National innovation surveys in Latin America: empirical evidence and policy implications

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I. National innovation surveys in Latin America: Empirical evidence and policy implications

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Acknowledgments

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1. Introduction

This publication is the result of a two year research project on "R&D cooperation in Latin American innovation strategies: empirical evidence and policy implications from National Innovation Surveys". The project has been carried out by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) with the financial support of the International Development Research Centre (IDRC). The project has benefited from the collaboration and the engagement of a team of researchers from Latin American countries and from the collaboration of National Statistical Offices.

Innovation policy gained growing attention in the Government Agenda of Latin American countries in the post-Washington consensus era. This rising political consideration for innovation, and for the policies to support it, entailed a shift in the prevailing policy paradigm from a minimalistic role of the State in the economy to the recognition of a broader domain for State intervention. At the same time, the political acceptance of the need for public policy to support innovation brought about a growing demand for evidence in terms of innovative behaviour of agents, their preferences, and their performance.

The evidence provided in the articles published in this report contributes to increase the knowledge about the functioning of national innovation systems and the behaviour of innovative agents in Latin America. At the same time, this collection of studies represents the first effort to validate national innovation survey data in a comparative perspective in the region and offers a critical analysis of the quality and the capacity of firm-level data and national innovation surveys to inform the policy debate, and better design and evaluate innovation policies.

Innovation surveys in Latin America are recent and the countries in the region lack the practice and the accumulated collective experience of developed countries in validating and analyzing data for policy purposes. The starting point is that national innovation surveys might represent a useful source of information for policy oriented research. In fact, a deeper and renewed understanding of the innovative conduct of firms, of entrepreneurial behaviour and of how, when and through which channels Latin American enterprises innovate is necessary to increase the capacity of designing more effective policies. Firm-level data can be used to better analyze innovation conducts and the impact of innovation on firms' competitiveness and productivity. National Innovation Surveys can provide useful insights for analyzing innovative conduct in the region, identifying patterns of technical change, and for learning and detecting taxonomies of innovation routines and patterns. However, information coming from those surveys needs to be complemented with additional and more aggregate data on production specialization and technological and scientific profile of the country, and much attention needs to be paid to the methodologies and hypothesis used for data analysis.

The following articles provide the results of the analysis of innovation surveys in 5 Latin American countries: Argentina, Brazil, Chile, Mexico and Uruguay. Those countries account for the 80% of total regional manufacturing value added and offer a good proxy of regional manufacturing performance. The diversity and the heterogeneity of these countries allow to grasp eventual asymmetries in innovative conducts and National Innovation Systems between small and big size economies, different specialization patterns, low and medium income economies and to take into account potential differences between growing and lagging economies.

The results presented in this issue represent a step forward with respect to existing literature about innovation in the region. They provide an analysis of cooperation and innovation in Latin America in a comparative perspective from different angles exploiting the variety and heterogeneity of innovation surveys between countries and they contribute to the analysis of the determinants of cooperation and innovation at the firm level in the case of peripheral countries. In addition, the results contribute to express a call for strengthening the innovation measurement agenda in Latin America to improve the contribute of micro-level data analysis for policy design and evaluation.

2. Cooperation and innovation: a topic of rising relevance in empirical analysis and in policy making

The concept of National System of Innovation and the evolutionary literature contributed to define innovation as the result of the interaction between different agents and settings, stressing the relevance of collaboration and cooperation as key features of the innovative process (Nelson and Winter, 1982; Kline and Rosenberg, 1986; Nelson, 1993; Dosi and Cimoli, 1994; Patel and Pavitt, 1994; Metcalfe, 1995; Cimoli, Dosi, Nelson and Stiglitz, 2006). It is widely recognized that firms do not innovate in isolation. Sectoral, firm-level and managerial studies confirm that collaboration, interaction and cooperation are key for innovation and technological change and that innovation is increasingly the result of a combination of a multiplicity of actors and sources.

Since the late 1990s, advanced countries carried out empirical analyses which contributed to increase the knowledge regarding the innovative behaviour of firms thanks to national innovation surveys (OECD, 2009; OECD, 2010). Firm level analyses on innovation are recent, but rich, and rising in depth and complexity. Cooperation and the relation of innovative firms with external agents and with the environment have been a key topic in those analyses.

The literature, which provides evidence mostly for advanced and European countries, focuses on the determinants of the decision of a firm to cooperate for innovation and the impact of cooperation on innovation performance (Cassiman and Veugelers, 1999, 2002; Hagerdoorn et al., 2000; Fritsch and Lucas, 2001; Leiponen, 2001; Tether, 2002; Cincera et al., 2003; Belderbos et al, 2004; Negassi, 2004; Bönte and Keilbach, 2005; Schmidt, 2005 Aschhoff and Schmidt, 2008; Arranz and Fernández de Arroyabe, 2008). Those studies follow different approaches, and focus on different determinants of cooperative behaviour of innovators. Some focus on the differences in choices and impact of cooperation by type of partner -clients/suppliers, competitors, research institutions- (Tether, 2002; Belderbos et al., 2005; Arundel and Geuna, 2004). Others analyze the impact of capital ownership and the propensity to cooperate of national and foreign firms (Faria and Schmidt, 2007). Some studies focus on the impact of size in determining openness to external sources and the role of absorptive capacities in determining the willingness to collaborate (Cassiman and Veugelers, 2002). The capacity of appropriating returns form innovation i.e. the appropriability strategy of firms and the tacitness of knowledge involved in innovation are also identified as key determinants of collaborative patterns (Cassiman and Veugelers, 2005; Chudnovsky, López and Rossi, 2008; Graversen and Mark, 2004).

In Latin America, national innovation surveys are a new experience. Scholars have started to explore that data only recently. Available analyses tend to focus on innovation performance, market structure and the role of multinationals, instead of systematically analyzing the functioning of innovation systems in the region (Crespi and Katz, 1999; Quadros, et al., 2001; Arza, 2005; Benavente, 2006; Chudnovsky et al., 2006; Marin and Bell, 2006).

On the policy side, in Latin America, during the last years there has been a growing consensus regarding the necessity to design and implement science and technology policies to foster catching up and long run development (Cimoli, Ferraz, Primi, 2009). Today, in line with the tendency of frontier economies in which much of public intervention for innovation focuses on promoting links among institutions and agents, the new innovation policy agenda in Latin America focuses on designing policies to support networking and cooperation among the agents of the innovation system.

How to support innovation cooperation among heterogeneous agents is a major policy concern in the region. Actually, most countries designed policies to support cooperation. There has been a growing interest on networks of excellence, public-private partnership for R&D, research consortia, etc. However, the performance of those policies is mixed and there is a lack of micro-evidence regarding firms' behaviour in that respect.

In this scenario, a sound analysis of the cooperative behaviour of innovative firms is crucial to support the design and implementation of better policies. Innovation surveys appear as a rich source of information to investigate innovative behaviour of firms. However, this is easier said than done, and

much work, attention and theoretical reflection is needed to advance in innovation analysis at the firm-level in the region. The papers presented in this issue go in this direction.

3. Exploring cooperative behaviour in Latin America: evidence from innovation surveys

This report includes six chapters based on the national innovation surveys of 5 Latin American Countries (Argentina, Brazil, Chile, Mexico and Uruguay). The first five papers are country case studies which analyze a specific aspect of cooperation for innovation profiting from the differences between the surveys and in response to primary policy challenges in each country. The sixth paper presents a comparative analysis of the determinants of cooperation in Latin American countries.[4]

The evidence presented in this volume is particularly rich since each country case study focuses on a specific aspect of cooperation and innovation. The Chilean study analyses the determinants of R&D cooperation and the impact of public policy. The Brazilian analysis differentiates the determinants of cooperation by type of partner. The Mexican survey allows for testing the determinants of cooperation in the case of product and process innovation. The Argentinean study analyzes the role of international versus local collaboration. The Uruguayan case studies combines' evidence from different types of surveys and focuses on the role of human capital in determining firm's openness. The comparative paper is the first attempt to carry out a comparative analysis based on innovation surveys in Latin America. The study highlights similarities and differences in cooperation between countries, and shows the limits of the comparability of data as they are collected nowadays. It concludes by identifying some recommendations to improve the comparability of innovation surveys in the region.

TABLE 1
REFERENCES: INNOVATION SURVEYS BY COUNTRY

Country	Survey
Argentina	National Innovation Survey 1998-2001
Brazil	3rd Technology Innovation Survey (PINTEC, 2005)
Chile	4th Innovation Survey (2005)
Mexico	2nd Innovation Survey (2001)
Uruguay	2nd Innovation Survey 2001-2003

Source: Own elaboration.

The determinants of cooperation and the impact of public policy

The article on "Cooperation partnerships in manufacturing: evidence from Chile" by Jose Miguel Benavente and Carmen Contreras analyzes the determinants of technical cooperation agreements in Chile. By estimating biprobit and poisson models and correcting for selection bias, the authors confirm the hypothesis that larger firms tend to innovate more. In Chile, technical cooperation appears to be inversely related with firm size suggesting that larger firms tend to vertically integrate their R&D activities. Results show that radical innovations are heavily dependent on the existence of technical cooperation contracts and that public support enhances technical cooperation among firms. Public support enhances technical cooperation among firms and with universities and research centres not only in quantity but also in quality. The authors show that sectorial behaviour may have a relevant

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[4]   The comparative paper analyzes the determinants of cooperation in 4 countries. Mexico is excluded from the comparative study for the lack of harmonisations of questions on cooperation.

effect, affirming that it is possible to identify "differences in cooperation culture among sectors." Firms receiving public support for their R&D activities show higher probabilities to sign cooperation agreements. This is quite tautological considering that collaboration is required as conditionality for receiving public support for R&D spending. What is interesting is that the authors show that firms which receiving public support for R&D tends to increase the number of contracts they sing. R&D subsidies would hence on the one hand impact on R&D performance, but also, indirectly they would promote linkages in the innovation systems.

The determinants of cooperation by type of partner

David Kupfer and Ana Paula Avellar analyze the Brazilian case in the article entitled, "Innovation and cooperation: evidence from the Brazilian Innovation survey." Kupfer and Avellar identify the reasons why Brazilian firms engage in innovative cooperation, emphasizing the relation between the types of partners using the PINTEC 2005. The authors run four probit models to identify the determinants of cooperation in general and then by type of partner (science and technology infrastructure, clients, suppliers and competitors and other firms of the group). The authors highlight that cooperation strategy is in its early stages in the Brazilian manufacturing and that there are few innovative firms (50%) of which only 15% are engaged in cooperative agreements for R&D. The Brazilian analysis also confirms the existence of a sectoral culture for innovation showing that the pharmaceutical, the chemical and the transport industry are those with the higher concentration of R&D collaborations. With respect to the type of partner, the chemical and transport sectors concentrate on cooperation with S&T infrastructure. The study confirms the literature for advanced economies in which absorptive capacity affects cooperative behaviour. Firms which carry out R&D on a continuous basis increase their chances to engage in cooperative arrangements for R&D.

Differences between cooperation for product and process innovation

Celso Garrido and Ramon Padilla Perez analyze "Cooperation for innovation in the manufacturing industry in Mexico." The authors start by recognizing that cooperation for innovation in Mexico's manufacturing industry is scant and, when it occurs, it takes place mainly between firms. The Mexican case study focuses on the differences in cooperative behaviour for product and process innovating firms. This distinction provides original econometric results that contrast and complement the existing literature: size and appropriability are associated only with cooperation for process innovation, while sectoral specificities and origin of capital are significant only to explain cooperation for product innovation. Size is not significantly associated to cooperation for product innovation. This paper shows that the characteristics, needs and benefits of cooperation vary notably not only among industrial sectors, but also between the object of cooperation (product vs. process innovation).

The role of international versus local collaboration

Valeria Arza and Andres Lopez analyze "The determinants of firms' distant collaboration: evidence from Argentina 1998-2001". This study starts with the premise that firms' international collaboration is positive for technology development and innovation. The initial hypothesis is that international cooperation requires stronger technological capabilities and firms' openness. Authors' findings confirm the hypothesis. By testing a multinomial logit model they test the determinants of cooperation as a function of proximity (national versus international). Foreign firms or those that trade intensively are more likely to cooperate abroad. Skilled labour intensive firms and firms that allocate more resources to innovation activities show higher probability of forming international partnerships. Arza and Lopez contribute to the ongoing debate on local versus international collaborations. The authors point out that in developing countries, fostering purely local collaborations may perpetuate the innovation systems backwardness and their lack of diversification, rather than promoting technological dynamism. International agreements should be promoted so as to avoid the trap of interacting within a community of firms with low technological capabilities.

The role of human capital and skills in determining cooperation for innovation

The article entitled, "Make, buy and cooperate in innovation: evidence from Uruguayan manufacturing surveys and other innovation studies" by Judith Sutz, Natalia Gras and Carlos Bianchi takes a peculiar perspective and explores the role of human capital in determining cooperative behaviour complementing the information coming from innovation surveys with other firm-level sources of information. The main assumption is that "cooperation for innovation is a knowledge exchange process driven by people". Results confirm that R&D employees, especially scientifically and technically trained employees- are among the most relevant determinant of cooperation for innovation within the Uruguayan industry, confirming the importance of the Cohen-Levinthal "absorptive capacity" concept (Cohen and Levinthal, 1990).

Cooperation for innovation in Latin America in a comparative perspective

The comparative paper by Primi and Rovira analyzes the determinants of cooperation for innovation in the manufacturing industry in 5 Latin American Countries (Argentina, Brazil Chile, Mexico and Uruguay). Innovation surveys in Latin America define cooperation in different ways. An analysis by type of partner is included, differentiating: a) cooperation with (S&T) Scientific and Technological infrastructure, such as universities and other research centers; b) cooperation with other firms, including cooperation with suppliers, clients and other institutions that are not part of the group, and c) cooperation with firms of the group. In Latin America, on average, the percentage of firms engaged in cooperative activities for innovation is residual, ranging from 5.7% of total firms in Chile to 13.9% in Argentina. In Chile, Brazil and Mexico, innovative firms tend to cooperate more with other firms (client and/or suppliers) rather than with science and technology institutes or other firms of the group. In Argentina and Uruguay, the preferred partners of innovative firms are, on the contrary, the S&T research centers and institutions. In terms of capital ownership, foreign firms cooperate more than domestic ones. As for size, bigger firms show a higher propensity toward cooperation with respect to small ones.

4. Improving innovation surveys to better inform policies: towards a new research agenda

Innovation is gathering increasing attention by the regional community of business analysts, experts and policy makers. There is a rising and varied demand for measuring innovation efforts and performance and for capturing the impact of policies. Measuring innovation through surveys is a recent and ongoing process in Latin America. The ECLAC-IDRC project represents a first exercise. Results show that there is much room for improving the capacity of surveys to capture innovative dynamics in the region, to increase comparability between countries, and to refine models and approaches to data analysis in order to draw meaningful conclusions to support decision makers.

The research behind the results published in this issue represented an important learning process for the region. One of the main strength of our approach has been the decision of looking critically into the data matching firm-level econometric analysis with the evidence coming from more aggregate innovation and production structure analysis. This has been possible by establishing a dialogue and community of practice between experts in industrial dynamics and innovation in the region, which looked into firm level data with the broader lenses of the structural and sectoral approach.

