].

In this context, cooperation in innovative activities, from a positive point of view, is likely to show mechanisms by which firms can profitably appropriate free flows of knowledge and protect them. Hence, these agreements are an interesting guide to normative regulation, which must try to consolidate mechanisms of incentives and at the same time avoid harming market competition.

To sum up, cooperative innovative activity summarizes many of the questions at stake in the economics of innovation literature, such as, "appropriability", spillovers, the relative roles of rivalry and cooperative outcomes, influence and role of public policy. Therefore, it is a topical policy issue, in the context of technology transfer (most prominently from universities to business), and in its interactions with competition policy. Both the OECD and the European Union support the idea of strong industry-science linkages to maximize the returns from both private and public research investments, and recognize a role for policy (OECD (2004a), OECD (2004b), European Commission (2004)).

In this context, it is important to understand which types of firms tend to engage in cooperative innovative activities, the motivations for such activity and whether public policy is effective in increasing collaborative research. The first two chapters of this dissertation

system results in an insufficient level of innovation relative to the second-best optimum. Moreover, theories of industrial organization typically predict that innovation should decline with competition, as more competition reduces the monopoly revenues that reward entry by new successful innovators (see, among others, Dasgupta and Stiglitz (1980), and Aghion and Howitt (1992)).

[2]See Geroski (1995), Nickell (1996), and Blundell, Griffith and Van Reenen (1999).

[3]See Aghion et al. (2005) for recent empirical evidence on an inverted -U relationship between competition and innovation.

present evidence about the determinants of cooperation in innovative activities. The first explores the determinants for the Spanish manufacturing sector, while the second one investigates cooperative innovative activity in four major European countries, France, Germany, Spain and the UK, using internationally comparable firm-level data for manufacturing and service sectors.

Innovation and productivity growth

The poor productivity performance of European countries relative to the US has been an important focus for government policy. In this sense, the "Lisbon Strategy" intends to deal with the low productivity and stagnation of economic growth in the EU. As pointed out by Sapir et al. (2003): "In the EU, there has been a steady decline of the average growth rate decade after decade and per-capita GDP has stagnated at about 70% of the US level since the early 1980s".

In the first three decades after World War II, Europe established an enviable reputation for both high growth and a high level of social protection. The long post-war expansion had been built on the basis of the generalisation of an already mature technological trajectory with well known organisational implications and rapid diffusion of the best practice. In short, Europe was catching up with the US both through investment and factor accumulation, and through imitation of leading-edge technologies.

In this sense, Sapir et al. (2003) emphasizes the fact that post-war growth in Europe was largely based on imitation and driven by capital accumulation. Europe's unsatisfactory growth performance during the last few decades is a symptom of its failure to transform into an innovation-based economy. A system built around the assimilation of existing technologies, mass production generating economies of scale, and an industrial structure dominated by large firms with stable markets and long term employment patterns no longer delivers in the world of today, characterised by economic globalisation and strong external competition (Sapir et al. (2003)).

What is needed now for European countries is to shift towards growth-based on innovation. Once European countries had moved closer to the technology frontier and also with the occurrence of new technological revolutions in communication and information, growth was driven to a greater extent by innovation and fast adaptation to technical progress. Innovation influences firm performance through a variety of channels that range from the effects of innovation on sales and market shares to changes in productivity and efficiency. Furthermore, important impacts of innovation at industry and national levels are, among others: changes in international competitiveness and in total factor productivity, emergence of knowledge spillovers of firm-level innovations, and an increase in the amount of knowledge flows through networks.

Academics and policy-makers have emphasised the importance of investment in research and development (R&D) as a contributor to long-term productivity growth. Regarding academic literature on this issue, since Griliches (1979), many empirical studies have focused on the link between R&D and productivity[4] and on the role of technological process and product innovations as productivity shifters[5]. In response to these concerns, the European Union has set itself the target of increasing R&D expenditure to 3% of the GDP by 2010 (this is part of the "Lisbon Strategy").

However, a framework broader than technological product and process innovation is needed. In this sense, the third edition of the Oslo Manual (OECD, 2005) expands the definition of innovation to include, besides product and process innovations, two additional types of innovations, organisational innovation and marketing innovation. Including marketing and organisational innovations gives a more complete framework that is better able to capture the changes that affect firm performance and contribute to the accumulation of knowledge.

The third chapter of this dissertation contributes to the literature on innovation and productivity by analyzing the effect of organizational innovation on productivity. An organisational innovation (see OECD, 2005) is the implementation of a new organisational method. These can be changes in (i) a firm's business practices (i.e., the implementation of new methods for organising routines and procedures of the conduct of work), (ii) workplace

[4] See Griliches (1995) for a survey.

[5] Crépon et al. (1998) propose a structural model that describes the link between R&D expenditure, innovation output and productivity.

organisation (i.e., the implementation of new methods for distributing responsibilities and decision-making autonomy among employees, for the division of work as well as new concepts for the structuring of activities), or (iii) external relations (i.e., the implementation of new ways of organising the relations to other firms or public institutions).

Changes in organisational methods can improve the efficiency and quality of firms' operations, thereby increasing demand or reducing costs. There are an increasing number of studies that suggest a significant and positive effect of various measures of organizational innovation on productivity. For example, one of the most significant findings on the relationship between organizational innovation and growth is given by Black and Lynch (2004). These authors find that as much as 30 percent of output growth from 1993-1996 in US manufacturing might be accounted for organizational practices (specifically for workplace practices and re-engineering efforts).

The third chapter focuses on the role of one of the most relevant organizational methods, outsourcing. In this sense, the third edition of the Oslo Manual (OECD, 2005) considers "outsourcing or subcontracting of business activities in production, procuring, distribution, recruiting and ancillary services" a new organisational method in a firm's external relations.

Structure of the dissertation

The dissertation is organized in three chapters. The first chapter explores the determinants of R&D cooperation using a sample of Spanish manufacturing firms. The data used correspond to the Third Community Innovation Survey (CIS3; period 1998-2000), carried out in Spain by the Instituto Nacional de Estadística (INE) under the name Encuesta de Innovación Tecnológica en las Empresas. This chapter focuses on the impact of information flows or spillovers on R&D cooperation, but also explores the role of the traditionally considered factors (firm size, cost and risk sharing, complementarities). The estimation methods used allow testing the endogeneity for the explanatory variables, which in other papers are assumed to be endogenous a priori. I find that the choice of an appropriate "structure" of endogeneity has important consequences for the estimates: only in this case do cost-risk sharing and complementarities have the expected positive effect. I also find that the overall picture of the importance of the explanatory variables depends on the estimation method. In this sense, two-step procedures overestimate the importance of spillovers. With a more efficient procedure, I find that cost-risk sharing is the most important determinant of R&D cooperation in Spain. Finally, the overall results on the importance of spillovers are consistent with the existing literature, but I find that a greater level of legal protection in the industry has a negative effect on R&D cooperation.

Different versions of this study have been presented at the European Summer School on Industrial Dynamics (ESSID) in August 2003, at the VII Encuentro de Economía Aplicada in June 2004, at the 32^{nd} EARIE meeting in September 2005 and at the I Escuela de Economía de la Innovación in July 2006. A version of this chapter has been accepted for publication in the *International Journal of Industrial Organization.*

The second chapter investigates cooperative innovative activity in four major European countries, France, Germany, Spain and the UK, using internationally comparable firm-level data for manufacturing and service sectors. Again, the source of the data is the Third Community Innovation Survey. The chapter examines the roles of knowledge flows, cost- and risk-sharing and public financial support in firms' decisions to collaborate. Results suggest that firms which place greater value on external information flows are more likely to cooperate with the research base than with other firms, and that firms facing appropriability problems are more likely to cooperate with the research base and with upstream and downstream firms than with direct competitors. I find evidence for Spain to suggest that firms collaborate to overcome risks and financial constraints. I also find that receipt of public support is positively related to undertaking collaborative innovation. In line with the focus of policy, this relationship is strongest for cooperation with the research base.

I presented a preliminary version of this chapter at the 33^{rd} EARIE meeting in August 2006. The current version, in collaboration with Laura Abramovsky, Elisabeth Kremp, Tobias Schmidt and Helen Simpson, has been accepted for publication in *Economics of Innovation and New Technology.*

The third chapter is aimed at analyzing the relationship between organizational innovation and productivity. I focus on the role of one of the most relevant organizational methods, outsourcing. Outsourcing is a make or buy decision and implies the modification of the boundaries of the firm. It must be seen as part of the organizational innovation process, carried out in the search for increasing flexibility and efficiency. Specifically, this chapter deals with outsourcing at the firm level and focuses on the role of contracting out of manufacturing activities. To address it, I develop and estimate a simple theoretical framework justifying the addition of outsourcing measures to the specification of a "traditional" production function. The framework developed leads to the estimation of a production function depending on traditional inputs (labor, capital and materials) and an index of production subcontracting. Specifically, both the effect of first-time outsourcing on productivity and the effect of the intensity of production subcontracting can be analyzed.

Using an unbalanced panel of Spanish manufacturing firms from the Encuesta sobre Estrategias Empresariales (ESEE), I find that for manufacturing as a whole, both the outsourcing decision and its intensity have a positive effect on productivity. When analyzing industry level results, I find that outsourcing intensity has a positive effect on productivity, mainly for firms belonging to light industries, while the decision of starting (stopping) outsourcing has the expected positive (negative) effect on productivity.

The simple theoretical framework presented in section 3.2 has shortcomings. These limitations are overcome in the last part of the chapter. In this sense, the third chapter ends with a first attempt at modelling and estimating a more structural framework for the specification of a production function considering the possibility of production subcontracting. This framework allows us to identify two "uses" for labour (labour used "directly" in the production of the final output and labour used in the production of the intermediate input). Results presented in the last section show plausible values for the elasticities of both labour "uses", capital and intermediate consumptions.

Different versions of this study have been presented at the XX Jornadas de Economía Industrial in September 2004, at the 32^{nd} EARIE meeting in September 2005, at the IX Encuentro de Economía Aplicada in June 2006 and at the Fourth CEPR School on Applied Industrial Organisation in May 2007.