In synthesis, national innovation surveys are useful instruments for increasing awareness regarding the innovative conduct of firms. However, more work is needed to consolidate information, harmonize data collection and data processing in the region. This is a mid-long term process which requires a permanent dialogue between experts, statisticians and policy makers. There is a need to capitalize on current efforts, but also to improve the current design of innovation surveys in order to

increase comparability between countries and to increase the capacity of capturing innovative dynamics and the capacity of policy makers to use the data appropriately. Strengthening the regional and participating in international dialogue on the issues is crucial.

Working with innovation surveys entails a series of issues regarding confidentiality. Actually, there are some restrictions on the side of National Statistical Offices to provide access to microdata from innovation surveys. This project has benefited from the collaboration and direct involvement of National Statistical Offices. It is desirable to simplify procedures for accessing and processing micro-data which also respect confidentiality issues in order to increase the usability of this relevant source of information.

At the same time, it is important to recall that innovation surveys are only one of the sources to analyze innovative behaviour in the region. Their use for orienting policy making should be cautious and done with "cum grano salis". Econometric analyses are useful, but the technique needs to be matched with sound theoretical approach. Innovation surveys should be used to explore the variety and diversity of firms strategies and analyses should avoid reducing firm-level based studies in an analysis of the behaviour of the "the representative firm". The advantage of national innovation surveys is to show differences in behaviours for helping policy makers understanding the type of reality in which their policies are going to be implemented. How to do it is an open and urgent issue. We hope that these studies will constitute a good starting point for working in this direction.

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II. Cooperation Partnerships in Manufacturing: Evidence from Chile

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Abstract

In this paper we study the determinants of technical cooperation agreements in a less developed country. By estimating biprobit and poisson models and correcting for selection bias we confirm previous evidence that larger firms tend to innovate more. However, technical cooperation is inversely related with firm size suggesting that larger firms tend to vertically integrate their R&D activities. Results show, however, that public support enhances technical cooperation among firms. This is especially relevant when results also show that radical innovations are, among other things, heavily dependent on the existence of technical cooperation contracts.

1. Introduction

It is now well accepted that innovation is a systemic phenomenon. The concept of National System of Innovation (NSI) stresses the importance not only on agents who participate in the innovation process but particularly on the relations among them. Today, most of the new agenda for public intervention on innovation is focused in promoting links among innovative related institutions rather supporting the institutions themselves.

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It is interesting to note, however, that most of the aggregate innovation indicators do not account for the richness of those links knowing that successful innovations heavily depend on the development and integration of new knowledge into the innovation process.

As suggested by the NSI literature (Lundvall, 1988) productive firms are at the heart of the innovation system where markets that sanction what have been developed is useful. Therefore, firms not only need to read tastes and needs from consumers but also understand new techniques and knowledge that may help them satisfies these needs in a profitable way.

There is a vast literature documenting the importance of external sources of information and knowledge and how firms decide to use it (Jaffe, 1986; Bernstein and Nadiri, 1988). Information and knowledge flows are also relevant for aggregate economic performance (Romer, 1990: Grossman and Helpman, 1991). But, as traditional information theory suggests, knowledge can only be useful if there exists relevant capabilities at the recipient level who could understand it.

Technological cooperation is one of the channels on how firms may learn from external sources. Tacit knowledge, scientific and productive experience, property rights enforcements, confidences are all issues that characterise the quality of the relationships among partners. Relative costs, knowledge availability and expected impact are also issues that shape these interactions. And, in this area we know very little. Especially for countries who are betting on innovation as a fundamental source for economic prosperity (Benavente, 2005).

In this paper, we aim to characterize technological cooperation mechanisms among innovative firms in the case of a less developed country, Chile. In particular, we seek to study the determinants of formal cooperation among firms and the strength of these agreements in the manufacturing sector where a major share of the innovations takes place (CNIC, 2008). We are also interested in the type of partners Chilean manufacturing firms would sign cooperation agreements with and the importance of foreign contractors among them.

To characterise these relationships we asked over a thousand plants about their innovation performance, sources of technical information, types of cooperation and other relevant variables following the OCDE guidelines documented in the Frascati and Oslo manuals.

By estimating biprobit and poisson models and correcting for selection bias, we confirm previous evidence that larger firms tend to innovate more. However, technical cooperation is inversely related with firm size suggesting that larger firms tend to vertically integrate their R&D and/or other innovative procedures. Lack of long term confidence relationships, property rights enforcement problems and the existence of high transactional costs may explain this pattern, thus confirming what interviewers mention as main obstacles to innovate.

Results show, however, that public support enhances technical cooperation among firms and with universities and research centres not only in quantity but also in quality. This is especially relevant when results also show that radical innovations are, among other things, heavily dependent on the existence of technical cooperation contracts.

Following this introduction, in the next section we present a brief summary of previous studies concerning technical cooperation among firms although most of them are done for developed countries. Then, in the third section we describe the survey used for this research and present data relating innovation, size and technical cooperation. To explore the impact of these and other observable characteristics of the firms, we present and estimate an econometric model in order to establish which firms are more likely to sign formal technical cooperation contracts as well as the persistence of them. All this is presented in the forth section. Finally, we summarize the main results and suggest avenues for further research.

2. Related literature

Theory and evidence on technical cooperation has mainly focused on the determinants of R&D contracts among firms. Based on the importance of information flows, incoming spillovers, appropriability conditions and relative costs are among the relevant issues considered on the probability of signing a cooperation agreement.

Evidence suggest that firms have a higher propensity to cooperate when they can absorb (receive and use) external public knowledge and when they can appropriate knowledge generated by their own innovative activities (Cassiman and Veugelers, 2002).

Results show that the ability of the firm to appropriate the returns from innovations also plays a role in signing cooperation agreements (Lopez, 2004) but will depend on with whom the agreements are signed (Mark and Graversen, 2004). For example, Atallah (2005) suggests that firms tend to cooperate among those with similar capabilities while Schmidt (2005) shows that firms with high intramural R&D budgets are more likely to cooperate with universities and research institutions than with suppliers and customers. Spillovers also play a role as suggested by Vencatachellum and Vesaevel (2006).

On the other hand, previous studies found that a positive impact of R&D cooperation on innovation performance may depend again on partners (Aschhoff and Schmidt, 2008; Cincera et al., 2003). Cooperation with competitors may increase cost reduction, while cooperation with research institutes is beneficial if the firm wants to develop products new to the market. These results show that the type of cooperation matters for the kind of innovation results obtained.

International cooperation has also been analyzed. It has been argued that foreign partners could increase expected spillovers especially for those receivers situated behind the technological frontier. However, international cooperation can increase transactional costs due to coordination problems, some of them in relation to the geographical distance (Lhuillery and Pfister, 2009).

3. Data description

In order to characterise the technical cooperation agreements of Chilean firms, we extensively use the database constructed from the Chilean Innovation Survey. The survey was designed following the CIS structure and is compulsory for respondents (Benavente and Crespi, 1996), conducted according to the OECD instructions defined in the Oslo and Frascati Manuals, and collected by the National Institute of Statistics.

In the case of Chile, the survey was designed to capture qualitative variations in the innovation activities of firms. Among the objectives of the survey was to identify the factors underlying these changes and to evaluate the efficacy and efficiency of public policy towards innovation and its related activities.

Cooperation in the Chilean survey is defined as the existence of any formal cooperation agreement for any innovative activity performed by the firm. The survey also explores cooperation with different partners like universities, public research organizations (PROs), private R&D labs, competitors, clients, suppliers or firms belonging to the same economic group.

Table 1 reflects the basic description of the Fourth version of the Chilean Innovation Survey that will be used in this study.[7] There are 3,122 firms in the dataset of which 1,494 (48%) have

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[7]   The fourth version performed during 2005 has considered firms from the manufacturing, mining, energy and services sectors.

declared to have carried out innovations during 2003 and/or 2004. These numbers are quite significant once compared to other countries, even developed ones (Hall & Mairesse, 2006).[8] During these two years, the most innovative enterprises in Chile were those from the mining sector with a 58% of innovative firms while Services showed the lowest level with a 43% of innovative firms.

TABLE 1
SAMPLE STATISTICS

All simple firms	3,122
Innovating firms	1,494
Percentage of all firms	47.85%
Manufacturing firms	1,269
Innovating manufacturing firms	640
(Percentage of manufacturing firms)	50.43%
Energy firms	150
Innovating manufacturing firms	72
(Percentage of energy firms)	57.81%
Mining firms	64
Innovating mining firms	37
(Percentage of mining firms)	57.81%
Services firms	1,412
Innovating services firms	613
(Percentage of services firms)	43.41%
Cooperating firms	185
(Percentage of innovating firms)	12.38%
Non-cooperating firms	1,309
(Percentage of innovating firms)	87.62%
Firms cooperating with universities	106
(Percentage of innovating firms)	7.1%
Firms cooperating with competitors	93
(Percentage of innovating firms)	6.22%
Firms cooperating with consultors	93
(Percentage of innovating firms)	6.22%
Firms cooperating with costumers	166
(Percentage of innovating firms)	11.11%

Source: Own elaboration.

Survey information shows that of all the innovative firms included in the sample, only a 12.4% of them have cooperated with others in order to perform innovation and/or R&D activities. For example, firms that cooperate with Universities are 106 representing a 7.1%, while firms that cooperate with Competitors are 96 representing a 6.2% of the total innovative firms. Firms which

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[8]   Main innovation statistics based on previous versions of the Chilean Innovation Survey could be found in Benavente (2005) and CNIC (2008).

cooperate with Consultants are 93 (6.2%) while 166 firms cooperate with Customers representing an 11% of the innovating firms.

      As suggested in the previous section, there are several elements that may explain the existence of technical cooperation among firms and/or other scientific institutions. Despite that, this issue will concentrate our attention during the remaining of the paper on analyzing innovation, firm size and cooperation. These variables are presented in graph 1.

FIGURE 1
SHARE OF INNOVATIVE AND COOPERATION AGREEMENTS BY SIZE (SALES)
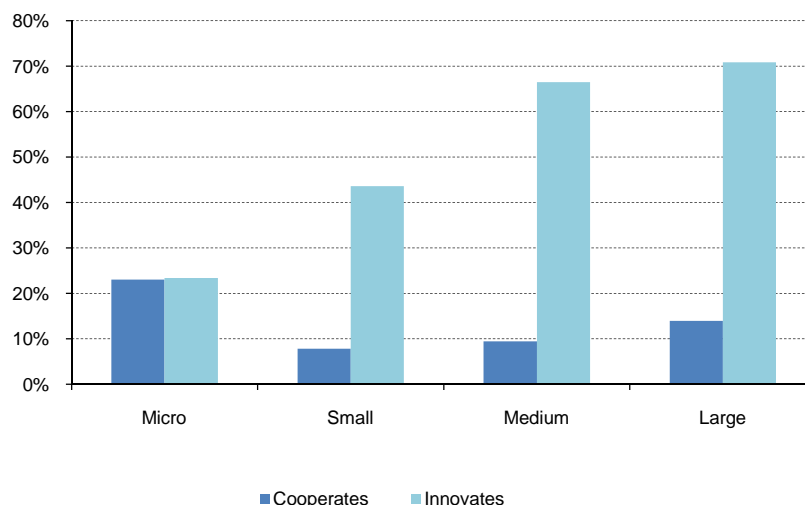
Source: 4th Chilean Innovation Survey.

      As noted in the graph, there exists a positive relationship between innovation and size. This result is consistent with evidence elsewhere where size, measured either by employment or sales tend to have a direct impact on the probability to invest in R&D, the amount of R&D resources invested and with the probability of performing innovation activities.[9] However, in the case of Chile, cooperation agreements seem not to have a close relationship with size. Moreover, in relative terms, micro firms tend to have tighter links with other agents once they innovate. Of course we are in the presence of size selection bias but it is interesting to note that knowledge specificity, property rights enforcement, transactional costs and spillovers in general could be playing a role and larger firms are more aware of them.

      In order to go one step further in analysing the richness of cooperation links among Chilean firms in Table 2, we present variables constructed from the survey most of them related with the obstacles for cooperation agreements. We have divided the sample in several sub samples depending on the sort of cooperation agreements. It is worth noting that categories in the last four columns are not excluding. That is, firms may have sign several cooperation agreements either with universities, private labs and/or suppliers or customers.

      Before moving to the results showed in the table, we need a brief explanation of the variables used.[10] Incoming spillovers measure the importance of non formal agreements as source of codified

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[9]   An extended survey about the relationship with firm size and R&D, innovation and related activities could be found in Benavente (2002).

[10] In the appendix an explanation of all variables used and how they were constructed is presented.

and some tacit form of transmission mechanism for innovations performed at the firm. They include professional conferences, exhibitions, meetings and access to academic and professional journals. The next three variables —easy imitation, lack of information and cost/risk, are ordinal variables which accounts for their importance as relevant obstacles for innovating. Legal protection stands for a categorical variable regarding if the firm has registered patents or signed knowledge agreements. Finally, employees and R&D intensity are presented to control for scale and innovation characteristics by the respondent firms.

TABLE 2
MEAN OF MAIN VARIABLES

	Sample	Non-cooperating firms	Cooperating firms	Cooperation with universities	Cooperation with competitors	Cooperation with consultors	Cooperation with customers
	(N=3,122)	(N=1,309)	(N=185)	(N=106)	(N=93)	(N=93)	(N=166)
Incoming spillovers	0.655	0.653	0.686	0.707	0.741	0.752	0.698
Easy imitation	0.727	0.725	0.726	0.783	0.806	0.795	0.771
Lack of info	0.283	0.289	0.183	0.160	0.182	0.150	0.174
Cost-risk	0.223	0.224	0.2	0.235	0.236	0.225	0.198
Legal protection	0.198	0.189	0.340	0.405	0.333	0.408	0.349
Employees	461.5	240.1	3,704.2	507.8	624.9	7 028.2	4 099.3
R&D intensity	0.012	0.011	0.021	0.032	0.020	0.020	0.158

Source: Own elaboration.

Starting with incoming spillovers, it is interesting to note that informal as opposite to formal cooperation agreements, like professional conferences, subscriptions to specialized journals or the like are more relevant for those which have formal cooperation agreements compared to non cooperative firms. That is, learning by looking or learning by interacting conform another mechanism on how firms interact to their environment, searching for ideas, knowledge and opportunities. It seems that interaction formally or informally, is an attitude and firms tend to exploit all forms of it.

From the obstacles point of view, evidence suggests that those already experiencing a formal cooperation contract are more aware about the imitation problem compared with their isolated partners. Up until now, it is not clear that the imitation issue explains why they have ended in a formal contract or as a result of the cooperation experience they have discovered how important the topic is.

Concerning information, results presented in Table 2 suggest that formal contracts may act as a relevant source of knowledge. But again, we do not know if cooperation agreements are signed in order to close informational gaps or as a result of the agreements firms realized how much knowledge they posses and their potential. It seems that cost and/or risk issues are not making an important difference among those with formal contracts compared to those without them.

Finally, it is interesting to notice that formal cooperation is related with knowledge protection and with R&D intensity. The econometric exercise that will be presented in the next sections may help to understand the relevance of each of these factors controlling for some other observed characteristics of the firms.

4. Econometric modelling and results

In order to analyse in more detail the relationship between technical cooperation and firms characteristics, in this section we estimate empirical models which relate perceptions, actions and decisions together with some observable firm characteristics with the probability of signing technical cooperation contracts. We will also analyze if differences exist depending on the institution that the contract is signed to as well as the number of contracts that a firm may have signed.

4.1   Signing technical cooperation agreements

We start by analysing the determinants of signing formal technical cooperation agreements in general despite whom they are signed with. Nevertheless, before moving on, it is important to note that the structure of the Fourth Innovation Survey in Chile has the inconvenience that many questions are only answered by firms which have done at least one innovation (innovative firms). In particular, all questions referring to cooperation activities are answered only by those innovative firms.

As suggested in the previous section, this feature of the data could lead to bias when analysing cooperation of firms. To solve this problem, we estimate the probability of signing formal cooperation contracts considering that a selection bias is in place. We do so by estimating a probit model controlling for selectivity under a Maximum Likelihood context. The dependent variable is that either the firm has agreed to a formal technological cooperation agreement outside their own firm or not. Results are presented in Table 3.

TABLE 3
DETERMINANTS OF THE PROBABILITY OF TECHNICAL COOPERATION AGREEMENTS.
RESULTS FROM THE PROBIT ESTIMATION WITH SAMPLE SELECTION

	Cooperate	Innovate (Selection equation)
Size	-0.728***	0.746***
	(0.268)	(0.105)
Size squared	0.069***	-0.057***
	(0.028)	(0.011)
Experience	0.001	0.003***
	(0.002)	(0.001)
Dummy Exports		0.470***
		(0.057)
Public support innovation activities	-0.142	
	(0.189)	
Public support in R&D	0.442**	
	(0.194)	
Information from public sources	-0.031	
	(0.122)	
Innovations new to the market	0.243*	
	(0.134)	
Have patents	0.258	
	(0.166)	
(Cost and risk are an obstacle for innovation	0.047	
	(0.152)	

(continued)

Table 3 (concluded)

	Cooperate	Innovate (Selection equation)
Lack of qualified workers as an obstacle for innovation	0.009	
	(0.126)	
Financial access as an obstacle for innovation	0.166	
	(0.136)	
Lack of information as an obstacle for innovation	-0.177	
	(0.154)	
Easy of imitation as an obstacle for innovation	-0.205	
	(0.138)	
Percentage of cooperation by sector	4.328***	
	(1.485)	
Legal protection index by sector	-0.916*	
	(0.533)	
Constant	0.457	-3.124
	(1.060)	(0.552)
Sectorial dummies included	Yes	Yes
athrho	-0.728*	
	(0.391)	
rho	-0.622	
	(0.240)	
Wald test of indep. eqns. (rho = 0):		
chi2(1)	2.74	
Prob > chi2	0.098	
Log pseudolikelihood	-957.99	
Wald chi2(29)	47.70	
Prob > chi2	0.0000	
Observations	1260	
Censored obs	569	
Uncensored obs	691	

Source: Own elaboration.
Note: Robust standard errors in parentheses.
*** significant at 1%.
** significant at 5%.
* significant at 10%.

Starting with the selection equation, results show that we are indeed in the presence of selectivity.[11] That is, there exist some firm characteristics that systematically affect the decision to innovate. Given that cooperation issues are only answered by those who have innovated, not considering this selection mechanism may bias the results (Heckman and MaCurdy, 1985).

Results shown on the last of column of Table 3 suggest that firm size, and both production and exporting experiences play a significant role in the decision of firms to innovate. These are consistent with previous studies which stress the relevance of scale and experience on Chilean innovating firms (Benavente, 2005; Alvarez and Lopez, 2005).

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[11] The null hypothesis of no selection is rejected at the 91% of confidence as indicated by the p-vale of the Chi square test reported in Table 3.

Moving now to the cooperation determinants, reported results show no major effect of traditional obstacles in signing these agreements. There is no evidence that costly and/or riskier innovations, the lack of qualified workers, or even how easy a innovation may be imitated act as a systematic obstacle in the probability that a firm agreed formal technical support from outside.

What is interesting to note is the positive link between novelty and cooperation. Results show that radical innovations —those which are new not only for the firm but also for the market— are linked with formal cooperation contracts. But it has to be noted that there are firm characteristics that are pro cooperation agreements. First is size. Results show that after controlling for selectivity, smaller rather than larger firms tend to have more chances of having a cooperation link.

This interesting result is suggesting that larger firms in the Chilean manufacturing sector tend to vertically integrate their research and innovative activities. It seems that this result is not related with the property rights regime since in the estimation we have controlled for the sectorial legal protection index. Moreover, the negative impact of this later variable on the probability of signing cooperation contracts shows that sectors that register more patents and/or have more know how agreements tend to have less technical agreements.

On the other hand, since we are controlling for non observable sectorial differences through the respective dummies, it seems that the lack of a relevant supply of agents could explain why larger firms find it difficult to delegate their innovative activities. This issue has been documented for the Chilean context elsewhere (Benavente, 2005). However, results show two very interesting aspects related with the probability of technical cooperation among firms.

Firstly, sectorial behaviour may have a relevant effect. Results clearly show sectors with more cooperation agreements are having a positive effect on the chances that a firm which belong to that sector signs a technical cooperation contract. We can speak of differences in "cooperation culture" among sectors. Moreover, the correspondent estimator associated to this variable is by far the largest compared to the rest, as seen in Table 3, suggesting that this sectorial culture is indeed a fundamental element explaining firms cooperative behaviour.

Secondly, the impact of public support in building links among different agents in the innovation environment. Results reported in Table 3 show that those firms receiving public support for their R&D activities show higher chances to sign cooperation agreements. This should be obvious since public support demand this links compulsory —as the new tax credit law passed during 2008 in Chile. But it also may reflect that R&D is not a routinary activity among Chilean firms, especially the smaller ones, and prefer to subcontract it if a public grant is awarded to them.

4.2   Strength of the Interactions: number of technical agreements

We want to move further in analysing the factors that affect how firms cooperate among them and/or with other agents of the NSI.[12] In the following econometric exercise we explore the determinant of the number of cooperation and the type of partners. Available data allows us to construct a variable which counts the number of cooperation that a firm has with different partners. It has to be noted that these partners could be firms of the same economic group, competitors, clients, suppliers, universities, research centres or public research institutes, national or international. In Table 4, we present results of a Poisson estimation procedure which relates firm characteristics and innovation obstacles with the number of technical cooperation agreements that a firm signed between 2003 and 2004.

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[12]   It is important to note that due to the lack of sufficient observations we were not able to disaggregate among different institutions that firms may have technical cooperation contracts (e.g. universities, private consultants or other firms).

TABLE 4
DETERMINANTS OF THE NUMBER OF TECHNICAL COOPERATION
AGREEMENTS. RESULTS FROM THE POISSON ESTIMATION

	Coefficients	Marginal Effects
Size	-0.007	-0.002
	(0.377)	(0.129)
Size squared	0.006	0.002
	(0.042)	(0.015)
Experience	0.0019	0.001
	(0.005)	(0.002)
Public support innovation activities	-0.507	-0.147
	(0.440)	(0.110)
Public support in R&D	0.982***	0.514**
	(0.342)	(0.263)
Information from public sources	0.160	0.054
	(0.276)	(0.091)
Innovations new to the market	0.889***	0.309***
	(0.283)	(0.100)
Have patents	0.700**	0.314*
	(0.315)	(0.179)
Cost and risk are an obstacle for innovation	0.490	0.152
	(0.344)	(0.097)
Lack of qualified workers as an obstacle for innovation	0.201	0.071
	(0.263)	(0.094)
Financial access as an obstacle for innovation	-0.066	-0.022
	(0.317)	(0.106)
Lack of information as an obstacle for innovation	-0.434	-0.133
	(0.364)	(0.098)
Easy of imitation as an obstacle for innovation	-0.589**	-0.180**
	(0.288)	(0.079)
Percentage of cooperation by sector	5.183	1.772
	(6.053)	(1.999)
Legal protection index by sector	-0.507	-0.174
	(1.766)	(0.603)
Constant	-2.016*	
	(1.190)	
Sectorial dummies included	Yes	Yes
Log pseudolikelihood	-90.165	
Wald chi2(29)	83.43	
Pseudo R2	0.1673	
Observations	691	
Predicted number of events	34.2%	

Source: Own elaboration.
Note: Robust standard errors in parentheses.
*** significant at 1%.
** significant at 5%.
* significant at 10%.

In terms of intensity, there are fewer variables that explain the number of cooperation agreements that Chilean firms have compared to those related with the probability of signing a contract.

On the one hand, radical innovations appear to promote a tighter link with other agents suggesting the more you introduce important innovations, the more relevant are cooperation contracts.

This is an interesting point especially in countries where innovation may expect to raise if conditions and incentives are in place.

On the other hand, public support also has a permanent effect. That is, firms which have received public support for their R&D activities tend to increase the number of contracts they sign. This is also very interesting since it seems that public support is not only closing informational gaps normally argued for why states should partially subsidize R&D projects but is also promoting a tighter relationship among NSI agents. If we believe that several externalities may increase the larger the number of linkages among technical demanders/suppliers, we have another argument in favour of public R&D incentives.

Results do not show, however, that firm size may have an effect on the number of formal interactions. As reported previously, size is important in explaining the probability of cooperating but here we found that has no impact on their intensity. There is, however, one obstacle that the evidence cites as important in explaining the number of cooperative agreements and —that is how easy imitation could be. Results show the higher the chances of having free riding behaviour – that is, expecting someone else to develop the innovation and later imitate it, the less the number of cooperation firms will tend to have to do the same. Because of the symmetry of the econometric model, with other things being equal, it is harder to imitate an innovation we would expect to have contact with a larger technical cooperation.

This last result raises the point about property rights enforcement since for countries producing non-sophisticated innovations, we may expect that links among NSI to be weak and maintained that way in time. A vicious circle may arise since R&D and innovation markets will find it difficult to emerge and mature. This may have an impact on aggregate indicators like TFP and economic performance at last.

4.3   Disentangling technological partners

The third model analyzes the type of partner chosen for cooperate. We classified partners by their national or international feature. Considering that Chile is far from the world's best practices especially in the manufacturing sector (Katz, 2000) we may expect that cooperation with international partners could result in innovations where higher level of technology is involved or closer to the international production frontier. In this case, there could be different features that affect the probability of cooperating with international partners compared to with national ones.

These types of cooperation could be complements rather than substitutes. It will be the case that some technological cooperation is already available at a local level and probably cheaper and other kind of knowledge probably more sophisticated and/or less costly could be available abroad.

Given that these complementary and/or substitution effects may exist, we control for it by using a Bivariate Probit model. Maximum Likelihood Estimation (MLE) is performed assuming that these two alternatives have a joint distribution function.[13] In this model we have two dichotomic dependent variables. One of them modelling the decision to sign a cooperation contract with a local agent whiles the other reflecting the decision of signing a cooperation contract with a foreign institution. Results of the Bivariate Probit estimation procedure are presented in table 5.

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[13]   We do not impose that they are complements or substitutes. We just control that decisions of signing cooperation agreements with local and/or foreign partners could be related.

TABLE 5
BIPROBIT ESTIMATION, TYPES OF COOPERATION

	National Cooperation	International Cooperation
Size	-0.450*	-0.322
	(0.248)	(0.252)
Size squared	0.053**	0.041
	(0.027)	(0.028)
R&D Intensity	0.259	-4.019**
	(1.050)	(2.040)
Public support innovation activities	-0.221	-0.137
	(0.219)	(0.206)
Public support in R&D	0.560**	0.534**
	(0.205)	(0.215)
Information from public sources	0.014	-0.122
	(0.140)	(0.155)
Innovations new to the market	0.299**	0.401**
	(0.145)	(0.163)
Have patents	0.335*	0.304*
	(0.180)	(0.182)
Cost and risk are an obstacle for innovation	0.129	0.140
	(0.173)	(0.176)
Lack of qualified workers as an obstacle for innovation	-0.038	0.069
	(0.140)	(0.147)
Easy of imitation as an obstacle for innovation	-0.156	-0.303**
	(0.151)	(0.154)
Percentage of cooperation by sector	3.327	12.608**
	(2.604)	(4.522)
Legal protection index by sector	-1.472	0.549
	(1.312)	(1.357)
Constant	-0.821	-2.666***
	(0.705)	(0.825)
Athrho		32.621***
		(1.946)
Rho		1
		0
Likelihood-ratio test of rho=0:		
Chi2 (1)		236.592
Prob > chi2		0.0000
Log likelihood		-240,82036
Observations		692

Source: Own elaboration.
Note: Robust standard errors in parentheses.
* significant at 10%.
** significant at 5%.
*** significant at 1%.

Results show that there is statistical evidence to support that variables which identify cooperation with national partners and cooperation with international partners have a jointly distributed function. Moreover, results clearly show that these two decisions are complements rather

than substitutes. That is, a firm that has higher chances to sign cooperation agreements with local partners also has higher chances to sign agreements with foreign partners.

This last result is in line with the argument that cooperation is rather a cultural behaviour. Moreover, results presented in Table 5 clearly show that the percentage of cooperation at the sectorial level has a positive effect on both kinds of agreements. Then the cultural aspect is not only relevant in explaining cooperation decisions despite to whom they are sign with but sectorial pattern also matters.

We also find that public support for R&D is relevant in explaining both types of cooperation as well as if innovations are clearly a major advance for local standards. Both variables, public support to R&D and innovations that are new for the market has positive and significant effects on the probability of signing cooperation contract despite the partners' origin.

It is interesting to note that there are some differences between both decisions. On the one hand, how easy an innovation could be imitated only plays a relevant role in firms signing agreements with foreign partners. A similar result is observed for R&D intensity. Both variables have a negative and significant effect on the probability of having technical cooperation contracts with foreigners. Although we do not have a clear idea on why this is, we may argue that more R&D intensive firms and/or those who are more aware about the imitation problem —for example, larger local owned natural resources intensive firms, tend to perform more in house R&D avoiding cooperation contracts, especially with foreign partners where unexpected and relevant competition may arise.

Finally, results show that firms that patent also have higher chances of signing technical agreements both with foreign and local partners, confirming that cooperation is a cultural pattern.

5. Concluding remarks

Innovation is without any doubt a collective process. However, knowledge needed for innovation surge partly could be subcontracted from abroad. Coasian economics suggest that this decision will depend mainly on transaction costs.

By using a rich database, we demonstrate that in the case of a less developed country, peer behaviour seems to be very important while deciding to outsource technical activities. Confidences, trust, and respect for property rights are different expressions of these transactional costs that in Chile's case are highly relevant in explaining the probability that a firm may sign a cooperation agreements as well as the amount of these technical contracts.

It is interesting to note that size plays no major role in the establishment of formal links with technology providers. Moreover, we find that larger firms tend to have lower probabilities of signing these contracts. Results clearly show, however, that if your firm is in a sector where technical cooperation is frequent and the legal protection of knowledge is fierce, then firms tend to interact more. Results also suggest that novelty plays a role since radical innovations are normally the result of a collective effort. Evidence then supports the idea that a virtuous circle between novelty and knowledge flow could arise.

But would these virtuous circles emerge from scratch? Results clearly suggest a positive impact of public support in R&D in creating these cooperation agreements. This could sound obvious, but what is new is how effective this effort is since the number of agreements rise because of public help. Again, transaction cost including information gaps seems to be reduced due to this support.