Policy implications

Productivity analysis performed at the aggregate level systematically shows a slower growth of the EU economy in the 90's when compared with the US (see, for example, Scarpetta et al. (2000)). This, although particularly strong for certain services sectors that intensively use information telecommunications technologies, has been the cause of greater concern and discussion on the ability of the European economy to develop, diffuse and apply the new technologies, and their capabilities of transforming them into an engine of growth. The "Lisbon Strategy", a policy response to this challenge, embodied a broad set of structural reform targets, with the strategic economic goals of creating the most competitive and dynamic knowledge-based economy by 2010. The development of these policies continues today, being a subject of primary attention. The results of this dissertation, focussed on the understanding of cooperation in innovative activities and the effect of innovation on productivity, have some general implications for these policies.

The premise is, as my results show, that innovative activity enhances productivity. The question is how to reinforce the best realisations of this fact. The research done on innovation and productivity has contributed to the literature by analyzing the effect of a particular form of organizational innovation on productivity.

Cooperation in innovative activities emerges from my results as a way, still very unequally developed across European countries, to face the challenges of technological developments by enhancing profitable innovation. This is a timely subject. Both the OECD and the European Union support the idea of developing stronger industry-science linkages. In this sense, in 2003, the British government conducted a major review of the extent of business-university collaboration, which suggested ways to improve government support for such activity[6]. The UK currently operates a number of schemes aimed at encouraging collaborative innovative activity between businesses and research institutions, and business-to-business linkages. In Germany, a significant amount of public funding for innovative activity is now directed towards research consortia comprising private businesses and scientific research institutions, and policies in France and Spain also emphasise public-private sector collabo-

[6] HM Treasury (2003).

ration[7].

My findings support the idea that both the presence of “incoming spillovers” and the ability to “appropriate” the returns from innovation stimulate cooperation, which means that the enlargement of collaborative practices can strengthen innovation and this can be policy-promoted. In fact, the results already show some positive association between cooperation and public support, which possibly stresses the presence of an already active supporting policy.

[7]See Abramovsky et al. (2004) for a summary for the UK, Fier et al. (2006) for information on the direction of funding in Germany, Acosta and Modrego (2001) for further information for Spain, and MNRT (2005) for further information for France.

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CHAPTER 1. DETERMINANTS OF R&D COOPERATION: EVIDENCE FROM SPANISH MANUFACTURING FIRMS

1.1. Introduction

In the ultimate interest of stimulating innovation, much attention has recently focused on the subject of cooperative firm R&D. These agreements, from the positive point of view, are likely to embody mechanisms by which firms can profitably appropriate free flows of knowledge and protect them. Hence, they are an interesting guide to normative regulation, which must try to consolidate mechanisms of incentives and at the same time avoid harming market competition.

R&D cooperation has thus become a major topic for policy makers. Most E.U. and national public funding for R&D is directed at stimulating cooperation between firms, and between firms and public institutions[8]. The rationale behind this policy is to generate or improve information flows or spillovers between these economic agents, as these spillovers are assumed to essentially lead to more economic growth[9] and a better performance of the national system of innovation.

Given this growing interest, the literature has recently paid attention to the relationship between R&D cooperation activity and spillovers. Cassiman and Veugelers (2002), henceforth CV, find that the firms' external information sources (incoming spillovers) and the flows out of the firms measured by the ability of firms to appropriate the returns from innovation (appropriability) have important and separately identifiable effects on the probability of R&D cooperation. Other works have studied the relationship between spillovers and R&D cooperation; see, for example, Belderbos et al. (2004) for evidence on this rela-

[8] See Acosta and Modrego (2001) for an example of public funding in Spain, and Abramovsky, Harrison and Simpson (2004) for a summary for the UK.

[9] See Griliches (1992) for a survey on the empirical evidence on the relationship between R&D spillovers and growth, and Romer (1990) for a theoretical discussion.

tionship from the Netherlands, and Kaiser (2002a) for evidence from the German service sector.

Besides knowledge flows, the literature has identified three major classes of motives for firms to become involved in R&D cooperation: cost and risk sharing[10], complementarities or skill-sharing[11], and factors related to the absorptive capacity of the firm[12]. Firstly, cooperative R&D agreements may be used by firms to set cost and risk-sharing rules in high-cost and risky settings. Hence, when cost and risk are important innovation hampering factors, firms would tend to make cooperative R&D agreements. Secondly, cooperative R&D is a vehicle for firms to learn skills and capabilities from their partners. As such, the greater the availability of technological know-how within the firm, the more likely it is to have complementarities between partners in a cooperative R&D agreement. Finally, one other determinant that is closely related to knowledge flows and complementarities is the idea of absorptive capacity. A firm's absorptive capacity is derived from its own R&D efforts and is a measure of its ability to benefit from other firms' R&D activity. The higher the absorptive capacity of the firm, the higher the benefits from R&D cooperation.

This chapter develops evidence about the determinants of R&D cooperation using a sample of Spanish manufacturing firms, focusing mainly on the importance of spillovers. The study is based on the model introduced by CV, although it departs from these authors to explore some econometric and substantial issues.

The contribution of this study to the empirical literature on R&D cooperation is three-fold. First, I show that an adequate treatment of endogeneity matters a great deal. I find evidence supporting the existence of an important effect of spillovers on R&D cooperation, although cost and risk sharing is the most important determinant for cooperation in Spain. In obtaining these results, I apply a complete treatment for endogeneity. Two alternative estimation methods are used: Two-stage conditional maximum likelihood (2SCML) and Conditional maximum likelihood (CML). These techniques allow me both to test for the

[10]See, among others, Belderbos et al. (2004), Hagedoorn (1993), Miotti and Sachwald (2003), Tether (2002), Tyler and Steensma (1995).

[11]For example, Hagedoorn (1993), Sakakibara (1997), Tyler and Steensma (1995).

[12]See, among others, Cohen and Levinthal (1989), Röller et al (2002), Sakakibara (1997), Tether (2002).

endogeneity of the explanatory variables which in other papers are assumed to be endogenous a priori and to obtain efficient estimates. I find that the choice of an appropriate "structure" of endogeneity is crucial and has important consequences for the estimates. I also find that, depending on the estimation method, a different picture of the importance of the explanatory variables is obtained. In this sense, two-step procedures overestimate the importance of spillovers and underestimate the impact of cost and risk sharing reasons on the probability of R&D cooperation.

Second, I obtain new insights on the topic due to the sample employed. On the one hand, I use a large sample of 2518 firms, in contrast with the 411 observations used by CV. This sample size allows me to obtain more accurate estimations and more precision applying hypothesis tests. On the other hand, compared with most European countries, the Spanish system of innovation is in an earlier stage of development. Compared with France, Germany and the United Kingdom, Spain presents the lowest proportion of firms with innovation expenditures and with intramural R&D. The R&D intensity (ratio of intramural R&D expenditure over total turnover) of Spanish firms performing R&D is, approximately, one third of the efforts of France, Germany and the United Kingdom. Spain also presents the lowest share of firms with R&D cooperation agreements[13]. As R&D cooperation is an important vehicle for improving the innovation performance of firms, this gap makes the study of those factors that may stimulate cooperation in R&D more interesting. Moreover, the structure of the Spanish manufacturing sector is characterized by a large share of small and low-technology firms, while the general finding in the literature is that firms from high-technology sectors and big firms are more likely to cooperate in R&D. It is worthy of exploring cooperation in such a context of small and low-technology firms.

Third, I extend CV's framework to the analysis of the determinants of R&D cooperation with competitors and I pay more attention to the relationship between cooperation and the effectiveness of different legal methods for protecting inventions or innovation.

The rest of the chapter is organized as follows. Section 1.2 introduces the data and

[13] See Abramovsky et al. (2004) for a detailed comparison in the innovation activities and performances at the national level for France, Germany, Spain and the United Kingdom.

presents some descriptive analysis of the sample. Section 1.3 introduces the framework for the analysis. The econometric specification is shown in Section 1.4. Section 1.5 presents the results. Finally, Section 1.6 concludes.

1.2. Data and descriptive analysis

The data used correspond to the Third Community Innovation Survey (CIS3; period 1998-2000), carried out in Spain by the Instituto Nacional de Estadística (INE) under the name Encuesta de Innovación Tecnológica en las Empresas. The Community Innovation Surveys take place every 4 years in European countries to investigate a firm's innovation activities. In 2001, the third wave was conducted and covered the period 1998 to 2000. The CIS3 follows the recommendations of the OSLO Manual on performing innovation surveys (see OECD and Eurostat, 1997).

Table 1.1. Characteristics of CIS3 in Spain

Responsible national authority	INE (Instituto Nacional de Estadstica)
Participation	Compulsory
Target population (number of employees)	10
Frame population	Official INE register of firms (DIRCE)
Covered sectors[1]	C, D, E, F, G, H, I, J, K, N, O
Stratification	Size, sectors
Sample	11778
Non-response analysis	no

[1]According to NACE classification: C (mining and quarrying), D (manufacturing), E (electricity, gas and water supply), F (construction), G (wholesale, retail trade, repair of motor vehicles), H (hotels), I (transport, storage and communication), J (financial intermediation), K (real estate, renting and business activities), N (health and social work), O (other community, social and personal service activities).

The Spanish CIS3 collected data on 11778 firms[14]. The population target was firms with

[14] 6094 in Manufacturing (NACE 15-37), 4778 in Services (NACE from 50 to 95), and the rest in Mining

Table 1.2. Sample Statistics

(Number and percentage of firms)

Manufacturing Firms	6026
Innovating Firms	2518 (41.8%)[1]
Non-cooperating Firms	2042 (81.1%)[2]
Cooperating Firms (at least one cooperative R&D agreement)	476 (18.9%)[2]
Firms Cooperating with Competitors	184 (7.3%)[2]
Firms Cooperating with Suppliers or Customers	316 (12.5%)[2]
Firms Cooperating with Research Institutions	425 (16.9%)[2]

[1]percentage with respect to manufacturing firms

[2]percentage with respect to innovating firms

10 or more employees. A firm is defined as the smallest combination of legal units that is an organizational unit producing goods or services. Participation is compulsory for firms and is based on stratified samples by size and sector. Unit non-response analysis is not carried out. Table 1.1 summarizes the main features of the survey for Spain.

The final sample of the manufacturing sector includes 6026 firms[15], 41.8% (2518 firms) of which report having introduced innovations during the reference period. This work restricts the attention to this subsample of innovating manufacturing firms. Innovating firms are defined as those which report having introduced product or process innovations, having ongoing innovation activities, or having abandoned innovation activities, and, at the same time, present a positive amount spent on innovation during the period 1998-2000.