The question is now on the efficiency side. Supporting directly R&D and/or technical cooperation rather than the institutions themselves may deliver better results. Recently an R&D tax credit law passed in Chile. The major difference with other tax exemption initiatives is that the research must be done between the beneficiary firm and a certified scientific centre. What the exception covers is an estimation of the transaction cost.

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Annex

Variable Definitions

- Easy Imitation: Variable which takes values of 0 if possible imitation is not an important obstacle for innovating, and takes values between 1 (low) and 4 (high) when imitation is declared to be an obstacle for innovating. It was rescaled between 1 (highly relevant) and 0 (not relevant).

- Incoming Spillovers: Variable which takes values of 0 if innovation ideas are not originated by Professional conferences, exhibitions, meetings and journals, and takes values between 1 (low) and 4 (high) when this activities are declared to be sources for innovating ideas. Rescaled between 1 (high) and 0 (not relevant).

- 'Basicness' of R&D: Variable which takes values of 0 if innovation ideas are not originated by institutional sources (Universities, Public Research Centres, etc.) and takes values between 1 (low) and 4 (high) when institutional sources are declared to be important for generation innovative ideas. Rescaled between 1 (high) and 0 (not relevant).

- Lack of Information: Variable which takes values of 0 if lack of information is not an obstacle, as declared by the firm, for the innovative process, and takes values between 1 (low importance) and 4 (high importance) when the lack of information is an obstacle for innovating. Rescaled between 0 (not relevant) and 1 (high).

- Legal Protection: Variable that takes values of 0 if the firm has no patents or know-how agreements and 1 in other case.

- Cooperation: Variable which takes values of 0 if the firm did not cooperate in innovative activities with any other agent (like suppliers, clients, competitors, consultants, universities, research institutes) and takes values of 1 if the firm declared to cooperate with at least one of the agents mentioned above.

- Cooperation with competitors: Variable which takes values of 1 when the firm has declared to cooperate in innovative activities with at least one of its competitors, and takes value 0 in other case.

- Cooperation with Consultants: Variable which takes values of 1 when the firm has declared to cooperate in innovative activities with private consultants or R&D laboratories, and takes values of 0 in other case.

- Cooperation with Suppliers or Customers: Variable which takes values of 1 when the firm has declared to cooperate in innovative activities with its suppliers or customers, and takes value 0 in other case.

- Cooperation with Universities: Variable which takes values of 1 when the firm has declared to cooperate in innovation activities with universities or public research institutes, and takes value 0 in other case.

- Cost-Risk: A variable constructed with the sum of the importance of the following declared obstacles for innovation: Difficulty of finding finance sources; High cost of innovate; High perceived risk; Payback period too long. The values of this variables are between 0 (not relevant) and 4 (very important obstacle), so the variable constructed had values between 0 and 16. The variable constructed was rescaled between 0 (not relevant) and 1 (highly relevant).

- Industry Level Imitation: Mean of the variable 'Easy Imitation' for each industry. The industry has been defined with a 2-digit classification.

- Industry Level of Incoming Spillovers: Mean of the variable 'Incoming Spillovers' for each industry. The industry has been defined with a 2-digit classification.

- Industry Level of Legal Protection: Mean of the variable 'Legal Protection' for each industry. The industry has been defined with a 2-digit classification.

- Industry Level of Cooperation: Mean of the variable 'Cooperation' for each industry. The industry has been defined with a 2-digit classification.

- Industry Level of Cooperation with Competitors: Mean of the variable 'Cooperation with Competitors' for each industry. The industry has been defined with a 2-digit classification.

- Industry Level of Cooperation with Consultants: Mean of the variable 'Cooperation with Consultants' for each industry. The industry has been defined with a 2-digit classification.

- Industry Level of Cooperation with Suppliers or Customers: Mean of the variable 'Cooperation with Suppliers or Customers' for each industry. The industry has been defined with a 2-digit classification.

- Industry Level of Cooperation with Universities: Mean of the variable 'Cooperation with Universities' for each industry. The industry has been defined with a 2-digit classification.

- R&D Intensity 2004: Ratio between intramural R&D expenditures and turnover.

- Size: Logarithmic function of 'number of employees' of the firm. This variable includes the contracted and sub-contracted workers.

- Size squared: square of the variable 'Size'.

III. Innovation and Cooperation: Evidence from the Brazilian Innovation Survey

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Abstract

Innovative Cooperation is regarded as an interesting alternative for a firm that is trying to improve its innovating performance in the market. Since the 1980s there has been an increase in cooperative activities between firms and institutions. The size, the sector, the appropriability regime, and the types of partners are investigated as motivating elements of the cooperative activities in the innovative firms. Based on data from PINTEC 2005, the aim of this study is to identify the reasons why Brazilian firms engage in innovative cooperation emphasizing the relation between the type of partners and the choice of cooperation for innovation.

1. Introduction

During the last decades, the intensification of the innovation-based competition process among firms and the consequent acceleration of R&D efforts have stimulated firms to adopt increasingly aggressive innovative strategies. In this context, innovative cooperation between different institutions can be considered an important way for firms to carry out technological activities in order to remain in a good position in market leadership.

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Since the beginning of the 1960s there has been an increase in the number of firms using innovative cooperation strategies. However, it is in the decades after the 1980s where the biggest increase in cooperative activities can be observed, when it became clear to firms that their internal expertise were no longer enough to obtain an innovative insertion in the market (Hagedoorn, 2002). Thus, cooperative activities started to represent opportunities of access to knowledge and complementary technological resources to accelerate the innovating process of the firm as well as to cost and risk sharing (Faria and Schmidt, 2007).

Facing this reality, many authors have been trying to identify, through empirical studies, the motives that lead to cooperative activities for innovation among firms and different institutions, such as universities, research institutions, clients and/or suppliers.

The aim of this paper is to identify the factors that lead Brazilian innovative firms to innovative cooperation, emphasizing the relation between the type of partners for cooperation (firms, universities, research centers, clients and suppliers) and the reasons for the choice of this strategy by Brazilian manufacturing industry.

To reach this objective, this article has been divided into 5 sections. Section 2 brings a brief review of literature on innovative cooperation, emphasizing the elements that motivate the company to choose the cooperation strategy for innovation. Section 3 presents some characteristics of innovative firms that cooperate in Brazil, taking into account the size of the companies and the industrial sectors they operate in. Section 4 shows the econometrical model which is adopted, some the characteristics of the sample and the results obtained during the study that was carried out to identify the variables that lead the firm to the decision to cooperate, and to show the correlation between these variables and the type of partners. And finally, in section 5, some conclusions of this study are presented.

2. Literature review

The innovative cooperation may be regarded as a fairly fast and efficient way for a firm to get external technological expertise and, thus, attempt to become a market leader in the field of technology.

Since the 1980s, and more intensely in the 1990s, innovative cooperation activities have become very popular especially in the sectors of biotechnology and information technology (Hagedoorn, 2002). Based on this, with the aim to identify which elements are related to the decision of the firm to cooperate with other companies, universities, clients and suppliers, to engage in innovative activities, there has been an expressive increase in empirical studies on this phenomenon (Tether, 2002; Cassiman and Veugelers, 1999, 2002; Negassi, 2004; Schmidt, 2005).

Hagedoorn (1993) systemizes the specific motives of a firm to carry out R&D activities. Box 1 presents some motives that justify innovative cooperation: to obtain scale and scope benefits in R&D, the need to incorporate complementary technology, costs sharing in R&D projects, absorption of the partner's tacit knowledge and reduction of the innovation cycle.

BOX 1
AN OVERVIEW OF MOTIVES FOR (STRATEGIC)
INTERFIRM TECHNOLOGY COOPERATION

I. Motives related to basic and applied research and some general characteristics of technological development:

-Increased complexity and intersectoral nature of new technologies. Cross-fertilization of scientific disciplines and fields of technology, monitoring of evolution of technologies, technological synergies, access to scientific knowledge or to complementary technology;

- Reduction, minimizing and sharing of uncertainty in R&D;

- Reduction and sharing of costs of R&D.

II. Motives related to concrete innovation processes:

- Capturing of partner´s tacit knowledge of technology, technology transfer, technological leapfrogging;

- Shortening of product life cycle, reducing the period between invention and market introduction.

III. Motives related to market access and search for opportunities:

- Monitoring of environmental changes and opportunities;

- Internalization, globalization and entry to foreign markets;

- New products and markets, market entry, expansion of product range.

Source: Based on Hagedoom (1993, p. 373)

With the objective to find new elements that explain the motivation of firms to cooperate, besides the motives presented by Hagedoorn (1993), authors such as Tether (2002) defend the thesis that innovative cooperation is more closely related to the type of innovation the firms carry out than to their characteristics. Based on data from innovative firms in the United Kingdom, the author presents evidence that firms which concentrate on radical innovation are more involved in cooperation and innovation than firms that concentrate on the development of incremental innovation.

Cassiman and Veugelers (2002) advance the debate and test the hypothesis that the decision of a firm to cooperate with other institutions is partly based on the flow of information that enters and leaves the firm. They show that in order to take advantage of this information flow, the firms need internal technological expertise, specifically R&D expertise. They consequently discuss the existence of complementarity (or replacement) between internal and external R&D resources presented by the choice of the company between "making or buying" R&D activities (Veugelers and Cassiman, 1999).

These authors show that firms which are more likely to cooperate are those who have the knowhow to efficiently receive and use the external expertise. The debate is based on the concept of "the absorption capacity" developed by Cohen and Levinthal (1989) which they define as the capacity of a firm to incorporate and successfully use the flow of external information or spillovers for the development of innovative activities for its own benefit.

With the aim to advance this debate, Cassiman and Veugelers (2002) built a model to identify to what extent the "incoming spillovers variable" and the "appropriability variable" affects the probability of a firm to cooperate with innovative activities, based on data for firms of the Belgian Community Innovation Survey. In this survey they come to the conclusion that "incoming spillovers" and "appropriability" affects the propensity of the Belgian companies to cooperate with R&D and also affirm that the effects of these variables can be different when the types of cooperative partners are taken into account.

Similar to the work done by Cassiman and Veugelers (2002), Schmidt (2005) analyses the R&D cooperation determiners for the German firms, based on data from the Third Community Innovation Survey (CIS 3). Not only does the author find a positive relation between the flow of

expertise and cooperative activities, but he also tests the hypothesis that the choice to cooperate is related to the type of partnership that is established. Based on this it can be observed that firms with a big intramural innovative capacity are more likely to cooperate with universities and research institutions than with suppliers or clients.

In the several researches that have been done, Veugelers and Cassiman emphasize that in order to understand the motives of a firm to cooperate, it is essential that its heterogeneity is taken into account. Firstly they consider the important factors that affect the probability of a firm to engage in innovative cooperation as well as the size of the firm and the industrial sector it operates in.

Regarding the size of the firm, a positive relation between innovating and size is considered. (Dachs et al, 2004). Veugelers and Cassiman (1999) have found evidence in his study that big Belgian firms that employ more than 500 workers, are more likely to carry out internal innovative activities and, at the same time establish cooperation partnerships, while small firms choose to carry out exclusively internal innovative activities, or to buy externally; in other words they cooperate to innovate.

Besides the company size variable, it is suggested that the decision to cooperate and innovate also depends on the characteristics of the industry. The industrial sector variable plays an important role in the process of understanding the behavioural dimensions of the firms as regards the probability to cooperate, such as technological opportunities of the firms and the cumulativity of expertise. (Veugelers and Cassiman, 1999; Tether, 2002)

Besides considering variables such as company size and industrial sector, these authors also include in their analyses the appropriability conditions as choice determiners for the firm to cooperate or not. However, there is little consensus in the international literature regarding the relationship between appropriability and cooperation.

Cassiman and Veugelers (2002) continue the debate and create an appropriability indicator considering two types of protection: legal protection, such as patents and copyrights; strategic protection, such as secrecy and complexity. Using a probabilistic model, the authors conclude that the more developed the appropriability capacity of a firm is, the more likely this firm is to cooperate with clients and suppliers. However no evidence about the decision to cooperate with universities or research centers is found in the research.

Thus, a new point of discussion is brought up: is the type of partner relevant to explain the reasons for a firm to opt for innovative cooperation?

Tether (2002) believes that understanding the motives for cooperation is related to the identification of the type of partner. Belderbos et al (2005) also regard the type of partner as an essential element to understanding the motives of firms for R&D cooperation. They conclude that firms who cooperate with competitors and suppliers focus on incremental innovation and productivity growth, while firms that cooperate with universities and research centers concentrate on radical innovation to increase market sales of products and services.

Some authors like Faria and Schmidt (2007) investigate which factors specifically induce companies to cooperate with foreign partners, located in other countries to carry out innovative activities. They find that German firms with external insertion are more likely to cooperate with foreign partners. Dachs et al (2004) test the same hypothesis as export firms, in other words, those who operate on the international market

Another element presented in the literature is related to the stimulating role of the government in projects of cooperation by means of policies aiming at firms that are interested in making partnerships. Negassi (2004) carries out a micro econometrical study with 3,801 firms in France, between 1990 and 1996, 46% of which were classified as innovative in this period. The author shows an increase in the number of companies engaging in cooperative activities with other companies when supported by the government. In this debate, Dachs et al (2004) stands out for being one of the few studies in the literature that presents no evidence of a positive relation between the participation of governmental R&D plans and an increase in cooperative activities among firms.

In the following sections, this paper intends to describe the characteristics of innovative firms that cooperate in Brazil and to identify the motives that induce firms to engage in innovative cooperation activities. Based on this, the paper also aims to identify the existence of a relation between appropriability and cooperation as well as to investigate whether the type of partner (other firms, universities, research centers, clients and/or suppliers) influences the choice of firms to cooperate in innovation.

3. Characterization of innovative firms and (others) those that cooperate to Brazilian innovation

Based on the theoretical referential regarding the motives for cooperation for innovation presented in the previous section, the aim of this section is to characterize the profile of the firms that are considered to be innovative and carry out activities of cooperation for the innovation of the Brazilian Industry of transformation, by means of empirical research.

The analysis is based on data collected during the Research of Technological Innovation (PINTEC 2005) for the Brazilian firms between 2003 and 2005. The concept of "innovative firm" is used for firms, which between 2003 and 2005, carried out innovation activities aimed at the product and, or the process. In Brazil, PINTEC (Pesquisa Industrial de Inovação Tecnológica /Industrial Technological Innovation Survey), from IBGE (Brazilian Institute of Geography and Statistics), is a survey that collected information on technological innovation of Brazilian industrial enterprises, which follows the methodology by the "Oslo Manual".

This Brazilian survey contains information about: (1) the characteristics of firms and their innovative efforts (expenditures for innovative activities, expenditure of internal and external R&D, acquisition of R&D, if the firm has R&D department, the qualification of the employees, etc.); (2) the kind of innovation (to the market or only to firm); (3) if the firm realized some cooperation and the partners, 4) if the firm participated of the some public policy in order to finance the innovative activities, etc.

It must also be clarified that according to PINTEC "cooperation and innovation" are regarded as the participation of the firm in R&D projects as well as projects of innovation in cooperation with other organizations, firms or institutions, which does not imply that those who are involved obtain instant commercial benefits. It can be verified in the literature on this subject that the type of partner is of great relevance to explain the accomplishment of this activity. This study considers 3 types of partners for cooperation:

(a) Cooperation with (S&T) Scientific and Technological infrastructure, such as universities and other research centers;

(b) Cooperation with other firms, including cooperation with suppliers, clients   and other institutions that are not part of the group.