Table 1.2 reports some sample statistics. It turns out that 476 firms in my sample of 2518 innovating firms (18.9%) have at least one cooperative R&D agreement. It is helpful to further distinguish among different types of cooperative R&D agreements depending on the kind of partner: 184 firms cooperate with competitors, 316 firms cooperate with suppliers or customers (vertically-related firms), and 425 firms cooperate with research institutions.

and quarrying (NACE 10-14), Electricity, gas and water supply (NACE 40-44) and Building (NACE 45).

[15]In this exercise, I drop a total of 68 manufacturing firms because of partially incomplete data.

Table 1.3. Cooperative R&D Agreement Combinations

(Number and percentage[1] of firms)

Cooperating firms with three types of agreements			159 (33.4%)
Cooperating firms with one or two types of agreements			
	Competitors	Suppliers or Customers	Research Institutions
Competitors	7 (1.5%)	9 (1.9%)	9 (1.9%)
Suppliers or Customers	–	35 (7.3%)	113 (23.8%)
Research Institutions	–	–	144 (30.2%)

[1] percentage with respect to Cooperating Firms (firms with at least one cooperative R&D agreement)

Table 1.3 shows that most firms maintain cooperative R&D agreements with different partners. Sixty-one percent of firms have agreements with at least two types of partners, and 33.4% cooperate with all three types. It is important to keep this in mind when analyzing cooperation by type of partner. For example, just 144 firms which cooperate with research institutions have agreements exclusively with these institutions, while the other 281 firms also maintain agreements with at least one other type of partner.

Table 1.4 shows the distribution of the sample of innovating manufacturing firms across industries and size. The sample presents a larger number in small firms (fewer than 200 employees) than in big firms (200 or more workers); 1748 and 770 firms, respectively. With respect to sector distribution, the sample shows a higher share of firms in low-technology sectors (63.9% of the firms belong to low-technology sectors). These facts are consistent with the Spanish manufacturing sector characteristics shown in the introduction. Focusing on R&D cooperation activity, innovative firms in high-technology manufacturing sectors and big firms are more likely to engage in cooperative activity.

Table 1.4. Number of innovating manufacturing firms by size and sector[1,2]

	Less than 200 employees	200 or more employees
Transport equipment	85 (14)	96 (38)
Chemicals	150 (49)	109 (52)
Machinery	139 (17)	46 (13)
Electrical	196 (36)	88 (39)
High-technology sectors	570 (116)	339 (142)
Food, beverages and tobacco	166 (15)	126 (33)
Textile and leather	197 (9)	45 (8)
Wood and paper	228 (10)	50 (11)
Rubber and plastic	81 (6)	37 (9)
Non-metallic mineral products	106 (11)	50 (22)
Metallic products	219 (24)	93 (39)
NEC and recycling	181 (16)	30 (5)
Low-technology sectors	1178 (91)	431 (127)
Manufacturing firms	1748 (207)	770 (269)

[1]number of innovating manufacturing firms with at least one cooperative R&D agreement between brackets

[2]Transport equipment (NACE 34-35); Chemicals (NACE 23-24); Machinery (NACE 29); Electrical (NACE 30-33); Food, beverages and tobacco (NACE 15-16); Textile and leather (NACE 17-19); Wood and paper (NACE 20-22); Rubber and plastic (NACE 25); Non-metallic mineral products (NACE 26); Metallic products (NACE 27-28); NEC and recycling (NACE 36-37)

1.3. A framework for the analysis

Based on the literature reviewed in the introduction, this chapter models the probability of cooperation as depending on spillovers, as well as the traditional variables which are thought to affect R&D cooperation (cost-risk sharing, complementarities, absorptive capacity of the firm, etc.). I include three variables related to the measure of spillovers, i.e., incoming spillovers (measured by the importance of publicly available information for the firm's innovation process), appropriability (measured by the effectiveness of the different strategic protection methods of innovations, the converse of which can be thought of as the extent of outgoing spillovers) and a measure of the importance of legal methods for protecting inventions or innovation at the industry level[16]. Detailed definitions of all employed variables can be found in Appendix 1.A.

Let me briefly comment on the expected effects of the explanatory variables.

Incoming spillovers are expected to have a positive effect on the probability of cooperation. The higher incoming spillovers are, the greater the scope for learning within cooperative R&D agreements, and hence the marginal profit to be derived from cooperation.

The sign of the effectiveness of strategic and legal protection methods (appropriability and industry level of legal protection), however, is not so clear a priori. The literature suggests two opposite effects of this variable on the probability of cooperation. The net effect will then depend on their relative importance. On the one hand, a low level of effectiveness increases the scope for the internalization of information flows between firms through cooperation in R&D. But, on the other hand, incentives to become a free rider on other firms' investments will reduce profitability and the stability of cooperative agreements.

The cost-risk variable, given the hypothesis of cost and risk sharing, is expected to show a positive effect on cooperation. To test for complementarities, a variable which measures the availability of technological know-how within the firm is included. This variable is expected

[16] As far as legal protection can be considered an industry variable rather than a firm-specific characteristic, only the average industry score for legal protection is employed. The industry is defined at the NACE 2-digit sector level.

to have a positive effect on cooperation.

Benefits from R&D cooperation depend on the absorptive capacity of the firm. In this sense, the higher the firm's absorptive capacity, the higher the returns that the firm can expect from access to external resources. On the one hand, theoretical models explicitly incorporate the need for a firm to conduct its own R&D in order to realize spillovers from other firms' R&D activity (Griffith, Redding and Van Reenen, 2003; Kaiser, 2002b; and Kamien and Zang, 2000). On the other hand, empirical studies, such as Cohen and Levinthal (1989, 1990); Griffith, Redding and Van Reenen (2003, 2004), have shown that firms' absorptive capacity depends on their own R&D intensity (R&D expenditures/turnover)[17]. So, R&D intensity is included as a measure of the absorptive capacity of the firm.

Additionally, firm's size is also included as a measure of the absorptive capacity of the firm. Therefore, I should expect a positive effect of the firm's size on the probability of cooperation. Size squared is considered to allow for a nonlinear effect of firm size.

The specification also includes the level of cooperation at the industry level, which is assumed to pick up unobserved industry-specific attributes that contribute to the decision of engaging in a cooperative R&D agreement. Table 1.5 summarizes the theoretical predictions along with the empirical findings at the end of Section 1.5.

[17] In the empirical literature, other variables have been used in order to measure the absorptive capacity of the firm. For example, Belderbos et al. (2004); and Fritsch and Lukas (2001) measure the R&D intensity by the ratio of R&D personnel to total personnel. Jaffe (1986) uses both the ratio of R&D expenditures on capital and the level of R&D expenditures. While Miotti and Sachwald (2003) and CV use a dummy variable for permanent R&D as an indicator of the absorptive capacity.

Table 1.5. Summary of hypothesis and empirical results for Spain

Variable	Hypothesis	Finding
Incoming spillovers	The importance of publicly available information has a positive effect on the probability of cooperation	True
Appropriability	The effectiveness of the strategic protection methods does not have a clear effect on the probability of cooperation	Positive effect
Industry level of legal protection	The effectiveness of the legal protection methods does not have a clear effect on the probability of cooperation	Negative effect
Cost-risk	The higher the importance of cost and risk as hampering factors for innovation, the higher the probability of cooperation	True
Complementarities	The availability of technological know-how within the firm has a positive effect on the probability of cooperation	True
R&D intensity	Benefits from R&D cooperation depend on the absorptive capacity of the firm; therefore, I expect a positive effect of R&D intensity on the probability of cooperation	True for cooperation with suppliers or customers
Size	Benefits from R&D cooperation depend on the absorptive capacity of the firm; therefore, I expect a positive effect of the firm's size on the probability of cooperation	True

1.4. Econometric specification

1.4.1. The problem of endogeneity

My concern is that some of the explanatory variables introduced in the former section are, in fact, endogenous. A priori, as in CV, I will consider the possible endogeneity of incoming spillovers, appropriability and R&D intensity. Additionally, in a departure from CV's paper, the cost-risk variable will also be taken as a possible endogenous variable. Endogeneity can arise in two different ways: omitted variables that I cannot include in the model and simultaneity in the decisions.

The propensity to cooperate in R&D can be correlated with unobserved factors that are also systematically correlated with some of the explanatory variables. First, concerning demand side factors, I can include managing capacity and quality, the choice of governance mode of R&D activities, the extent to which the firm is open to new ideas, the permeability of the firm, reputation, outward-looking style of management and tacitness of the firm's knowledge assets. For example, it is reasonable to think that the higher the manager's openness to new ideas, the higher the propensity to R&D cooperation. Additionally, the culture of openness to new ideas seems to affect, among others, the use of public sources of information (incoming spillovers) and the manager's risk aversion. Second, as for supply-side factors, I can consider the geographical proximity and the accessibility to an intensive technological area[18]. Third, of supply-demand interaction factors, I can include repeated interactions with the same partner, the length of the cooperation relationship and previous R&D cooperation agreements.

In addition to the omitted variables problem, spillovers, R&D intensity and cost-risk are also expected to be endogenous variables due to a simultaneity problem. Firstly, cooperative R&D agreements can be used to manage external knowledge flows[19], which implies that

[18]These factors can affect R&D cooperation simultaneity and variables such as R&D intensity, incoming spillovers, the effectiveness of strategic protection methods (appropriability) and the accessibility to appropriate sources of finance.

[19]See, for example, Kamien, Müller and Zang (1992).

the decision to cooperate can influence incoming spillovers as well as the effectiveness of appropriation strategies. Secondly, several studies[20] have found evidence supporting the endogeneity of R&D intensity when analyzing the R&D cooperation decision because of simultaneity in the decisions. In this sense, R&D intensity may increase if R&D cooperation makes own R&D expenditures more effective. Finally, when firms use cooperative R&D agreements to share cost and risk, the effects of cooperation can influence the importance given to these variables as obstacles to innovation.