(c) Cooperation with firms of the group

In order to be part of a group of studies coordinated by CEPAL, a sectoral classification that is different from the one used by PINTEC is employed, in other words, the 23 constituent industrial sectors of the National Classification of Economic Activities (CNAE) are aggregated in 14 sections as shown in Box 2.

BOX 2
SECTORAL CLASSIFICATION

SECTORS CLASSIFICATION – STUDY 14 sectors	SECTORS PINTEC – CNAE – BRAZIL 23 sectors
D.3: shoes and leather products	Shoes and leather products
D.4: wood and paper	Wood
	Paper
	Furniture
D.5: edition and impression	Edition and impression
D.6: oil and derivatives	Oil and derivatives
D.7: chemical	Chemical (excluded pharmaceuticals)
D.8: pharmaceuticals	Pharmaceuticals
D.9: minerals no metals	Minerals no metals
	Metallurgy
D.10: metals products	Metals products
D.11: machinery	Machinery
	Office Equipment
	Precision Equipments to hospitals and to industrial automation
D.12: electrical machines	Electrical machines
D.13: transportation material	Transportation material
D.14: others manufactures n.e.c.	Plastic and rubber products
	Electronic products to communication
	Recycling
D.1: foods, drinks and tobacco	Foods and Drinks
	Tobacco
D.2: textiles and clothes	Textile
	Clothes and accessories

Source: Own elaboration.

According to the results presented at PINTEC 2005, the Brazilian Transformation Industry predominantly consists of non-innovative firms. It can be verified in chart 1 that of the 12,009 firms present in the research about 50% (5,964 firms) can be regarded as innovative firms. Among these firms a small number declares to have carried out cooperation activities, irrespective of the partner between 2003 and 2005, or in other words, 15.2 % of the innovative firms cooperate with R&D.

The most distinguished types of partners for cooperation are industries, such as suppliers, clients and other firms out of the group with 12.14 % of the innovative firms, or in other words, 724 innovative firms are involved in this type of cooperation. In second place is the cooperation with Scientific and Technological infrastructure (S&T) (490 firms) representing 8.22 % of the innovative firms. The least representative type of partners are the firms of the group (283 firms) with a participation of 4.75 % of the innovative companies.

TABLE 1
CHARACTERIZATION OF INNOVATIVE BRAZILIAN FIRMS
THAT COOPERATE - PINTEC 2005
(Number and Participation)

	Number and (%)
Firms (Observations)	12,009
Innovative firms (% all firms)	5,964 (49.66)
Cooperating Firms (% of innovative firms)	907 (15.21)
Cooperating with STI (% of innovative firms)	490 (8.22)
Cooperating with other firms (% of innovative firms)	724 (12.14)
Cooperating with firms of the group (% of innovative firms)	283 (4.75)

Source: Own elaboration.
Note: This includes cooperation with suppliers, clients or other firms outside the group. It includes competitors.

Initially, it is important to comprehend the Brazilian specificities about the innovative behaviour of the Brazilian firms, and then to discuss about the motives that firm choice to cooperate in innovation. Some studies analyzing the innovation of Brazilian manufacturing firms suggest that their technological behaviour is related to sector, technical system of production, capital foreign and size (Kupfer and Rocha, 2005; Kannebley Jr, Porto and Pazzelo, 2004)

The innovation rhythm of Brazilian industry presents specificity by sectors, because it is more related with the sector than OECD countries. The R&D activities in Brazil are concentrated on sectors intensives in scale (including foods, textile, and shoes) with specialized suppliers of mechanical and electrical machinery (Zucoloto and Toneto, 2005).

Table 2 shows the heterogeneity about the innovative and cooperative behaviour by sectors. The 907 firms that cooperate with some type of partner (15.21% of the innovative firms) are distributed in 14 industrial sectors as shown in table 2. This table presents in decreasing order the pharmaceutical sector (D8), the chemistry sector (D7), and the Transportation material sector (D13) as the sectors that most carry out most cooperation activities, irrespective of the partner, among the innovative firms, with participations of 28.68%, 27.18%, and 23.70% respectively.

TABLE 2
PARTICIPATION OF THE INNOVATIVE FIRMS THAT
COOPERATE BY ACTIVITY SECTOR

	Innovative Firms (A)	Cooperative Firms (B)	% (B) / (A)
D.1: foods, drinks and tobacco	939	128	13.63
D.2: textiles and clothes	642	44	6.85
D.3: shoes and leather products	276	33	11.96
D.4: wood and paper	712	63	8.85
D.5: edition and impression	192	23	11.98
D.6: oil and derivatives	66	9	13.64
D.7: chemical	379	103	27.18

(continued)

Table 2 (concluded)

	Innovative Firms (A)	Cooperative Firms (B)	% (B) / (A)
D.8: pharmaceuticals	136	39	28.68
D.9: minerals no metals	437	78	17.85
D.10: metals products	383	39	10.18
D.11: machinery	706	124	17.56
D.12: electrical machines	223	49	21.97
D.13: transportation material	346	82	23.70
D.14: others manufactures n.e.c.	527	93	17.65
Total Firms	5,964	907	15.21

Source: PINTEC 2005.

Regarding the size of the firms that innovate and carry out cooperation activities in order to innovate, it can be verified, through table 3, that the PINTEC sample mostly concentrates on small firms. Of the 5,964 innovative firms, 2,648 employ less than 100 workers, and the 1,186 firms with more than 500 employees are innovative firms.

Verifying the participation of the cooperating innovative firms, in relation to the total number of innovative firms, it can be noticed that the large firms have much greater participation. Among the innovative firms, the cooperative firms represent about 39% of these firms.

TABLE 3
PARTICIPATION OF THE INNOVATIVE FIRMS THAT COOPERATE BY SIZE

By Size (Number of Employees)	Innovative Firms (A)	Cooperative Firms (B)	% (B) / (A)
10 – 49	1,551	98	6.3
50 – 99	1,097	94	8.5
100 – 249	1,306	145	11.10
250 – 499	824	109	13.23
> 500	1,186	461	38.87
Total Firms	5,964	907	15,21

Source: PINTEC 2005.

An important indicator that shows the internal effort to carry out innovative activities and which must be considered refers to the number of workers participating in R&D activities in relation to the total number of workers of the firm. Considering the total number of firms in this research, the number of workers engaged in innovative activities in innovative firms is 0.46% of the total number, whereas in cooperating innovative firms this number reaches 1.28%, or in other words, the ratio of workers engaged in innovative activities in cooperative firms is about 1/100.

In chart 4 it can be observed that the ratio of workers engaged in R&D activities to the total number of workers of the firm shows similar characteristics in all the sectors: in the cooperating innovative firms the ratio of workers engaged in cooperative activities is superior to that of the innovative firms. This can be justified by the fact that cooperating firms show greater internal innovative efforts than other firms which characterizes cooperative activities as complementary activities of the internal effort and not as replaceable activities.

However, an important heterogeneity should be emphasized among the sectors of the Brazilian transformation Industry. According to chart 4 it can also be observed that the cooperating innovative firms among all the sectors show distinct characteristics as regards this relation.

TABLE 4
NUMBER OF EMPLOYEES (NE) IN R&D IN RELATION TO THE TOTAL NUMBER OF EMPLOYEES OF INNOVATIVE FIRMS AND INNOVATIVE FIRMS THAT COOPERATE

Sector	Innovative Firms	Cooperative Firms
	NE R&D / NE Total (%)	NE R&D / NE Total (%)
D.1: foods, drinks and tobacco	0.16	0.31
D.2: textiles and clothes	0.06	0.32
D.3: shoes and leather products	0.05	0.14
D.4: wood and paper	0.15	0.40
D.5: edition and impression	0.15	0.51
D.6: oil and derivatives	0.82	2.06
D.7: chemical	1.30	1.96
D.8: pharmaceuticals	1.06	1.53
D.9: minerals no metals	0.31	0.84
D.10: metals products	0.29	0.69
D.11: machinery	1.11	2.22
D.12: electrical machines	0.95	1.84
D.13: transportation material	1.46	2.42
D.14: others manufactures n.e.c.	0.71	2.03
Total Firms	0.463	1.28

Source: PINTEC 2005.

Another indicator of the internal efforts is the expenditure on internal activities of R&D in relation to the total expenditure on innovative activities. In most of the industrial sectors the amount spent on internal activities of R&D in relation to the total amount is superior in cooperative firms; 29.4% in cooperative firms and 20.9% in non-cooperative firms. According to chart 5, it can be confirmed that cooperative firms a priori already carry out internal efforts of R&D.

TABLE 5
EXPENDITURE ON INNOVATIVE ACTIVITIES AND EXPENDITURE ON INTERNAL ACTIVITIES OF R&D IN INNOVATIVE FIRMS THAT COOPERATE
(R$ 1,000 and %)

Sector	Innovative Firms			Cooperative Firms		
	Innovative Activities Total (1000 R$) (A)	Internal R&D Activities (1000 R$) (B)	% (B) / (A)	Innovative Activities Total (1000 R$) (C)	Internal R&D Activities (1000 R$) (D)	% (C) / (D)
D.1: foods, drinks and tobacco	4,080,727.41	314,342.67	7.70	1,538,532.06	158,985.60	10.33
D.2: textiles and clothes	1,011,253.69	90,037.28	8.90	108,244.94	36,314.46	33.55

(continued)

Table 5 (concluded)

Sector	Innovative Firms			Cooperative Firms		
	Innovative Activities Total (1000 R$) (A)	Internal R&D Activities (1000 R$) (B)	% (B) / (A)	Innovative Activities Total (1000 R$) (C)	Internal R&D Activities (1000 R$) (D)	% (C) / (D)
D.3: shoes and leather products	555,855.44	66,597.29	11.98	210,420.98	51,900.67	24.67
D.4: wood and paper	1,915,893.84	192,052.87	10.02	802,127.34	83,403.12	10.40
D.5: edition and impression	660,768.47	18,769.29	2.84	188,645.16	5,336.83	2.83
D.6: oil and derivatives	1,764,080.34	949,922.28	53.85	1,559,903.08	942,172.06	60.40
D.7: chemical	2,914,088.56	683,912.97	23.47	1,639,356.98	466,722.14	28.47
D.8: pharmaceuticals	1,038,727.35	180,462.22	17.37	510,973.24	110,345.27	21.60
D.9: minerals no metals	3,008,976.01	289,820.63	9.63	1,598,899.36	193,082.52	12.08
D.10: metals products	1,231,921.15	87,183.55	7.08	260,177.10	22,450.62	8.63
D.11: machinery	3,581,692.60	694,764.54	19.40	1,963,561.59	375,146.23	19.11
D.12: electrical machines	1,052,513.75	394,837.89	37.51	764,350.98	316,519.86	41.41
D.13: transportation material	7,445,695.44	2,466,724.41	33.13	5,629,171.96	1,997,044.71	35.48
D.14: others manufactures n.e.c.	3,462,499.69	605,925.50	17.50	1,212,185.28	345,156.51	28.47
Total Firms	33,724,693.73	7,035,353.38	20.90	17,986,550.06	5,104,580.61	29.40

Source: PINTEC 2005.

As it was mentioned before, it is important to consider the type of cooperating partner to better understand the behaviour of the Innovative firms in Brazil, as shown in table 6.

Firms employing more than 500 workers represent the largest participation among the innovative firms. This group of firms concentrates the major number of cooperative firms, and the most important partner to cooperation is other firm (31.7%) than the cooperation with firms of the group (17.6%).

Firms that employ no more than 50 workers carry out more cooperative activities with other firms, such as suppliers and clients (5.0%).This group of firms presents a distinguishing participation in the cooperation with institutions of S&T (3.5%) and in the cooperation with firms of the group (0.6%). (Table 6)

TABLE 6
CHARACTERIZATION OF THE BRAZILIAN INNOVATIVE FIRMS
THAT COOPERATE BY TYPE OF PARTNER AND BY SIZE
(Number and Participation)

By Size *(Number of Employees)*	Number and % of innovative firms *(total firms)*	Number and % of cooperative firms *(on innovative firms)*	Number and % of coop firms with S&T institutions *(on innovative firms)*	Number and % of coop firms with other firms (i) *(on innovative firms)*	Number and % of coop firms with other firms of the group *(on innovative firms)*
10 – 49	1,551 (33.2%)	98 (6.3%)	54 (3.5%)	77 (5.0%)	9 (0.6%)
50 – 99	1,097 (45.0%)	94 (8.6%)	31 (2.8%)	77 (7.0%)	15 (1.4%)
100 – 249	1,306 (60.0%)	145 (11.1%)	68 (5.2%)	114 (8.7%)	29 (2.2%)
250 – 499	824 (67.4%)	109 (13.2%)	53 (6.4%)	80 (9.7%)	26 (3.2%)
> 500	1,186 (79.2%)	461 (38.9%)	284 (23.9%)	376 (31.7%)	204 (17.2%)

Source: PINTEC 2005.
Note: (i)This includes cooperation with suppliers, clients or other firms outside the group. It includes competitors.

Table 7 shows the importance of the sector when choosing the innovative firms by the type of cooperative partner. As to cooperation with infrastructure of S&T the distinguishing sectors are the Chemical sector and the Transport Material sector with participations of 14.4% and 12.7% respectively. Regarding the cooperation with firms of the group, the Petrol sector and the Electrical Equipment sector are the most outstanding with participations of 5.5% and 5.2% respectively

TABLE 7
CHARACTERIZATION OF THE BRAZILIAN INNOVATIVE FIRMS
THAT COOPERATE BY TYPE OF PARTNER AND BY SECTOR
(Number and Participation)

Sector	Number and % of innovative firms *(total firms)*	Number and % of cooperative firms *(on innovative firms)*	Number and % of coop firms with S&T institutions *(on innovative firms)*	Number and % of coop firms with other firms (i) *(on innovative firms)*	Number and % of coop firms with other firms of the group *(on innovative firms)*
D.1: foods, drinks and tobacco	3,789 (32.5%)	251 (6.6%)	106 (2.8%)	211 (5.6%)	48 (1.3%)
D.2: textiles and clothes	4,784 (29.3%)	141 (3%)	53 (1.1%)	137 (2.9%)	10 (0.2%)
D.3: shoes and leather products	1,490 (32.7%)	101 (6.8%)	69 (4.6%)	95 (6.4%)	5 (0.4%)
D.4: wood and paper	4,309 (30.9%)	126 (2.9%)	44 (1%)	100 (2.3%)	15 (0.4%)
D.5: edition and impression	1,451 (36.5%)	36 (2.5%)	13 (0.9%)	33 (2.3%)	8 (0.6%)
D.6: oil and derivatives	103 (50,1%)	11 (11.1%)	9 (8.3%)	5 (4.4%)	6 (5.5%)
D.7: chemical	1,574 (49.5%)	254 (16.2%)	115 (7.3%)	226 (14.4%)	55 (3.5%)
D.8: pharmaceuticals	326 (52.4%)	60 (18.4%)	41 (12.6%)	40 (12.4%)	7 (2.1%)
D.9: minerals no metals	2,234 (27.5%)	193 (8.6%)	155 (7%)	168 (7.5%)	35 (1.6%)
D.10: metals products	2,668 (31.1%)	173 (6.5%)	48 (1.8%)	128 (4.8%)	12 (0.4%)
D.11: machinery	3,055 (44.1%)	288 (9.4%)	147 (4.8%)	261 (8.5%)	41 (1.3%)
D.12: electrical machines	865 (45.7%)	109 (12.6%)	56 (6.5%)	50 (5.8%)	45 (5.2%)
D.13: transportation material	1,024 (36.5%)	144 (14.1%)	47 (4.6%)	130 (12.7%)	50 (4.9%)
D.14: others manufactures n.e.c.	2,280 (35.5%)	250 (11%)	142 (6.2%)	154 (6.8%)	34 (1.5%)

Source: PINTEC 2005.