1.4.2. System of simultaneous equations

Due to the endogeneity of a number of variables, I consider a system of simultaneous equations (see Appendix 1.B for details). The model is composed of a structural equation that is of primary interest (the cooperation equation) and a set of reduced form equations for the potential endogenous explanatory variables (incoming spillovers, appropriability, R&D intensity and cost-risk variable). The unobservable propensity to cooperate in R&D (y_1^*) is assumed to be a linear function of a set of observed exogenous explanatory variables ($\mathbf{z}_1$); such as the firm's size and the industry level of legal protection methods, a set of (possible) endogenous explanatory variables ($\mathbf{y}_2$) and an error term (u_1). Let y_1 equal 1 if the firm cooperates.

$$y_1^* = \mathbf{z}_1\boldsymbol{\delta}_1 + \mathbf{y}_2\boldsymbol{\alpha}_1 + u_1 \tag{1.1}$$

$$y_1 = 1\left[y_1^* > 0\right] \tag{1.2}$$

I assume that the endogenous explanatory variables are functions of the exogenous variables that determine cooperation ($\mathbf{z}_1$), a set of other exogenous variables ($\mathbf{z}_2$) and an error term ($\mathbf{v}_2$).

$$\mathbf{y}_2 = \mathbf{z}_1\boldsymbol{\Delta}_{21} + \mathbf{z}_2\boldsymbol{\Delta}_{22} + \mathbf{v}_2 = \mathbf{z}\boldsymbol{\Delta}_2 + \mathbf{v}_2 \tag{1.3}$$

The arguments I presented before suggest that u_1 and $\mathbf{v}_2$ are correlated. The model described by equations (1.1) – (1.3) is applicable when $\mathbf{y}_2$ is correlated with u_1 due to omitted

[20] See, among others, Becker and Dietz (2004), Colombo and Garrone (1996), and Veugelers (1997).

variables and when $\mathbf{y}_2$ is correlated with u_1 because y_2 is determined jointly with y_1 if y_1^* appears in a linear structural equation for $\mathbf{y}_2$[21].

I assume that $u_1$and $\mathbf{v}_2$ have a joint normal distribution with mean zero and finite positive covariance matrix:

$$\mathbf{\Omega} \equiv \begin{bmatrix} \sigma_{u_1}^2 & \mathbf{\Sigma}_{u_1\mathbf{v}_2} \\ \mathbf{\Sigma}_{\mathbf{v}_2 u_1} & \mathbf{\Sigma}_{\mathbf{v}_2\mathbf{v}_2} \end{bmatrix} \tag{1.4}$$

Under joint normality of $(u_1, \mathbf{v}_2)$, I can write.

$$u_1 = \mathbf{v}_2\boldsymbol{\theta}_1 + e_1 \tag{1.5}$$

where $\boldsymbol{\theta}_1 = \mathbf{\Sigma}_{\mathbf{v}_2\mathbf{v}_2}^{-1}\mathbf{\Sigma}_{\mathbf{v}_2 u_1}$

1.4.3. Estimation methods

Once the endogeneity of some variables is recognized, it is clear that the estimation of the model by OLS or other techniques that do not allow for the endogeneity is inappropriate and has important consequences, i.e., in applying OLS, I will not be able to consistently estimate any of the coefficients of equation (1.1). For instance, in the empirical literature, the importance of cost and risk as obstacles to innovation has typically been considered an exogenous determinant for R&D cooperation. However, considering this variable as exogenous, it is hard to reach any broad generalization on the relation between R&D cooperation and cost-risk sharing[22]. Therefore, a proper treatment of endogeneity is necessary to obtain consistent estimates.

[21] In this case, $\mathbf{y}_2$ has the reduced form given by equation (1.3) (for a further discussion of this topic, see Maddala, 1983, Chapter 7; and Wooldridge, 2002, Chapter 15). In my case, notice that the variables used are contemporaneous, so it is plausible to think that the propensity or intention to cooperate (y_1^*), and not the actual action (y_1), should be used as an explanatory variable for $\mathbf{y}_2$.

[22] Miotti and Sachwald (2003) find that sharing costs and risks is not a significant determinant of the probability of R&D cooperation, while Tether (2002) find a positive and significant effect. Moreover, CV find a positive and significant effect of the importance of cost as a hampering factor for the innovation process of the firm, and, at the same time, the importance of risks has a negative and significant effect on R&D cooperation.

Moreover, the fact of considering an explanatory variable to be exogenous or endogenous can yield very different pictures of its importance[23].

Due to its importance, my choice is to apply a complete treatment for the endogeneity problem. Instead of, as in CV, assuming the endogeneity of some explanatory variables and using less efficient two-step procedures to obtain the final estimates, the methods applied in this study allow me, at a slight computational cost, to both test for the endogeneity of some explanatory variables of interest and obtain more efficient estimates. I use maximum likelihood estimation in order to present the final findings, while a two-step approach is used for the initial exogeneity test of some explanatory variables.

Firstly, estimating this model, I use a two-stage conditional maximum likelihood method (2SCML). This approach is due to Rivers and Vuong (1988).[24] A convenient feature of this procedure is that it provides an estimate of $\boldsymbol{\theta}_1$that can be used to test for the endogeneity of $\mathbf{y}_2$. This method is a two-step estimation procedure. In the first step, the (assumed) endogenous variables ($\mathbf{y}_2$) are regressed on all the (assumed) exogenous variables ($\mathbf{z}$). In the second step, the residuals of the first-step regressions ($\widehat{\mathbf{v}}_2$) are used as independent variables in the cooperation equation (joint with $\mathbf{z}_1$and $\mathbf{y}_2$). The usual probit t-statistic of $\widehat{\mathbf{v}}_2$ is a valid test of the null hypothesis that $\mathbf{y}_2$ is exogenous. The Rivers-Vuong approach is used for the initial test of whether $\mathbf{y}_2$ is exogenous[25].

Once the exogeneity of some explanatory variables is tested, the system of equations is estimated by conditional maximum likelihood (CML)[26]. The log likelihood function for an

[23] For example, CV considers the importance of publicly available information sources as endogenous and, using a two-step procedure, find a positive and significant effect of this variable on R&D cooperation. On the other hand, considering public incoming spillovers as exogenous, Belderbos et al. (2004) find no evidence on the effect of this variable on the probability of R&D cooperation.

[24] See Wooldridge (2002) for a recent review of this method.

[25] Note that if $\theta_1 \neq 0$, we have only estimated the coefficients up to scale.

[26] The CML estimator is a full-information maximum likelihood estimator. It is based on the entire system of equations, treats all equations and parameters jointly and gives direct estimates of the coefficients. System methods of estimation (CML) are preferred to and asymptotically better than limited information methods, or single-equation methods (2SCML), since the latter neglect information contained in other equations while the former bring efficiency gains. Moreover, the use of full information or system methods in model

individual in this model is (see Appendix B for details).

$$\log L = y_{i1} \log \mathbf{\Phi} \left(\frac{\mathbf{z}_{i1}\boldsymbol{\delta}_1 + \mathbf{y}_{i2}\boldsymbol{\alpha}_1 + (\mathbf{y}_{i2} - \mathbf{z}_i\mathbf{\Delta}_2)\,\boldsymbol{\theta}_1}{\left(1 - \boldsymbol{\theta}_1^{\prime}\mathbf{\Sigma}_{\mathbf{v}_2\mathbf{v}_2}\boldsymbol{\theta}_1\right)^{\frac{1}{2}}} \right) \tag{1.6}$$

$$+(1 - y_{i1}) \log \left[1 - \mathbf{\Phi} \left(\frac{\mathbf{z}_{i1}\boldsymbol{\delta}_1 + \mathbf{y}_{i2}\boldsymbol{\alpha}_1 + (\mathbf{y}_{i2} - \mathbf{z}_i\mathbf{\Delta}_2)\,\boldsymbol{\theta}_1}{\left(1 - \boldsymbol{\theta}_1^{\prime}\mathbf{\Sigma}_{\mathbf{v}_2\mathbf{v}_2}\boldsymbol{\theta}_1\right)^{\frac{1}{2}}} \right) \right]$$

$$-\frac{m}{2}\log(2\pi) - \frac{1}{2}\log|\mathbf{\Sigma}_{\mathbf{v}_2\mathbf{v}_2}| - \frac{1}{2}\left[(\mathbf{y}_{i2} - \mathbf{z}_i\mathbf{\Delta}_2)\,\mathbf{\Sigma}_{\mathbf{v}_2\mathbf{v}_2}^{-1}\,(\mathbf{y}_{i2} - \mathbf{z}_i\mathbf{\Delta}_2)^{\prime} \right]$$

1.4.4. Identification strategy and identification assumptions

The specification described above requires a set of variables ($\mathbf{z}_2$ in the notation I have been using) that are exogenous determinants of the endogenous explanatory variables but that are not determinants of the probability of cooperation. I have included in $\mathbf{z}_2$ the basicness of R&D, export intensity, industry level of incoming spillovers, industry level of appropriability, industry level of R&D intensity and industry level of cost-risk. In what follows, I define these variables, and I present the economic intuition behind these exclusion restrictions and the cases when they are included.

Kamien and Zang (2000) propose a model in which the benefit that firms obtain from incoming spillovers depends on their own R&D approach. Firms with a basic R&D approach are more likely to benefit from incoming spillovers. Following this argument, one can expect that the more basic the R&D is, the higher the score on incoming spillovers will be. The basicness of R&D is approximated by the importance of information from universities and research institutes for the innovation process. When incoming spillovers are considered an endogenous variable, basicness of R&D is included in $\mathbf{z}_2$.

The strategic protection variable can be influenced by the competitive environment of the firm. Export intensity is used as a measure of the competitive environment of the firm. The underlying premise is that competition is higher in international markets than in domestic ones, and only the most productive firms are able to make positive profits from exporting, and so there is self-selection into these markets (see Melitz, 2003). The export market is

estimation makes use of the cross-equation correlations of the disturbances.

one of substantial dynamism and exports are an important driver of firm performance (see Bernard and Jensen, 1999). So, the higher the export intensity, the higher the competition. When appropriability is considered an endogenous variable, export intensity is included in $\mathbf{z}_2$.

Also included in $\mathbf{z}_2$ as exclusion restrictions are industry-level measures (at the 2-digit NACE level) of the potentially endogenous variables[27]. These 2-digit NACE level variables are intended to capture the effect of unobserved industry-specific attributes on the corresponding potentially endogenous firm-specific variable.

The relevance and validity of these instruments are discussed in the next section.

1.5. Results

In this section, the basic model of cooperation is estimated, and the endogeneity of some explanatory variables and the relevance and validity of the instruments are tested. Once a "structure" of endogeneity is determined, the importance of different motives for participating in cooperative R&D is discussed without distinguishing the type of partner. Next, separate models for cooperation with competitors, cooperation with suppliers or customers, and cooperation with research institutions are estimated. Before this, Table 1.6 gives descriptive statistics on the main variables. As expected, most of the mean values are higher for cooperating than for non-cooperating firms.

1.5.1. Dealing with endogeneity

Table 1.7 shows the estimated coefficients of the independent variables for probit models. Standard errors are estimated for these coefficients. Regression *a* ignores endogeneity and shows the results of a one-step probit model (single-equation probit), regressions *b* to *d* show the results of 2SCML estimations, while regression *e* shows the results of CML estimation.

[27] The idea of using industry levels as instruments is conventional in microeconometric literature (see, for example, Pakes, 1983).

Table 1.6. Descriptive Statistics[1]

	Sample Mean	Mean non-cooperating Firms	Mean Cooperating Firms	Mean Cooperation with Competitors	Mean Cooperation with Suppliers or Customers	Mean Cooperation with Research Institutions
	(N=2518)	(N=2042)	(N=476)	(N=184)	(N=316)	(N=425)
Incoming Spillovers	0.438	0.427	0.485***	0.515***	0.508***	0.490***
	(0.310)	(0.310)	(0.307)	(0.299)	(0.304)	(0.305)
Appropriability	0.214	0.186	0.335***	0.363***	0.374***	0.349***
	(0.316)	(0.298)	(0.362)	(0.366)	(0.366)	(0.363)
Industry Level Legal Protection	0.131	0.129	0.137***	0.139***	0.137***	0.137***
	(0.040)	(0.040)	(0.039)	(0.039)	(0.039)	(0.039)
Size	1.930	1.845	2.298***	2.385***	2.341***	2.329***
	(0.577)	(0.547)	(0.556)	(0.600)	(0.573)	(0.543)
Cost-Risk	0.477	0.468	0.515***	0.553***	0.538***	0.517***
	(0.317)	(0.322)	(0.291)	(0.278)	(0.282)	(0.288)
Complementarities	0.689	0.694	0.666	0.663	0.674	0.665
	(0.322)	(0.327)	(0.298)	(0.295)	(0.289)	(0.297)
R&D intensity	0.016	0.012	0.035***	0.055***	0.042***	0.036***
	(0.118)	(0.038)	(0.259)	(0.414)	(0.317)	(0.274)

***difference in means between cooperating and non-cooperating firms significant at 1%, **significant at 5%, *significant at 10%

We test the null hypothesis of equality of two means. Under the null hypothesis, the quantity $T = \frac{\sqrt{\frac{n_1 n_2}{n_1+n_2}}(\overline{X}_1 - \overline{X}_2)}{\sqrt{\sigma_1^2 \frac{n_1}{n_1+n_2-2} + \sigma_2^2 \frac{n_2}{n_1+n_2-2}}}$ has the distribution t with $n_1 + n_2$ degrees of freedom, where n_i, $\overline{X}_i$, and σ_i^2 (i=1, 2) are the number of observations from the sample of population i; the mean of the variable from the sample of population i; and the variance from the sample of population i, respectively

[1]standard deviations in parenthesis

Testing the endogeneity

Three different "structures" of endogeneity are considered a priori. Firstly, and following CV, regression b shows the 2SCML estimations considering incoming spillovers, appropriability and R&D intensity to be endogenous variables. Coefficients accompanying residuals of first-step regressions for incoming spillovers and appropriability are significant. Hence, exogeneity of these two variables is rejected. Meanwhile, the exogeneity of R&D intensity cannot be rejected.

Secondly, in regression c, I also consider cost-risk an endogenous variable. Again, I reject the exogeneity of incoming spillovers and appropriability, while the exogeneity of R&D intensity cannot be rejected. The exogeneity of cost-risk is rejected.

Finally, and due to the previous results, in regression d I consider incoming spillovers, appropriability and cost-risk to be endogenous variables. Consistent with the previous findings, the exogeneity of these three variables is rejected.

Note that, when estimating the model by the CML exogeneity of incoming spillovers, appropriability and cost-risk are also rejected (see regression e). This is the preferred "structure" of endogeneity and the one used to obtain the marginal effects.

Does the "structure" of endogeneity matter?

The "structure" of endogeneity is crucial and has important consequences for the significance and sign of the estimated coefficients.

Firstly, considering cost-risk to be an endogenous variable has an important effect on its sign. When it is "correctly" considered to be an endogenous variable, I find that it has a positive and significant effect (see regressions c, d and e), while, this variable presents a negative and significant effect when it is taken as exogenous (see regression b). Additionally, the sign of the variable complementarities seems to depend on the endogeneity of cost-risk. It has a positive and significant effect if cost-risk is "correctly" considered to be an endogenous variable (see regressions c, d and e), while it shows a negative and significant effect when the endogeneity of cost-risk is not taken into account (see regressions a and b).

Secondly, the character of R&D intensity also seems to affect the results. When it is

Table 1.7. Results of Regressions for Cooperation. Testing the Endogeneity[1]

	(*a*) Cooperation (Single-Eq. Probit)	(*b*) Cooperation (2SCML)	(*c*) Cooperation (2SCML)	(*d*) Cooperation (2SCML)	(*e*) Cooperation (CML)
Constant	-4.524^{***}	-4.621^{***}	-7.366^{***}	-7.609^{***}	-3.849^{***}
	(0.406)	(0.505)	(1.162)	(1.197)	(0.473)
Incoming Spillovers	0.217^{**}	2.662^{***}	1.822^{***}	2.124^{***}	0.717^{*}
	(0.109)	(0.518)	(0.576)	(0.504)	(0.386)
Appropriability	0.432^{***}	3.081^{***}	2.671^{***}	2.875^{***}	1.319^{***}
	(0.096)	(0.746)	(0.770)	(0.731)	(0.473)
Ind. Level Legal Protection	0.075	-4.016^{***}	-3.323^{***}	-2.977^{***}	-1.281^{**}
	(0.860)	(1.038)	(1.075)	(1.039)	(0.650)
R&D Intensity	3.136^{***}	6.558	6.407	2.039^{***}	0.873
	(0.814)	(4.343)	(4.178)	(0.720)	(0.614)
Size	1.989^{***}	1.510^{***}	1.974^{***}	1.886^{***}	0.888^{***}
	(0.326)	(0.378)	(0.412)	(0.408)	(0.284)
Size squared	-0.287^{***}	-0.219^{***}	-0.289^{***}	-0.279^{***}	-0.132^{**}
	(0.072)	(0.077)	(0.081)	(0.082)	(0.062)
Cost-Risk	0.293^{**}	-0.572^{***}	2.749^{**}	2.903^{**}	1.953^{***}
	(0.116)	(0.139)	(1.266)	(1.318)	(0.553)
Complementarities	-0.220^{**}	-0.242^{*}	1.094^{**}	1.220^{**}	0.817^{***}
	(0.111)	(0.132)	(0.521)	(0.539)	(0.224)
Ind. Level Cooperation	2.887^{***}	2.599^{***}	2.520^{***}	2.850^{***}	1.209^{***}
	(0.321)	(0.492)	(0.470)	(0.363)	(0.283)
$\theta_{\text{incoming spillovers}}$	–	-2.958^{***}	-2.117^{***}	-2.418^{***}	-0.848^{**}
		(0.535)	(0.591)	(0.522)	(0.405)
$\theta_{\text{appropriability}}$	–	-2.774^{***}	-2.358^{***}	-2.561^{***}	-1.184^{**}
		(0.751)	(0.775)	(0.736)	(0.417)
$\theta_{\text{R\&D intensity}}$	–	−4.280	−4.127	–	–
		(4.375)	(4.209)		
$\theta_{\text{cost-risk}}$	–	–	-2.578^{**}	-2.736^{**}	-1.883^{***}
			(1.269)	(1.321)	(0.564)
LL	−998.411	−895.287	−891.401	−891.867	−2217.254
χ^2	332.41^{***}	449.63^{***}	459.81^{***}	451.53^{***}	–
N	2518	2518	2518	2518	2518

***significant at 1%, **significant at 5%, *significant at 10%

[1]standard errors between brackets.

"correctly" considered to be an exogenous variable, I find that it has a positive and significant effect on the probability of cooperation (see regression d), while this variable loses its significance when it is considered to be endogenous (see regressions b and c).

Also, the sign and significance of the industry level of legal protection depend on considering the endogeneity problem. The single-equation probit is the only case where this variable is not significant, while the other estimates show a negative and significant effect.

Finally, and fortunately, the character of cost-risk and R&D intensity does not seem to affect the sign and significance of incoming spillovers and appropriability (compare regressions b, c, d and e).

Testing the relevance and validity of instruments

A plausible instrument must satisfy two conditions: relevance and validity. The relevance condition can be tested by examining the results of the first-step regressions. Table 1.A1 (see Appendix 1.C) shows the first-step regressions from which the residuals of incoming spillovers, appropriability and cost-risk for regression d in Table 1.7 have been obtained. As expected, each instrument is significant in the first-step regression in question. The F tests for joint significance of the exclusion restrictions in the first-step regression for incoming spillovers, appropriability and cost-risk are, respectively, 66.57, 16.40 and 13.87, which allows me to reject the null hypothesis.

In addition, Table 1.A1 shows two different R^2 as measures of the relevancy of instruments, i.e., the partial R^2 (R_p^2) and the corrected partial R^2 ($\overline{R}_p^2$)[28]. For the appropriability and the cost-risk regressions, our estimations yield larger values for $\overline{R}_p^2$ than for R_p^2. In the case of incoming spillovers regression, R_p^2 is slightly greater than $\overline{R}_p^2$. Showing these results, I can conclude that the instruments have enough relevance to explain all the endogenous regressors.[29]

In my estimation framework, testing the orthogonality condition is more problematic.

[28] The R_p^2 (see, for example Bound, Jaeger and Baker, 1995) is the R^2 of the first-step regressions with the included instruments partialled out (note that equations (1.1) and (1.3) include common exogenous variables). The $\overline{R}_p^2$, proposed by Shea (1997) takes the correlations among the instruments into account.

[29] See Baum, Schaffer and Stillman (2003) for a comparative interpretation of R_p^2 and $\overline{R}_p^2$.