4. Econometric evidence

Based on the profile description of the innovative firms that cooperate, by the size of the firms and the industrial sectors, made in the previous item, this section presents the results of the econometric study carried out in order to identify the variables that affect the decision of the firm to cooperate and how this differs when different types of partners are considered. These variables emphasize the relation between the appropriability strategies of the firms, such as their methods of protection, brands and patents and the decision to cooperate with universities, other firms and with the group they belong to.

4.1 Methodological procedures

The employment of the Probit model aims to estimate probabilities that may occur during a certain event. In this study the model aims to estimate the probability of firms engaging in activities of cooperation.

Four models were built with the following dependent variables:

- Model 1- Cooperation, regardless of the partner.

- Model 2- Cooperation with Science and Technology infrastructure.

- Model 3- Cooperation with Industries, companies out of the group such as suppliers, clients or competitors.

- Model 4- Cooperation with Firms of the Group.

The explanatory variables used in the models are divided into 3 groups: micro-characteristics of the firms, capabilities and obstacles. Among the characteristics of the firms are selected variables of size, age, origin of capital and engagement of the company in international commerce. The variables that embody the firms' capabilities include indicators of innovative efforts, number of employees of R&D/ Total number of Employees (skill), engagement in continuous activities of R&D, as well as result indicators such as the variable of appropriability (Aprop). The third group is composed of variables that show the obstacles to innovation, as regards the qualification of personnel and the identification of market opportunities (Box 3).

BOX 3
EXPLANATORY VARIABLES OF THE MODELS

Micro characteristics of the firms	
Age	Number of the years of the firm.
Size	ln (Number of employees).
Size2	ln (Number of employees)2.
Foreign Capital (FCap)	Dummy variable that takes the value 1 if the firm has more than 10% of foreign capital, 0 otherwise.
Export Coefficient (Exp)	Proportion of International sales on total of sales.
Capabilities	
Skills	Proportion of R&D employment on total number of employees.
R&D Continuous (Con)	Dummy variable that takes the value 1 if the firm realize R&D continuous activities and 0 otherwise.
Appropriability (Aprop)	Dummy variable that takes the value 1 if the firm asks and/or obtains patents in Brazil or in the rest of the world.
Differentiation / Novelty of innovation (Diff)	Dummy variable that takes the value 1 if the firm has obtained innovative results novel for the market (local, regional or international). It takes the value 0 if the firm obtained results novel only for the firm.
Sale Effort (SEffort)	Value of the investments of firm with marketing and efforts to sale.
Public Support (Pub)	Dummy variable that takes the value 1 if the firm has received public financial support for innovation activities and 0 otherwise.
Technological Opportunities on the S&T Infrastructure (TO1)	Dummy variable that takes the value 1 if the firm assigns high importance the external information on the S&T infrastructure and 0 otherwise.
Technological Opportunities on the Industry (TO2)	Dummy variable that takes the value 1 if the firm assigns high importance the external information on the Industry (Suppliers, Clients, Competitors) and 0 otherwise.
Technological Opportunities on the Group (TO3)	Dummy variable that takes the value 1 if the firm assigns high importance the external information on the Group and 0 otherwise.

(continued)

Box 3 (concluded)

	Constraints
Lack of qualified personnel (Qualif)	Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of qualified personnel, 0 otherwise.
Lack of access to finance (Finan)	Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of availability of financial resources, and 0 otherwise.
Lack of access to inform on technology (Techn)	Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of availability of information about technologies, and 0 otherwise.
Lack of access to information on markets (Mark)	Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of availability of information about markets and 0 otherwise.

Source: Own elaboration.

4.2 Characteristics of the sample

Initially, some characteristics of the analyzed sample are worth presenting. The firms of the sample that cooperate regardless of the partner have an average of 553 employees. When approached distinctively, this figure is even bigger, reaching the average number of 1.681 employees in the group of firms that cooperate for innovation with the group in which they participate.

Regarding the innovative effort of the firms of the sample it can be affirmed that in firms who cooperate with all the partners, on average, 8% of the employees are involved in activities of R&D. This percentage goes up to 10% when it concerns firms that cooperate with industries.

Only 12% of the cooperative firms could count with the financial support of the government to carry out innovative activities. The financial support of the government was the lowest among companies cooperating with infrastructure of S&T. (3%).

According to the result indicators of the innovation of the companies, only 18% of these firms follow some kind of appropriability strategy. Regarding the type of partners, firms that cooperate with other companies of the group show the highest percentage (14%).

TABLE 8
DESCRIPTIVE STATISTICS OF THE VARIABLES OF THE MODEL

Variable	Name		Cooperation with all partners	Cooperation with S&T institutions	Cooperation with Industry	Cooperation with Group
Size	Empl	Med	553.02	881.93	589.40	1,681.32
Skills	Skills	Med	0.08	0.05	0.10	0.09
Foreign Capital	Cap	%	28	21	13	20
Public Support	Pub	%	12	3	7	10
Differentiation	Dif	%	25	7	12	20
Appropriability	Aprop	%	18	5	9	14
Lack of access to finance	Finan	%	8	1	5	6
Lack of access to information on markets	Mark	%	11	2	7	8
Lack of access to inform on technology	Techn	%	9	1	7	8
Lack of qualified personnel	Qualif	%	7	1	3	5

Source: Own elaboration.

4.3 Discussion of the results

The results in chart 9 show 5 explanatory variables whose associated coefficients are statistically different from zero in the four models that are presented: size of the firm, differentiation, source of the capital, information about the infrastructure of S&T and obstacles to qualification of personnel.

The coefficient related to the size of the company variable, measured by the number of employees, is positive and statistically significant, which means that the bigger the company is, the greater the chances of cooperation are.

The differentiation strategy, measured by either the innovation of the product or the process for the market, presents a positive and statistically significant coefficient. This shows that the firms with a differentiation strategy have bigger chances to cooperate than firms that do not.

The coefficient related to the origin of the capital is positive and statistically significant, which means that if the firm possesses more than 10% of foreign capital, the bigger the chances to cooperate are.

All the models regard the information variable, obtained at the infrastructure of S&T and measured as an external source of information, as of high and average importance. The companies that consider this information as of high and average importance are more likely to cooperate for innovation.

The shortage of qualified labor also increases the chances of the firm to cooperate. This shortage is a relevant obstacle in the four models as the coefficients associated to this variable are positive and statistically significant. According to this result it may be assumed that firms engage in cooperative activities when unable to ensure themselves with intra-firma qualified labor, thus stimulating partnerships with other organizations.

Another variable which, except for model 4, presents a positive and statistically relevant coefficient is the financial support of the government. Firms that cooperate with infrastructure of S&T and with other firms are more likely to cooperate when receiving financial support from the government for innovative activities.

The appropriability variable presents, only in model 2, a coefficient which is positive and statistically significant. Firms that possess appropriability strategies are more likely to cooperate with infrastructure of S&T.

The R&D continuous variable changes its significance between the models. When only the cooperation between S&T infrastructure (model 2) and Group (model 3) is considered, this variable becomes positive and statistically significant. A hypothesis for this result is based on the fact that these kinds of cooperation are focused on basic research that needs a persistent effort on R&D.

Model 2 presents the age variable, which is measured by the period of existence of the firm. This variable presents a positive and statistically significant coefficient, which shows that older firms are more likely to cooperate with infrastructure of S&T. Another variable in this model is the skill variable measured by the employees taking part in R&D in relation to the total number of employees. The coefficient presented by this variable is positive and statistically relevant, thus showing that firms with more personnel involved in R&D in relation to the total number of employees are more likely to cooperate with S&T infrastructure.

Models 2 and 3 present the R&D variable with a positive coefficient which is statistically significant, showing that firms engaged in constant activities of R&D are more likely to cooperate with S&T infrastructure and with industry, clients, suppliers and competitors.

Table 9 presents the group as an essential external source of information. The result shows that firms who consider the group as an essential external source of information to be of high and average importance are more likely to cooperate with firms of the group.

TABLE 9
RESULTS OF THE PROBIT MODELS

	Independent Variables	Model 1	Model 2	Model 3	Model 4
		Cooperation with all counterparts	By type of partner		
			STI infrastructure	Industry	Group
Micro Characteristics of Firm	Intercept	-3.035 (0.359)***	- 4.220 (0.541) ***	-3.329 (0.338) ***	-3.455 (0.387)***
	Age	0.0000 (0.003)	0.006 (0.004)*	0.001 (0.003)	-0.006 (0.004)
	Size (ln n. employees)	0.170 (0.036)***	0.179 (0.044)***	0.129 (0.039)***	0.169 (0.053)***
	Size squared ((ln n employees)^2)	0.000 (0.0000)	0.000 (0.0000)	0.000 (0.0000)	0.000 (0.0000)
	Foreign Capital	0.331 (0.088)***	0.228 (0.103)**	0.191 (0.090)**	1.404 (0.116)***
	Export Coefficient	-0.191 (0.418)	0.022 (0.509)	-0.007 (0.419)	-0.730 (0.589)
Capabilities	Skills	0.272 (0.413)	0.945 (0.415)**	-0.436 (0.549)	0.045 (0.800)
	R&D Continuous	0.183 (0.114)	0.288 (0.148)**	0.202 (0.118) *	-0.019 (0.165)
	Appropriability	0.091 (0.080)	0.154 (0.095)*	0.120 (0.082)	0.088 (0.110)
	Differentiation	0.344 (0.083)***	0.319 (0.101)***	0.301 (0.086)***	0.433 (0.123)***
	Sale Effort	-0.031 (0.082)	0.054 (0.098)	0.009 (0.084)	0.148 (0.113)
	Inf S&T Infra	0.583 (0.082) ***	1.112 (0.112)***	0.477 (0.085)***	0.473 (0.118)***
	Inf Industry	0.251 (0.155) *	0.050 (0.191)	0.831 (0.196)***	0.062 (0.208)
	Inf Group	0.500 (0.290)*	0.033 (0.470)	0.341 (0.294)	0.480 (0.201)***
	Public support	0.144 (0.082)*	0.416 (0.094)***	0.136 (0.084)*	0.051 (0.114)
Constraints	Lack of qualified personnel	0.186 (0.102)*	0.234 (0.115)**	0.206 (0.102)**	0.271 (0.135)**
	Lack of access to finance	0.043 (0.125)	-0.034 (0.140)	0.047 (0.126)	-0.296 (0.172)
	Lack of access to info. On technology	0.029 (0.113)	-0.020 (0.128)	0.058 (0.114)	0.223 (0.152)
	Lack of access to information on markets	0.147 (0.121)	0.242 (0.133)	0.121 (0.121)	0.210 (0.154)

(continued)

Table 9 (concluded)

		Model 1	Model 2	Model 3	Model 4
	Independent Variables	Cooperation with all counterparts	By type of partner		
			STI infrastructure	Industry	Group
Statistics of Models	Pseudo-R2	0.1524	0.2534	0.1375	0.3134
	Observations	1.258	1.258	1.258	1.204
	Log Likelihood	-713.95921	-501.6066	-680.41664	-366.1449

Source: Own compilation.
*** significant at 1%.
** significant at 5%.
* significant at 10%.

Table 10 presents the marginal effects of the previously described Probit models. Through these results the marginal probability of each of the variables can be determined.

The appropriability variable, which is the aim of this study, presents non-conclusive results. In model 2 only is the associated coefficient positive and statistically significant. This shows that the chances to cooperate with S&T infrastructure increase by 3.6% when the firm adopts appropriability strategies. It must be stated, however, that even though no positive coefficients are presented in the other models, all variables show positive signs which demonstrates the absence of an inverted relation between the appropriability variable and the cooperation variable.

Model 1 shows that a 1% increase in size of the firm results in a 6.4% increase in probability to cooperate. Another important result is presented by the origin of capital variable. The chances of firms to cooperate for innovation increase by 12.7% when they own more than 10% of foreign capital. It is important to mention that firms who realize continuous R&D increase their chances to cooperate by 6.7% as demonstrated by the continuous R&D variable. Accordingly, firms that carry out differentiation strategies increase by 12% the chances to cooperate regardless of the type of partner. Regarding the government support variable, it can be concluded that support of the government implies in a 5.5% increase in the chances of the firm to cooperate with any kind of partner.

In Model 2, a 1% size increase of the company implies that its chances to cooperate increase by 4.1%. With regard to foreign capital, companies possessing more than 10% of foreign capital increase their chances to cooperate by 5.5%. The skill variable in model 2 shows that the chances of the firm to cooperate increase by 21.8% provided there is a 1% increase in employees engaged in R&D activities in relation to the total amount of employees. As for cooperation with S&T structure, support from the government for innovative activities, increases the chances of the firm to carry out this kind of cooperation by 10%.

The results in Model 3 show that chances of the firm to cooperate increase by 4.4% on assumption that the company increases its size in 1%. The origin of capital possessing more than 10% of foreign capital increases in 6.7% the chances of the firm to cooperate with other firms of the industry, such as clients, suppliers and competitors.

In Model 4, a 1%-size increase of the firm increases in 2.7% the probability of this firm to cooperate. The firm possessing foreign capital increases its chances to cooperate with the group it belongs to by 31.1%. The chances to cooperate in innovation decrease by 4% if the lack of financial support is regarded as of high or average importance by the firms of the group.

TABLE 10
MARGINAL EFFECTS OF THE MODELS

		Model 1	Model 2	Model 3	Model 4
	Independent Variables	Cooperation with all counterparts	By type of partner		
	Intercept		STI infrastructure	Industry	Group
Micro Characteristics of Firm	Age	0.000 (0.001)	0.001 (0.001)	0.000 (0.001)	-0.001 (0.001)
	Size (ln n. employees)	0.064 (0.014)***	0.041 (0.010) ***	0.044 (0.013) ***	0.027 (0.008)***
	Size squared ((ln n employees)^2)	0.000 (0.000)	0.000 (0.0000)	0.000 (0.0000)	0.000 (0.0000)**
	Foreign Capital	0.127 (0.034)***	0.055 (0.026)***	0.067 (0.032)**	0.311 (0.030)**
	Export Coefficient	-0.072 (0.158)	0.005 (0.1179)	-0.0027 (0.144)	-0.115 (0.093)
Capabilities	Skills	0.103 (0.156)	0.218 (0.096)**	-0.149 (0.188)	0.007 (0.127)
	R&D Continuous	0.067 (0.041)*	0.060 (0.028)**	0.067 (0.037)*	-0.003 (0.027)
	Appropriability	0.034 (0.030)	0.036 (0.022)*	0.041 (0.028)	0.014 (0.017)
	Differentiation	0.128 (0.030)***	0.072 (0.023) ***	0.102 (0.029) ***	0.066 (0.018)***
	Sale Effort	-0.012 (0.031)	0.012 (0.022)	0.003 (0.029)	0.023 (0.017)
	Inf S&T Infra	0.215 (0.029)***	0.240 (0.023)***	0.160 (0.028)***	0.066 (0.017)***
	Inf Industry	0.091 (0.053)*	0.011 (0.042)	0.219 (0.036)***	0.062 (0.208)
	Inf Group	0.169 (0.084)**	0.065 (0.075)	0.106 (0.080)	0.550 (0.201)*
	Public support	0.055 (0.031)*	0.100 (0.024)*	0.047 (0.029)	0.008 (0.450)
Constraints	Lack of qualified personnel	0.071 (0.039)*	0.057 (0.029)**	0.072 (0.036)**	0.046 (0.024) *
	Lack of access to finance	0.016 (0.048)	-0.008 (0.032)	0.016 (0.044)	-0.041 (0.021)**
	Lack of access to info. On technology	0.011 (0.043)	-0.005 (0.029)	0.020 (0.040)	0.038 (0.028)
	Lack of access to information on markets	0.056 (0.047)	0.060 (0.036) *	0.042 (0.043)	0.210 (0.029)

Source: Own compilation.
*** significative at 1%.
** significative at 5%.
* significative at 10%.