The usual tests of overidentifying restrictions applied in IV or GMM estimation are not valid in a probit estimation framework. To test the orthogonality condition, a regression of the generalized residuals obtained from estimate d in Table 1.7 on the exclusion restrictions is shown in Table 1.A2 (see Appendix 1.C). Only the industry level of cost-risk is weakly significant (with an associated t-ratio equal to 1.64). This regression gives some faith in the instruments used. However, the validity of this regression for testing the orthogonality condition is not conclusive, and other tentative "experiments" have not been so optimistic[30].

I assume that it is difficult to find perfectly exogenous instruments within the CIS, where every question is closely related and, moreover, cross-section data is used. In what follows, and taking this caveat into account and having found some evidence about the orthogonality of the instruments, I will assume the validity of the instruments and the results obtained will be conditional on this assumption.

Additionally, two arguments are in my favor. Firstly, when the instruments used are not perfectly exogenous, the inconsistency of IV estimates depends on the relevance of the instruments[31]. The lower the relevance, the higher the inconsistency. And thus, the high relevance of my instruments can mitigate the inconsistency with not-perfectly exogenous instruments. Secondly, assuming the existence of invalid instruments, Hahn and Hausman (2005) find that the 2SLS has a smaller finite sample bias and MSE than the OLS under a wide range of conditions. So, in such a context of not-perfectly exogenous instruments, the 2SLS does better than the OLS in many cases[32].

[30] Considering the case of a linear probability model, the Sargan test of overidentifying restrictions rejects the joint null hypothesis of correct model specification and the validity of the overall set of instruments.

[31] See, for example, Buse (1992); Hall, Rudebusch and Wilcox (1996); Nelson and Startz (1990a, 1990b); and Staiger and Stock (1997) for the study of the consequences of low relevance of instruments in an instrumental variables estimation context.

[32] The conditions under which the 2SLS is still preferred to the OLS are derived for a linear model with one endogenous variable, and I cannot check them in my framework.

1.5.2. Determinants of cooperation

Table 1.8 shows the impact of the explanatory variables considered throughout this study on the probability of R&D cooperation. Regression *a* pays no attention to endogeneity problems, while regressions *b* and *c* estimate the model by 2SCML and CML respectively, considering incoming spillovers, appropriability and cost-risk to be endogenous variables. The preferred outcome is estimate *c*. Estimates *a* and *b* are used for checking the importance of the estimation method on the results. I find that the overall picture of the importance of the explanatory variables depends on the estimation method. In this sense, two-step procedures overestimate the importance of spillovers.

I can conclude that incoming spillovers and appropriability have a positive and significant impact on the probability of cooperation, although the impact of the effectiveness of strategic methods is almost double. In the first place, the higher incoming spillovers are, the greater the scope for learning within cooperative R&D agreements, and hence the marginal profit to be derived from cooperation. Secondly, the more effective strategic protection is, the better firms control the outflow of commercially sensitive information, and the more likely they are to engage in cooperative agreements. Fortunately, the sign and significance of these variables do not depend on the estimation method, but the magnitudes clearly vary according to the method. Above all, 2SCML and CML yield very different pictures of the impact of incoming spillovers on R&D cooperation.

It seems that the industry level of legal protection has a negative effect on R&D cooperation. A high level of legal protection methods in an industry may hamper the internalization of information flows between firms through cooperation in R&D, and hence their negative effect on this kind of practice. Taking this together with the findings on appropriability, it may be that cooperative activity is a method of internalizing outgoing knowledge flows in industries where legal protection methods are weak, and for firms for whom more strategic methods of appropriating returns are more important.

Cost-risk sharing is the most important determinant for cooperation[33]. This variable

[33] This fact is clear when estimating by CML (see regression *c*). 2SCML estimation does not yield a

Table 1.8. Results of Regressions for Cooperation. Marginal Effects[1]

	(*a*) Cooperation (Single-Eq. Probit)	(*b*) Cooperation (2SCML)	(*c*) Cooperation (CML)
Incoming Spillovers	0.049**	0.440***	0.252*
	(0.024)	(0.106)	(0.130)
Appropriability	0.097***	0.596***	0.464***
	(0.021)	(0.150)	(0.164)
Ind. Level Legal Protection	0.016	−0.617***	−0.451**
	(0.194)	(0.216)	(0.226)
R&D Intensity	0.709***	0.423***	0.307
	(0.186)	(0.150)	(0.213)
Size	0.450***	0.391***	0.312***
	(0.071)	(0.082)	(0.098)
Size squared	−0.064***	−0.057***	−0.046**
	(0.015)	(0.016)	(0.022)
Cost-Risk	0.066**	0.602**	0.687***
	(0.026)	(0.273)	(0.213)
Complementarities	−0.049**	0.253**	0.288***
	(0.025)	(0.111)	(0.086)
Ind. Level Cooperation	0.653***	0.591***	0.425***
	(0.071)	(0.109)	(0.090)
LL	−998.411	−891.867	−2217.254
χ^2	332.41***	451.53***	–
N	2518	2518	2518

***significant at 1%, **significant at 5%, *significant at 10%

[1]standard errors between brackets. The coefficients are the marginal effect of the independent variable on the probability of cooperation, ceteris paribus.

has the greatest impact on the probability of cooperation (with a marginal effect equal to 0.687). This fact possibly stresses the lack of external private finance for innovative activity and the lack of venture capital investment, which is particularly true in Spain.

The effect of firm size is positive and significant, with evidence of a concave relation. In this case, the estimated marginal effect is similar among the estimation methods.

The hypothesis that firms with a higher availability of technological know-how are more likely to cooperate is confirmed. Finally, R&D intensity seems to lose significance when estimating by CML (the associated t-ratio is 1.42).

1.5.3. Determinants of cooperation with different types of partners

As shown in Section 1.2, most firms in the sample maintain agreements with different partners. For example, it is important to take into account that when I am analyzing the subsample of firms that cooperate with research institutions, I am considering almost the whole sample of cooperating firms.

Table 1.9 presents the marginal effects for CML estimations of separate models for cooperation with different types of partners. I consider incoming spillovers, appropriability and cost-risk to be endogenous variables[34].

The effectiveness of strategic protection has a significant and positive effect on cooperation with the three types of partners. The higher the control over the information flows out of the firm (through strategic protection methods), the higher the probability of cooperation with any type of partner. Moreover, apart from the level of cooperation in the industry, appropriability is the most important determinant for cooperation with competitors. Only

clear picture about the importance of the determinants for R&D cooperation. When estimating by 2SCML, appropriability, cost-risk and industry level of cooperation have impacts around 0.6 (see regression *b*).

[34] Table 1.A3 (see Appendix 1.C) shows the tests for endogeneity. In some cases, I find only weak evidence for endogeneity of incoming spillovers and appropriability. However, for consistency, I still consider these variables endogenous. Note that, when analyzing the pooled cooperation decision, the exogeneity of R&D intensity is not rejected with an estimated coefficient accompanying residuals of the first-step regression for R&D intensity smaller than its estimated standard error (see regressions *b* and *c* in Table 1.7).

Table 1.9. Results of Regressions for Cooperation with different types of partners. Marginal Effects[1]

	(*a*) Cooperation with Competitors (CML)	(*b*) Cooperation with Suppliers or Customers (CML)	(*c*) Cooperation with Research Institutions (CML)
Incoming Spillovers	0.145	0.152	0.219*
	(0.096)	(0.117)	(0.131)
Appropriability	0.247*	0.445***	0.485***
	(0.140)	(0.150)	(0.161)
Ind. Level Legal Protection	−0.186	−0.347	−0.437*
	(0.211)	(0.220)	(0.226)
R&D Intensity	0.213	0.327*	0.180
	(0.200)	(0.188)	(0.177)
Size	0.163*	0.239***	0.331***
	(0.087)	(0.092)	(0.097)
Size squared	0.017	−0.031	−0.052**
	(0.018)	(0.020)	(0.021)
Cost-Risk	0.414	0.591**	0.740***
	(0.278)	(0.241)	(0.200)
Complementarities	0.154	0.249**	0.315***
	(0.116)	(0.099)	(0.081)
Ind. Level of Cooperation with Competitors	0.587***	–	–
	(0.120)		
Ind. Level of Cooperation with Suppliers or Customers	–	0.438***	–
		(0.111)	
Ind. Level of Cooperation with Research Institutions	–	–	0.398***
			(0.099)
LL	−1848.246	−2062.711	−2114.616
N	2518	2518	2518

***significant at 1%, **significant at 5%, *significant at 10%

[1]standard errors between brackets. The coefficients are the marginal effect of the independent variable on the probability of cooperation, ceteris paribus.

la imitación de tecnologías.

El bajo crecimiento económico en la UE durante las últimas décadas es síntoma de su fracaso en transformarse en una economía sustentada en la innovación. Un sistema construido en base a la asimilación de tecnologías existentes, la producción en masa y una estructura industrial dominada por empresas grandes no encaja en el mundo de hoy, caracterizado por la globalización económica y por una fuerte competencia internacional (Sapir et al. (2003)).

Los países europeos necesitan orientarse hacia un crecimiento basado en la innovación. La innovación afecta al funcionamiento y resultados de las empresas a través de una variedad de canales, que van desde los efectos de la innovación sobre ventas y cuotas de mercado a los cambios en la productividad y eficiencia de las empresas. Además, la innovación tiene otros efectos importantes a nivel industrial y nacional tales como: cambios en la competitividad internacional y en la productividad total de los factores, la aparición de flujos de información derivados de las innovaciones empresariales y el incremento de flujos de conocimiento a través de las redes.

Tanto académicos como responsables de política económica han remarcado la importancia de la inversión en Investigación y Desarrollo (I+D) como motor de crecimiento de la productividad de largo plazo. En relación con la literatura académica sobre este tema, desde Griliches (1979), muchos estudios empíricos se han centrado en la relación entre I+D y productividad[82], y en el papel de las innovaciones tecnológicas de proceso y de producto como impulsores de la productividad[83]. En respuesta a estas inquietudes, la UE se ha fijado el objetivo de aumentar el gasto en I+D hasta el 3% del PIB antes de 2010 (este objetivo es parte de la "Estrategia de Lisboa").

Sin embargo, es necesario un marco más amplio que aquél en el que sólo se considera la innovación de producto y de proceso. En este sentido, la tercera edición del Manual de Oslo (OCDE, 2005) amplía la definición de la innovación para incluir, además de la innovación de producto y de proceso, dos tipos adicionales de innovación: (i) la innovación

[82] Griliches (1995) contiene una revisión de esta literatura.