5. Final remarks

Innovative cooperation between different institutions to carry out innovative activities can be regarded as an important resource for a firm to remain in a market-leading position. However, as regards Brazil through results obtained during the PINTEC 2005, this strategy is still in its early stages. The transformation industry presents a small number of innovative firms (50%) of which only 15% cooperate in R&D.

Due to the interest in the motivating factors of innovative cooperation, several studies in the literature (Veugelers and Cassiman, 1999; Cassiman and Veugelers, 2002; Schmidt, 2005) emphasize the need to take the homogeneity of the firms into account. Among the important factors are the size of the firm, the industrial sector it operates in, the origin of its financial resources, the appropriability strategy of the firm and most importantly the type of cooperative partner.

The industrial sectors with the Brazilian transformation industry that contain the largest number of cooperating innovative firms are the pharmaceutical sector (D8), the chemistry sector (D7), and the Transport sector (D13), irrespective of the partner, among the innovative firms, with participations of 28.68%, 27.18%, and 23.70% respectively.

Bigger Brazilian firms present at the PINTEC 2005 cooperate more than smaller firms, or in other words, 50% of large innovative firms realize innovative cooperation. With respect to the type of partner, the Chemical and Transport sectors concentrate on cooperation with S&T Infrastructure. A hypothesis for this result is based on the fact that they concentrate on basic research done by these institutions.

Based on this scenario, the study carried out an econometric study similar the one realized in the international literature. The evidence found coincides in many aspects with the results obtained from other countries.

With respect to the size of the firm, as well as the results obtained by Veugelers and Cassiman (1999), Negassi (2004) and Fristch and Lukas (2001), the coefficient related to the size of the company variable, measured by the number of employees, is positive and statistically significant, which means that the bigger the company is, the greater the chances of cooperation are. It should be emphasized that Model 1 shows a 1% increase in size of the firm results in a 6.4% increase in probability to cooperate.

As shown by Cassiman and Veugelers (2005) to Belgian firms, for Model 2, the appropriability variable presents a positive and statistically significant coefficient. Firms that possess appropriability strategies are more likely to cooperate with infrastructure of S&T.

Another variable that was analyzed refers to continuous R&D as an option for cooperation. Negassi (2004) finds in his study that for Belgian firms the realization of continuous R&D activities increases the chances of the firm to cooperate. The author also states that these continuous R&D activities enable companies to absorb external expertise thus stimulating the choice to cooperate, following the concept of "the absorption capacity" of Cohen and Levinthal (1989).

The result obtained in Model 1 of this present study is similar to that found by Negassi (2004), as it shows that a 1% increase in size of the firm results in a 6.4% increase in probability to cooperate. Another important result is presented by the origin of capital variable. The chances of firms to cooperate for innovation increase by 12.7% when they own more than 10% of foreign capital. It is important to mention that firms who realize continuous R&D increase their chances to cooperate by 6.7% as demonstrated by the continuous R&D variable.

As regards the origin of resources as a determining factor for the choice to cooperate, the result obtained in model 3 shows that firms the possession of more than 10% of foreign capital, increases by 6.7% the chances of a firm to cooperate with other firms of the industry, such as clients, suppliers and competitors. In Model 4, the firm possessing foreign capital increases its chances to cooperate with the group it belongs to by 31.1%

Another variable that was tested in this study refers to public support, with results coinciding with those found by Negassi (2004) for French firms. Model 1 shows that support of the government implies in a 5.5% increase in the chances of the firm to cooperate with any kind of partner. As for cooperation with S&T structure, support from the government for innovative activities, increases the chances of the firm to carry out this kind of cooperation by 10%.

This paper contributes in an original way to the emerging debate on innovation and cooperation in emerging economies. New research is needed on the basis of new methods and better measures, and on the reasons and motivations which explain the scant performance in cooperation, especially in light of the prevailing specialization pattern. There is a need to increase the knowledge on the performance in cooperation and innovation in high tech sectors by SMEs and the role of appropriability gaps and lack of complementary assets in explaining the scant propensity to engage in cooperative activities.

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Annex

TABLE 1A
MARGINAL EFFECTS. COOPERATION WITH ALL PARTNERS

	dy/dx	Std. Err.	z	P>z	[95% Interv. Conf.]		X
Age	0.00	0.00	0.02	0.98	-0.02	0.00	28.67
Size (ln n. employees)	0.06	0.01	4.69	0.00	0.04	0.09	6.02
Size squared ((ln n employees)^2)	0.00	0.00	0.61	0.54	0.00	0.00	5900000
Foreign Capital	0.12	0.03	3.73	0.00	0.06	0.19	0.30
Export Coefficient	-0.07	0.16	-0.46	0.64	-0.38	0.24	0.07
Skills	0.10	0.15	0.66	0.51	-0.20	34.95	0.05
R&D Continuous	0.06	0.04	1.65	0.10	-0.01	0.15	0.81
Patenting	0.03	0.03	1.14	0.25	-0.02	0.09	0.51
Differentiation	0.12	0.03	4.21	0.00	0.07	0.19	0.57
Sale Effort	-0.01	0.02	-0.38	0.70	-0.00	0.05	0.57
Inf S&T Infra	0.21	0.03	7.42	0.00	0.15	0.24	0.57
Inf Industry	0.09	0.05	1.71	0.08	-0.01	0.19	0.92
Inf Group	0.17	0.08	2.01	0.04	0.00	0.33	0.95
Public support	0.05	0.03	1.76	0.08	-0.00	0.11	0.40
Lack of qualified personnel	0.07	0.04	1.81	0.08	-0.00	0.15	0.32
Lack of access to finance	0.01	0.05	0.34	0.73	-0.08	0.10	0.18
Lack of access to info. on technology	0.01	0.04	0.25	0.80	-0.08	0.09	0.22
Lack of access to info. on markets	0.05	0.05	1.20	0.23	-0.03	0.15	0.20

TABLE 1B
MARGINAL EFFECTS. COOPERATION WITH S&T INSTITUTIONS

	dy/dx	Std. Err.	z	P>z	[95% Interv. Conf.]		X
Age	0.00	0.00	1.63	0.10	0.00	0.00	28.67
Size (ln n. employees)	0.04	0.01	4.04	0.00	0.02	0.06	6.02
Size squared ((ln n employees)^2)	0.00	0.00	1.12	0.26	0.00	0.00	5900000
Foreign Capital	0.05	0.03	2.10	0.04	0.00	0.10	0.30
Export Coefficient	0.00	0.12	0.04	0.96	-0.23	0.24	0.07
Skills	0.22	0.09	2.28	0.02	0.03	0.40	0.05
R&D Continuous	0.06	0.03	2.17	0.03	0.06	0.12	0.82
Patenting	0.04	0.02	1.6	0.10	-0.00	0.08	0.51
Differentiation	0.08	0.02	3.24	0.00	0.03	0.12	0.56
Sale Effort	0.01	0.02	0.56	0.58	-0.03	0.05	0.57
Inf S&T Infra	0.25	0.02	10.46	0.00	0.19	0.28	0.56
Inf Industry	0.01	0.04	0.27	0.79	-0.07	0.09	0.924
Inf Group	0.06	0.07	0.86	0.39	-0.08	0.21	0.95
Public support	0.10	0.02	4.20	0.00	-0.06	0.13	0.05
Lack of qualified personnel	0.06	0.03	1.95	0.05	0.00	0.11	0.32
Lack of access to finance	-0.00	0.03	-0.24	0.80	-0.07	0.05	0.18
Lack of access to info. on technology	-0.00	0.03	-0.16	0.87	-0.06	0.05	0.22
Lack of access to info. on markets	0.06	0.04	1.69	0.09	-0.01	0.13	0.20

TABLE 1C
MARGINAL EFFECTS. COOPERATION WITH INDUSTRY

	dy/dx	Std. Err.	z	P>z	[95% Interv. Conf.]		X
Age	0.00	0.00	6.10	0.00	0.03	0.07	5.54
Size (ln n. employees)	0.04	0.01	1.13	0.26	0.00	0.00	6200000
Size squared ((ln n employees)^2)	0.00	0.00	1.63	0.10	-0.01	0.10	0.23
Foreign Capital	0.07	0.03	1.02	0.30	-0.02	0.08	0.22
Export Coefficient	-0.00	0.14	-0.30	0.76	-0.04	0.03	0.10
Skills	-0.15	0.18	0.23	0.81	-26.39	33.47	0.00
R&D Continuous	0.07	0.04	3.61	0.00	0.04	0.13	0.37
Patenting	0.04	0.03	5.40	0.00	0.08	0.16	0.48
Differentiation	0.10	0.02	6.45	0.00	0.10	0.18	0.76
Sale Effort	0.04	0.03	1.94	0.05	0.00	0.10	0.43
Inf S&T Infra	0.00	0.03	2.64	0.01	0.02	0.14	0.16
Inf Industry	0.16	0.03	0.26	0.79	-0.10	0.13	0.04
Inf Group	0.22	0.04	0.68	0.49	-0.08	0.16	0.05
Public support	0.05	0.03	-0.31	0.75	-0.10	0.07	0.07
Lack of qualified personnel	0.07	0.04	2.87	0.00	0.27	1.42	0.08
Lack of access to finance	0.02	0.04	1.94	0.05	0.00	0.12	0.32
Lack of access to info. on technology	0.02	0.04	-0.24	0.76	-0.05	0.05	0.18
Lack of access to info. on markets	0.04	0.04	-0.16	0.88	-0.05	0.04	0.22

TABLE 1D
MARGINAL EFFECTS. COOPERATION WITH GROUP

	dy/dx	Std. Err.	z	P>z	[95% Interv. Conf.]		X
Age	-0.00	0.00	-1.46	0.14	-0.00	0.02	28.62
Size (ln n. employees)	0.03	0.00	3.20	0.75	0.01	0.04	6.07
Size squared ((ln n employees)^2)	0.00	0.00	2.30	0.02	0.00	0.00	6200000
Foreign Capital	0.31	0.03	10.50	0.00	0.25	0.37	0.31
Export Coefficient	-0.11	0.09	-1.24	0.21	-0.29	0.07	0.07
Skills	0.01	0.13	0.06	0.95	-0.24	0.26	0.05
R&D Continuous	-0.00	0.03	-0.11	0.90	-0.05	0.05	0.85
Patenting	0.01	0.01	0.80	0.42	-0.02	0.05	0.52
Differentiation	0.07	0.02	3.69	0.00	0.03	0.10	0.58
Sale Effort	0.02	0.02	1.32	0.18	-0.01	0.06	0.58
Inf S&T Infra	0.06	0.02	3.86	0.00	0.03	0.10	0.57
Inf Industry	0.06	0.21	0.31	0.76	-0.05	0.07	0.93
Inf Group	0.55	0.21	0.78	0.43	-0.03	0.08	0.05
Public support	0.01	0.02	0.45	0.66	-0.02	0.04	0.42
Lack of qualified personnel	0.05	0.02	1.88	0.06	-0.02	0.09	0.32
Lack of access to finance	-0.04	0.02	0.48	0.63	-0.03	0.04	0.18
Lack of access to info. on technology	0.04	0.03	1.36	0.05	0.00	91.00	0.22
Lack of access to info. on markets	0.21	0.03	1.26	0.21	-0.02	0.09	0.20

Source: PINTEC 2005.

IV. Cooperation for innovation in the manufacturing industry in Mexico

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Abstract

Cooperation is of great importance to innovation. Empirical studies have focused mainly on the determinants of overall cooperation and by type of partner. The aim of this paper is to identify the main factors associated with cooperation for innovation in the manufacturing industry in Mexico, using firm-level data from the innovation survey, distinguishing between product and process innovation. This distinction provides original econometric results that contrast and complement the existing literature: size and appropriability are associated only with cooperation for process innovation, while sectoral specificities and origin of capital are significant only to explain cooperation for product innovation.

1. Introduction

The existing literature widely recognises that technical change is a collective activity and an outcome of interaction (Kline and Rosenberg, 1986; Johnson, 1992; Edquist, 1997; Fagerberg et al., 2005). As a result, cooperation between firms and suppliers, users, universities and research centres, among others, is of great importance to improve and create new products and processes (Lundvall 1992; Tether, 2002; Arundel and Geuna, 2004). The increasing microeconomic data available on innovation

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activities have spurred the elaboration of a wide array of empirical studies on the determinants of cooperation for innovation (e.g. Tether, 2002; Belderbos et al., 2004; Veugelers and Cassiman, 2005; Arranza and Fernández de Arroyabe, 2008), due to the dissemination of innovation surveys.

This paper aims to identify the main factors associated with cooperation for innovation in the manufacturing industry in Mexico, using firm-level data from the Mexican Innovation Survey (MIS) on manufacturing and services undertaken in 2001.[18] This survey provides information on firms that claimed to cooperate with other firms, universities and research centres, as well as data on firm's background characteristics (size, origin of capital, sector, etc.) and strategies (export activities, R&D intensity, use of external sources of knowledge, etc.).

The existing empirical literature has concentrated on studying the determinants of overall cooperation for innovation and the determinants by type of partner (e.g. Fritsch and Lucas, 2001; Leiponen, 2001; Cassiman and Veugelers, 2002; Tether, 2002; Belderbos et al, 2004; Bönte and Keilbach, 2005). Yet no efforts have been made to study the determinants of cooperation by type of innovation, distinguishing between product and process innovation. Empirical studies show that the determinants of product innovations differ importantly from those of process innovations (Cabagnols and Le Bas, 2002; Kannebley et al. 2005; Padilla-Pérez, 2006). In this line, the central hypothesis of this paper is that the determinants of cooperation for product innovation differ from those of cooperation for process innovation. The MIS, in contrast to other national innovation surveys in Latin America (e.g. Argentina, Brazil, Chile and Uruguay), provides information to study the factors associated with cooperation for innovation, distinguishing by type of innovation.

This study relies on descriptive statistics and econometrics to analyse background characteristics and strategies of innovative firms, and how these factors relate to cooperation for innovation. Previous studies on innovation and technological capabilities in Mexico (e.g. Cimoli, 2000; Padilla-Pérez, 2006; Garrido and Padilla, 2009 show that product and process innovations are not very common in the manufacturing industry. Other studies show a high level of concentration of the innovation activity in a few large local and foreign firms, at the same time that small and medium-sized enterprises (SMEs) conduct scant innovation activities. The evidence presented in this study confirms that collaboration for product or process innovations between firms and universities or research centres is scant. Instead firms cooperate with other firms, including subsidiaries of the same economic conglomerate which they belong to.