[83] Por ejemplo, Crépon et al. (1998) proponen un modelo estructural para analizar la relación entre gastos en I+D, innovación y productividad.

organizativa y (ii) la innovación de la comercialización. Considerando estos dos tipos de innovación, se obtiene un marco más completo para tener en cuenta de forma más precisa los cambios que afectan al funcionamiento de las empresas y que contribuyen a la acumulación de conocimiento.

El tercer capítulo de esta tesis contribuye a la literatura que estudia la relación entre innovación y productividad analizando el efecto que la innovación organizativa tiene sobre la productividad. Una innovación organizativa (véase OCDE, 2005) es la puesta en práctica de un nuevo método de organización. Éstos pueden ser: (i) cambios en las prácticas empresariales (por ejemplo, sistemas de gestión de los conocimientos nuevos o mejorados de manera significativa), (ii) cambios en la organización del trabajo dentro de la empresa (por ejemplo, la puesta en práctica de métodos nuevos para distribuir responsabilidades y la autonomía en la toma de decisiones por parte de los trabajadores), o (iii) cambios en las relaciones con el exterior (es decir, la puesta en práctica de maneras nuevas de organizar las relaciones con otras empresas o instituciones públicas).

Los cambios en los métodos de organización pueden mejorar la eficiencia y la calidad de las actividades de las empresas, y de este modo pueden incrementar la demanda y reducir los costes. Hay un número cada vez mayor de estudios que sugieren un efecto significativo y positivo de diversos tipos de innovación organizativa en la productividad. Por ejemplo, Black y Lynch (2004) aportan uno de los resultados más significativos sobre la relación entre innovación organizativa y crecimiento. Estos autores encuentran que el 30% del crecimiento del output en el sector manufacturero de EEUU durante el período 1993-1996 se debió a prácticas organizativas.

El tercer capítulo se centra en el papel de uno de los métodos organizativos más relevantes, el outsourcing (externalización o subcontratación). En este sentido, la tercera edición del Manual de Oslo (OCDE, 2005) considera la "externalización o subcontratación de actividades económicas de producción, distribución, contratación de personal y contratación de servicios" un método nuevo de organización en las relaciones exteriores de las empresas.

A.2. Objetivos y metodología

Tal y como se dijo en la introducción, el objetivo de esta tesis es el estudio de dos de los temas de investigación más relevantes relacionados con la Economía de la Innovación: (i) la cooperación en actividades de innovación, y (ii) la relación entre innovación y productividad.

En concreto, el objetivo de la primera línea de investigación es el estudio empírico de los determinantes de la cooperación en actividades de innovación. El primer capítulo de la tesis se centra en el estudio de estos determinantes en el caso de las empresas manufactureras españolas, mientras que el segundo capítulo realiza una comparación internacional de dichos determinantes utilizando datos de Alemania, España, Francia y Reino Unido. En ambos capítulos se utilizan datos procedentes de la Community Innovation Survey (CIS).

La segunda línea de investigación (tercer capítulo de la tesis) se centra en el análisis del impacto de una de las innovaciones organizativas más relevantes, el outsourcing, sobre la productividad a nivel de empresa. En este caso se utilizan datos de la Encuesta sobre Estrategias Empresariales (ESEE).

Antes de resumir los objetivos y metodología de cada uno de los capítulos se realiza una breve descripción de las bases de datos utilizadas.

A.2.1. Bases de datos utilizadas

Community Innovation Survey (CIS)

Los datos utilizados en los dos primeros capítulos corresponden a la tercera oleada de la Community Innovation Survey (CIS) que tuvo lugar en el año 2001.

La CIS se realiza cada cuatro años y tiene como objetivo estudiar las actividades innovadoras de los países europeos. La encuesta se realiza siguiendo las directrices metodológicas definidas en el Manual de Oslo de la OCDE y su contenido está armonizado entre los diferentes países europeos, lo que permite la comparabilidad internacional.

Esta encuesta facilita información a nivel de empresa sobre la estructura del proceso de innovación (I+D y otras actividades innovadoras) y permite mostrar la relación entre dicho proceso y la estrategia tecnológica de las empresas, los factores que influyen en su capacidad para innovar y el rendimiento económico de la empresa.

La información que contiene se refiere a adquisición de nuevas tecnologías, innovaciones tecnológicas, actividades de I+D, gastos en innovación, regionalización de los gastos de innovación, impacto económico de la innovación tecnológica, objetivos de la actividad innovadora, fuentes de ideas innovadoras, obstáculos a la innovación y otras innovaciones no tecnológicas.

La encuesta va dirigida a empresas industriales, de la construcción y de los servicios de diez o más asalariados, cuya actividad económica principal se corresponde con las secciones C a la O de la Clasificación Nacional de Actividades Económicas de 1993 Rev 1.

En España, la CIS toma le nombre de Encuesta sobre Innovación Tecnológica en las Empresas y es realizada por el INE.

Encuesta sobre Estrategias Empresariales (ESEE)

En el tercer capítulo se utilizan datos procedentes de la Encuesta sobre Estrategias Empresariales (ESEE).

La ESEE es una encuesta de panel a empresas industriales manufactureras que, iniciada con los datos correspondientes a 1990, se ha venido realizando hasta la actualidad. Esta encuesta fue diseñada por el Programa de Investigaciones Económicas (PIE) de la Fundación Empresa Pública (FEP). En la actualidad es cofinanciada por el Ministerio de Industria, Turismo y Comercio y por la Fundación SEPI.

La ESEE se basa en una muestra dinámicamente representativa (articulada en dos grandes submuestras, empresas con más y menos de 200 trabajadores), a la que se ha investigado en un conjunto amplio de aspectos relacionados con temas de economía industrial (incluyendo las actividades innovadoras)[84]. La selección inicial de empresas se realizó combinando criterios de exhaustividad y de muestreo aleatorio. En el primer grupo se incluyeron las empresas de más de 200 trabajadores, a las que se requirió su participación. El segundo grupo quedó formado por las empresas con empleo comprendido entre 10 y 200 trabajadores, que fueron

[84] Una descripción detallada de esta encuesta se encuentra en Fariñas y Jaumandreu (1999).

seleccionadas por muestreo estratificado, proporcional con restricciones y sistemático con arranque aleatorio.

En cuanto a su contenido, la ESEE está orientada a recoger información sobre las estrategias de las empresas, es decir sobre aquellas decisiones que adoptan en relación a los instrumentos de competencia a su alcance. De una forma general, podemos clasificar la información que proporciona la ESEE en los siguientes apartados: (i) Actividad de la empresa, productos y procesos de fabricación, (ii) Clientes y proveedores, (iii) Costes y precios, (iv) Mercados, (v) Actividades tecnológicas, (vi) Comercio exterior, (vii) Empleo y (viii) Datos contables.

A.2.2. Objetivos y metodología en el estudio de los determinantes de la cooperación en I+D: El caso de las empresas manufactureras españolas

En comparación con el resto de países europeos, el sistema español de innovación está en una fase de desarrollo menos avanzada. En un estudio reciente de Abramovsky et al. (2004), en el que se comparan las actividades y resultados de la innovación para Alemania, España, Francia y Reino Unido utilizando datos de la tercera oleada de la Community Innovation Survey (CIS3), se pone de manifiesto que España presenta el menor porcentaje de empresas con gastos en innovación. Esta diferencia es especialmente importante en el caso de los gastos de I+D interna. Además, la intensidad en I+D (ratio de los gastos en I+D interna sobre cifra de negocios de la empresa) en España es, aproximadamente, un tercio del esfuerzo en Alemania, Francia o Reino Unido, y esta diferencia es sistemáticamente mayor en los sectores intensivos en tecnología. Igualmente, España presenta la menor proporción de empresas con acuerdos de cooperación en actividades de innovación.

Este diferencial en el desarrollo de las actividades innovación hace aún más interesante el estudio del fenómeno de la cooperación en innovación para el caso español. El fomento de las actividades de cooperación, dado su carácter de catalizador de la innovación, puede ser un instrumento útil y, por tanto, necesario en la convergencia de España con la media europea.

El objetivo concreto de este capítulo es el estudio empírico de los determinantes de la cooperación en actividades de I+D utilizando datos de empresas españolas. El trabajo se centra en el estudio de la importancia sobre la propensión a cooperar de factores tales como: los flujos de información o "spillovers", la capacidad de absorción de la empresa, el reparto de costes y riesgo entre los socios del acuerdo, el intercambio de conocimientos, etc.

Como se dijo anteriormente, se utilizan datos de la Encuesta sobre Innovación Tecnológica en las Empresas del año 2001.

En este estudio se aplican técnicas microeconométricas que permiten hacer tests sobre la posible endogeneidad de variables explicativas que en otros estudios son consideradas endógenas a priori. Concretamente, se aplica un método de estimación máximo verosímil condicional que tiene en cuenta los posibles problemas de endogeneidad.

A.2.3. Objetivos y metodología en el estudio de los determinantes de la cooperación en actividades de innovación: Evidencia para cuatro países europeos

Este segundo capítulo analiza la cooperación en actividades de innovación en cuatro países europeos, Francia, Alemania, España y Reino Unido. Una vez más la fuente de los datos es la Community Innovation Survey, lo que permite comparar los resultados obtenidos entre los diferentes países. En concreto, se utilizan datos de la tercera edición de la CIS (año 2001).

En este capítulo se examina, entre otros, el papel de los flujos de conocimiento, el reparto de costes y riesgo, y la importancia de las ayuda públicas en la decisión de establecer acuerdos de cooperación en actividades de innovación. En este estudio se utilizan datos tanto de empresas manufactureras como de servicios.

El problema de endogeneidad de alguna de las variables explicativas es tratado aplicando un método de estimación en dos etapas.

A.2.4. Objetivos y metodología en el estudio del impacto del outsourcing en la productividad

El tercer capítulo analiza la relación entre innovación organizativa y productividad. En concreto, el estudio se centra en el papel de una de las innovaciones organizativas más relevantes, el outsourcing. El outsourcing implica la modificación de la "frontera" de la empresa y debe considerarse como un fenómeno de innovación organizativa cuya finalidad última es incrementar la flexibilidad y eficiencia de las empresas. Específicamente, este capítulo se centra en el outsourcing a nivel de empresa y en el papel de la subcontratación de la producción (compras a terceros de productos terminados o componentes a medida para la empresa).

Para realizar este análisis, se desarrolla y estima un marco teórico sencillo que justifica la incorporación de medidas de outsourcing a la especificación de una función de producción "tradicional". Este marco implica la estimación de una función de producción dependiendo de los inputs tradicionales (trabajo, capital y materiales) y de un índice de subcontratación de la producción.

La estimación de dicha función de producción se lleva a cabo teniendo en cuenta la existencia de variables endógenas y predeterminadas. Para ello se aplica el Método Generalizado de Momentos, GMM (ver Arellano y Bond (1991) para una descripción de este método).

Este marco teórico sencillo tiene algunas limitaciones que son tratadas en la última parte del capítulo. En este sentido, el tercer capítulo finaliza con una primera tentativa de modelizar y estimar un marco más estructural en el que se especifica una función de producción considerando la posibilidad de la subcontratación de la producción. Este marco permite identificar dos "usos" para el trabajo (trabajo usado "directamente" en la producción de bien final y el trabajo usado en la producción de un input intermedio). En este caso la ecuación relevante a estimar presenta restricciones no lineales en los parámetros, por lo que en la estimación se utiliza GMM no lineal.

A.3. Aportaciones y resultados principales

A.3.1. Determinantes de la cooperación en I+D: Evidencia para las empresas manufactureras españolas

Aportaciones

En primer lugar, este trabajo pone de manifiesto que un tratamiento riguroso de la endogeneidad tiene una gran importancia. El método de estimación utilizado permite hacer tests de endogeneidad sobre variables explicativas que en otros estudios se asumen endógenas a priori. Se obtiene que la elección de una "estructura apropiada" de endogeneidad es crucial y tiene consecuencias importantes para las estimaciones.

En segundo lugar, la muestra de empresas utilizada es muy interesante. Por una parte, se utiliza una muestra amplia compuesta por 2.518 empresas. Este tamaño muestral permite obtener estimaciones precisas y tests de hipótesis fiables. Por otra parte, tal y como se dijo anteriormente, el sistema español de innovación está en una fase de desarrollo menos avanzada comparado con la mayoría de los países europeos. Debido a que la cooperación en actividades en I+D es una práctica útil para mejorar el funcionamiento de la innovación empresarial, este diferencial respecto al resto de países europeos hace aún más interesante el estudio de los factores que estimulan la cooperación en este tipo de actividades. Además, el sector manufacturero español está compuesto mayoritariamente por empresas pequeñas de sectores poco intensivos en tecnología. En general, los estudios demuestran que las empresas grandes y en sectores de tecnología alta presentan una mayor propensión a cooperar en actividades de I+D, y por lo tanto es de gran interés estudiar este tipo de cooperación en un contexto como el español, caracterizado por la existencia de empresas pequeñas y de sectores poco intensivos en tecnología.

Resultados principales

Los resultados principales que se obtienen son los siguientes:

i) Los "spillovers" recibidos[85] tienen un efecto positivo en la probabilidad de cooperar. En este sentido, cuanto mayor sea la información libremente disponible para la empresa, mayores son los beneficios que se pueden explotar a través de acuerdos de cooperación.

ii) La apropiabilidad a nivel de empresa tiene un efecto positivo en la propensión a cooperar. Cuanto mayor sea el control a través de métodos estratégicos de protección[86] de los flujos de información por parte de la empresa, mayor es la propensión a cooperar (la eficacia de los métodos estratégicos de protección disminuye el riesgo de comportamientos oportunistas por parte de otras empresas). Sin embargo, el nivel de eficacia de los métodos legales[87] a nivel industria parece tener un efecto negativo sobre la cooperación. En este sentido, una excesiva protección a través de estos métodos puede dificultar la internalización de los flujos de información que se comparten con los socios de los acuerdos.

iii) Para España, la posibilidad de compartir costes y riesgos es el principal determinante de la cooperación en actividades de I+D. Este hecho puede ser reflejo de la falta de inversión privada o la escasez de capital riesgo, lo que lleva a las empresas a compartir los costes y riesgos de las actividades de innovación con otras empresas o instituciones.

iv) La capacidad de absorción de la empresa y la capacidad tecnológica de la empresa tienen efectos positivos sobre la probabilidad de cooperar. Cuanto mayor sean estas variables, mayores son los beneficios potenciales de la cooperación con otras empresas o instituciones.

v) Diferenciando por tipo de socio, caben destacar tres hechos. En primer lugar, en el caso de la cooperación con empresas competidoras, la variable que tiene un efecto mayor sobre la probabilidad de cooperar es la apropiabilidad. Es decir, la capacidad de control a través de métodos estratégicos de protección de los flujos de información es crucial en la decisión de

[85] La variable "spillovers" recibidos se define como la importancia para el proceso de innovación de las empresas de las fuentes de información accesibles públicamente. En concreto, estas fuentes de información son Conferencias profesionales, reuniones y revistas especializadas, y ferias y exhibiciones.

[86] Estos métodos incluyen: Secreto de fábrica, complejidad en el diseño y tiempo de liderazgo sobre los competidores.

[87] Estos métodos incluyen: Patentes, registros de modelos de utilidad, marcas de fábrica y derechos de autor.

cooperar con competidores directos. En segundo lugar, los "spillovers" recibidos sólo tienen un efecto positivo en la probabilidad de cooperar con instituciones de investigación. En este sentido, la información libremente disponible para la empresa sólo tiene un efecto positivo en la cooperación con socios tales como universidades, laboratorios comerciales, organismos públicos de investigación, etc. En tercer lugar, la posibilidad de compartir costes y riesgos es el principal determinante de la cooperación en actividades de I+D con proveedores o clientes y con instituciones de investigación.

A.3.2. Un análisis de los acuerdos de cooperación en innovación: Evidencia para cuatro países europeos

Aportaciones

Las aportaciones principales de este estudio respecto a la literatura existente y respecto al capítulo anterior son las siguientes:

i) Se obtiene resultados comparables para cuatro grandes países europeos (Alemania, España, Francia y Reino Unido). Esto es posible gracias a la utilización de datos procedentes de la tercera edición de la Community Innovation Survey (CIS), encuesta para la que se dispone de un cuestionario armonizado entre los países europeos.

ii) Además de las empresas manufactureras, se analiza el sector servicios. La utilización de datos del CIS es particularmente adecuado para analizar las actividades de innovación en el sector servicios ya que esta encuesta considera una perspectiva amplia de la innovación (más allá del concepto de gasto de I+D interna).

iii) Se analiza el efecto del apoyo financiero público para actividades de innovación (préstamos, subvenciones) en la propensión a cooperar en actividades de innovación.

Resultados principales

Los resultados principales obtenidos son:

i) Se encuentra evidencia a favor de una relación positiva entre el grado en el que las empresas pueden beneficiarse de los flujos de información externos ("spillovers" recibidos[88]) y la propensión a establecer acuerdos de cooperación en actividades de innovación. Este efecto es especialmente importante a la hora de cooperar con organismos de investigación, mientras que esta propensión disminuye a la hora de cooperar con empresas competidoras pertenecientes a la misma industria.

ii) También se encuentra evidencia a favor de un efecto positivo de la importancia de los métodos estratégicos de protección (secreto de fábrica, complejidad en el diseño y tiempo de liderazgo sobre los competidores). Este efecto es significativo para el caso de acuerdos de cooperación con organismos de investigación, con proveedores y con clientes. El efecto es menos importante en el caso de cooperación con competidores.

iii) Los resultados para el caso español son sensiblemente diferentes, especialmente al compararlos con los obtenidos para Alemania y Reino Unido. Para España se encuentra que, especialmente en el sector industrial, la empresas más grandes son más propensas a cooperar, y que las empresas cooperan para compartir los costes y los riesgos derivados de las actividades de innovación. Este resultado puede derivarse de diferencias entre España y el resto de países analizados en el mercado de capitales y en la disponibilidad y coste de las fuentes de financiación externas para actividades de innovación.

iv) El hecho de recibir apoyo financiero público tiene un efecto positivo sobre la probabilidad de cooperar. Este efecto es especialmente importante en el caso de la cooperación con organismos de investigación (como universidades y organismos públicos de investigación). Esto coincide con la orientación que se quiere dar a la financiación pública para la innovación, la cual intenta incentivar este tipo de acuerdos de cooperación y promover la transferencia tecnológica desde las universidades a las empresas.

[88] Importancia para el proceso de innovación de las empresas de las fuentes de información accesibles públicamente Conferencias profesionales, reuniones y revistas especializadas, y ferias y exhibiciones.

A.3.3. Innovación organizativa y productividad: un análisis del impacto del outsourcing en la productividad de las empresas

Aportaciones

En primer lugar, en este estudio se propone un marco teórico que permite estimar el impacto del outsourcing en la productividad. Concretamente, el marco desarrollado permite evaluar el impacto de la decisión de subcontratación (empezar y dejar de subcontratar) y de la intensidad de la subcontratación.

En segundo lugar, mientras que la literatura empírica existente sobre este tema se ha centrado en los efectos sobre la productividad a nivel industrial y nacional, este análisis se lleva a cabo a nivel de empresa. Además se utilizan datos de panel, lo que permite tener en cuenta la heterogeneidad inobservada entre las empresas y analizar efectos temporales.

En tercer lugar, la base de datos utilizada permite utilizar una medida directa de la subcontratación de la producción. En concreto, se tiene información sobre compras a terceros de productos terminados o componentes a medida para la empresa. En este sentido, en la literatura empírica, el outsourcing se ha medido de modos diversos y utilizando diferentes perspectivas. La mayor parte de estas aproximaciones utilizan información a nivel de industria y procedentes de tablas input-output. Además, en muchos casos se utilizan medidas imprecisas.

Resultados principales

Las conclusiones principales de las estimaciones realizadas son las siguientes:

i) El outsourcing tiene un efecto positivo sobre la productividad. Se obtiene un efecto positivo del índice de subcontratación en la productividad de las empresas. Concretamente, se obtiene una elasticidad del output respecto a la intensidad de la subcontratación de 0,14.

ii) No sólo la intensidad en la subcontratación, sino también la decisión de empezar o dejar de subcontratar tiene impacto. En este sentido, empezar a subcontratar tiene un efecto positivo sobre la productividad de las empresas, mientras que dejar de subcontratar

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