The paper is divided into four sections. The following section 2 discusses the conceptual framework of cooperation for innovation, examining different strands of theoretical literature, as well as the motives and benefits arising from cooperation. This second section also reviews the existing literature to identify factors that are potentially associated with cooperation. Section 3 presents the empirical analysis making use of descriptive statistics and econometrics. Section 4 concludes, highlighting general policy implications and opportunities to improve the methodology of the MIS.

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[18] This paper is part or a regional project on R&D cooperation in Latin America, coordinated by the Economic Commission for Latin America and the Caribbean (ECLAC) and the International Development Research Centre (IDRC) from Canada. The countries included in this project are Argentina, Brazil, Chile, Colombia, Mexico and Uruguay, all of which have conducted innovation surveys in previous years. The project aims to elaborate comparative studies between countries, using common frameworks and methodologies. This paper contributes with the study of the Mexican case.

2. The conceptual framework

2.1 Cooperation for innovation

Evolutionary economic theories assume that technical change is a non-linear process.[19] Innovation is seen as a set of linkages, realised through an interactive process that is both internal and external to the firm.[20] Such interactions take part not only at the beginning, but rather throughout the innovation process (Kline and Rosenberg, 1986). Although in-firm activities play a crucial role, there are some very important technical change processes that are external to the firm, such as relationships with universities, R&D laboratories, customers, suppliers and competitors (Bell and Pavitt, 1995).

As a result of interactions, different pieces of knowledge become combined in new ways, new knowledge is created and existing knowledge is disseminated and absorbed. Technical change is seldom an individual activity; it is rather a collective activity and an outcome of communication and interaction (Johnson, 1992).[21] In addition, innovative and competitive firms are compelled to access external sources of knowledge to face current international trends, such as growing global competition due to trade and investment liberalisation, increasing complexity of new technologies and rapid pace of technical change.

Cooperation for innovation between firms and other innovation-oriented organisations may take place through informal or formal mechanisms (joint ventures, research partnerships, license contracts and equity holding, among others). There are several benefits arising from cooperating in innovation activities. First, it may increase the efficiency of investments in R&D and other innovation-related activities by reducing the duplication of efforts and reaping the benefits of synergies in R&D (Silipo and Weiss, 2005). Second, cooperation gives access to external complementary resources to better exploit existing resources (Hagerdoorn et al., 2000). Third, the externalities created by technological spillovers may be internalised through cooperation, enhancing the appropiability of research results. Fourth, cooperation creates new investment opportunities in highly-profitable, but risky activities, by sharing costs and risks among participants. Fifth, it fosters knowledge transfer and technological capability building (Eisenhardt and Schoonhoven, 1996).

There are different strands of literature that study why firms cooperate in R&D activities and what the results of such cooperation are, from a theoretical perspective. From a transaction cost perspective, research partnerships are explained as a hybrid form of organisation between hierarchical transactions within the firm and contractual transactions in the market place (Pisano, 1990). This strand emphasises transaction cost efficiency and knowledge complementarity as the main motivations to cooperate (Belderbos et al, 2004; Arranza and Fernández de Arroyabe, 2008). Transaction costs are minimised through own development within the firm, but this strategy restricts access to external knowledge. On the other hand, cooperation allows access to external knowledge, but may reduce the benefits coming from the innovation (Veugelers and Cassiman, 2005).

From a strategic management perspective, cooperation is seen as a mechanism to improve competitiveness, since it gives access to complementary resources needed to exploit better the existing resources (Hagerdoorn et al., 2000). In this line, the resource-based view of the firm, one of the approaches adopted by strategic management scholars, points out that cooperation is a popular way to obtaining critical resources for the firm, acknowledging that competitive advantages may arise not only from own resources, but also from accessing external resources through cooperation (Belderbos et al, 2004; Arranza and Fernández de Arroyabe, 2008).

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[19]   In contrast, the linear approach assumes that technical change can be explained entirely by demand or supply considerations. See, for instance, Schmookler (1966) and Landes (1969).

[20]   Kline and Rosenberg (1986) define it as a "chain linked" process.

[21]   This systemic approach has set up the foundations for the widespread literature on systems of innovation. See, for example, Freeman (1987), Lundvall (1992b), Nelson (1993) and Edquist (1997).

In turn, industrial organisation scholars have focused on resource allocation and economic welfare effects of cooperation in R&D (Hagerdoorn et al., 2000). Imperfect appropriability, commonly resulting from R&D activities, affects the decision and benefits from cooperating. On the one hand, when technological spillovers are high, cooperating firms that internalise these spillovers are more profitable than non-cooperating firms. On the other hand, imperfect appropriability increases the incentive of firms to free ride on each other's R&D efforts (Veugelers and Cassiman, 2005).

The literature that studies research cooperation with specific partners is also prolific. The importance of lead customers or users in helping to develop new products and processes is widely recognised (e.g. Lundvall, 1992; Shaw, 1994). These partnerships provide complementary knowledge, a better understanding of user behaviour and needs, and enhance the opportunities that innovation is adopted by other firms within the same user community (Teece, 1992; Tether, 2002). Alternatively, universities and public research centres play a major role in originating and promoting the diffusion of knowledge and technologies that contribute to industrial innovations (Gibbons *et al*. 1994; Mansfield and Lee, 1996; Rivera, 2002; Arundel and Geuna, 2004; Segarra-Blasco and Arauzo-Carod, 2008). In particular, research universities are important sources of fundamental knowledge and industry relevant technology in modern knowledge-based economies (Mowery and Sampat, 2005). Universities and research centres are especially useful for basic and long-term strategic research, the type of research that many firms consider too expensive to conduct it alone (Tether, 2002).

Empirical studies on R&D cooperation have used mainly firm-level data from the European Community Surveys (CIS). Several papers have studied the determinants of R&D cooperation by type of partner (e.g. Fritsch and Lucas, 2001; Leiponen, 2001; Cassiman and Veugelers, 2002; Tether, 2002; Belderbos et al, 2004; Bönte and Keilbach, 2005, and Arranza and Fernández de Arroyabe, 2008). They have found that the factors associated with a higher propensity to cooperate vary between different partners. For instance, Belderbos et al. (2004) point out that firm size has a positive and significant impact on cooperation with all partners, while expenditures on R&D have a positive impact only on vertical (suppliers and customers) and institutional cooperation (research centres and universities). By the same token, the choice of R&D partner depends on the needs of the firm. For instance, Arranza and Fernández de Arroyabe (2008) argue that cooperation with suppliers and customers is most important for accessing complementary resources, and contribute with valuable information on user needs, markets and technology. In contrast, cooperation with universities and public research centres, especially for advanced technologies, offers substitute resources, i.e. technological knowledge that is not easily available in the entrepreneurial environment or offered in the markets.

However, no efforts have been made to study the determinants of cooperation by type of innovation, i.e. distinguishing between cooperation aimed at developing new processes from that aimed at developing new products.[22] As mentioned before, the MIS inquires whether the firm had a cooperation agreement to innovate products or processes. This information offers the opportunity to conduct an original analysis on the factors associated to cooperation distinguishing by type of innovation.

There have been various attempts in the existing literature to identify different types of firm-level technological capabilities and each type has been associated with different activities, different types of innovation and different firm's background characteristics and strategies (e.g. Bell and Pavitt, 1993; Lall, 1993; and Romijn, 1999; Viotti, 2002). Similarly, some scholars have studied the product life cycle distinguishing between product and process innovations (Utterback and Abernathy, 1975; Hobday, 1995; Klepper, 1996). These authors argue that different firm-level technological capabilities

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[22] Following the Oslo Manual, a product innovation is "the implementation/commercialisation of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer" (OECD, 1990, p. 8). In turn, a process innovation is "the implementation/adoption of new or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these" (OECD, 1990, p. 8).

are needed to innovate products or processes and that those capabilities depend upon the stage of development of the firm and the industry.

Existing literature on the determinants of process and product innovations also supports the relevance of central hypothesis of this research. Empirical and theoretical studies have concluded that large firms devote more efforts to process innovation than small firms (Pavitt et al. 1987; Scherer, 1991; Cohen and Keppler, 1996; Yin and Zuscovitch, 1998; Padilla-Pérez, 2006) and that there are significant differences across industrial sectors in their propensity to innovate process or products (Klevorick et al., 1995). Using innovation surveys, some empirical studies have analysed the determinants of product and process innovations (Cabagnols and Le Bas 2002; Kannebley et al., 2005; Gooroochurn and Hanley, 2007). They have found that some factors, such as a firm's background characteristics (export orientation, origin of capital and sectoral differences), use of external sources of knowledge, R&D intensity and appropriability strategy are significant to explain differences in the propensity to innovate either products or processes.

This subsection reviewed the main concepts and findings of the existing literature. The next subsections describe the selection of dependent and independent variables used in the quantitative analysis.

2.2 Dependent variables

The econometric analysis presented in the next section of this paper includes three dependent variables: cooperation for product innovation, cooperation for process innovation and overall cooperation for innovation (either or both type of cooperation). It must be mentioned that cooperation for innovation is a more flexible and broader concept than cooperation in R&D, since product and process innovations may be only new to the firm and with no involvement of formal R&D activities. The MIS does not ask about the motivations for establishing these links or how successful the cooperation had been, restricting the empirical analysis.

To choose the factors potentially associated with cooperation for innovation the empirical and theoretical literature was reviewed; specific characteristics of the MIS were also taken into account. Independent variables were divided into two groups: background characteristics and strategies (see Appendix 1 for further details on dependent and independent variables).

2.3 Background characteristics

Firm *size*, measured by the number of employees, is expected to have a positive effect on the propensity to cooperate.[23] Large firms in average carry out more R&D and are more likely to possess absorptive capacities to benefit from research partnerships. Large firms are also more likely to be involved in multiple technologies and innovation projects that may require various partnerships (Belderbos et al., 2004; Negassi, 2004). Firm size squared is also included allowing for a non-linear relationship. As for previous empirical studies, Fritsch and Lukas (2001); Tether (2002); Belderbos et al. (2004); Negassi (2004); Veugelers and Cassiman (2005); and Arranza and Fernández de Arroyabe (2008) among others, show that there is a positive impact of size on R&D cooperation. Following the existing literature discussed previously, it is expected that size has a positive impact on cooperation for process innovation, but not on cooperation for product innovation.

A dummy variable for firms that are part of a group is included. A firm that is part of a group may have access to technological and financial resources that make it more attractive for cooperation agreements, but on the other hand it may have less incentives to cooperate with external sources, since

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[23] There are many empirical studies that have analysed the relationship between innovative activity and firm size. See Rothwell and Dodgson (1994) and Freeman and Soete (1997) for further details on the relationship between firm size and innovation.

it may find within the group all the knowledge it needs. Similarly, a dummy variable for origin of capital is included. Foreign subsidiaries may have greater resources to cooperate, but at the same time fewer incentives to do it given their access to the resources from the multinational company (Veugelers and Cassiman, 2005).

Finally, the regression controls for sector-specific characteristics, i.e. the sector in which the firm operates. The existing literature recognises that in general firms that belong to different industrial sectors have important dissimilarities in terms of pace of technological change, needs to access external sources of knowledge and the type of sources they interact with (Pavitt, 1984; Klevorick et al., 1995; Cohen *et al.*, 2002). In this line, links with public research centres and universities are more important for firms operating in science-based fields, and fast developing technologies such as biotechnology and new materials. *Sector* is also expected to be significant in the analysis by type of innovation, since, as mentioned, different sectoral trajectories are characterised by different types of innovation and, in turn, dissimilar propensity to cooperate with external sources of knowledge.

2.4 Strategies

R&D intensity is expected to increase the probability of cooperation for innovation. The higher the intensity, the larger the number of projects and the opportunity to cooperate. R&D intensity denotes absorptive capabilities, i.e. the ability to learn from the work of others and from their environment (Cohen and Levinthal, 1990), as well as the ability to identify new technological opportunities and create new relationships with external sources of knowledge. To test the importance of R&D intensity three variables are included in the econometric analysis: R&D expenditure as a percentage of total sales, R&D personnel as a percentage of total number of employees and the presence of an R&D department within the firm. Regarding empirical studies, Fritsch and Lukas (2001), Tether (2002), Belderbos et al. (2004) and Negassi (2004), among others, show that R&D intensity is positively associated with R&D cooperation.

More complex or novel innovations are more likely to demand interaction with external sources of knowledge, since the probability that the firm has all knowledge needed for generating such innovations is lower. More complex innovations involve also greater market uncertainty (Fritsch and Lukas, 2001; Tether, 2002). An ordinal variable to distinguish between innovations that are new to the firm, new to the country and new to the world is included. This variable is relevant only for overall cooperation and cooperation for product innovation, since, as described in Appendix 1, the innovation survey asks firms about the degree of novelty of new products, but not about that of new processes.

A higher share of sales to foreign markets (*exports*) is expected to be positively correlated with cooperation for innovation. The access to new and bigger markets generates economic incentives for increased innovative effort, and hence to cooperate. Given the growing competition in international markets, which are characterised by high-quality and differentiated goods, short response times, etc., companies that want to compete successfully in these markets, and indeed to survive, are compelled to innovate.[24]

The importance of public resources to fund innovation projects is assessed through a dummy variable (1 if it the firm claimed to receive public funds, 0 otherwise). The effect of this variable on cooperation for innovation is not clear since, on the one hand, public funds may disincentive cooperation through reducing financial bottlenecks within the firm; on the other hand, public funds may be designed to incentive cooperation (Belderbos et al., 2004), for instance funds to foster university-industry links.

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[24] A wide range of theoretical and empirical studies has pointed to a positive relationship between exports and technical change. See, for instance, Soete (1990), and Dosi et al. (1990).

Incoming spillovers and appropriability have been widely studied in the existing literature as factors potentially associated to cooperation for innovation (De Bondt and Veugelers, 1991; Kesteloot and Veugelers, 1995; Cassiman and Veugelers, 2002; Belderbos et al., 2004). These factors affect the rate of innovation and the ability of the firm to appropriate the returns from innovation. There is a positive relation between external information flows and the decision to cooperate. At the same time, firms that are more effective at appropriating the results of their innovations are also more likely to cooperate (Cassiman and Veugelers, 2002). The sources for incoming spillovers are usually situated in the public domain. A dummy variable is included in the analysis and is equal to one if the firm claimed that conferences, seminars, fairs and exhibitions were an important source of knowledge. As for appropriability, it is measured through a dummy variable which is equal to one if the firm has been granted with at least one patent. Additionally, dummy variables are included for trademark, patent, technical assistance and property rights agreements. If the firm has signed technology-related agreements with local or foreign firms, it is expected to be more open to cooperate for innovation.

Lastly, dummy variables to capture factors constraining in-firm innovation, or barriers to innovate, are included in the analysis. The dummy for high economic risk captures restrictions due to financial uncertainty or uncertain economic results of the innovation. High cost captures barriers caused by lack of financial resources or high costs of innovation. Other two barriers to innovate are lack of qualified personnel and low client's receptiveness.

3. Empirical evidence

3.1 The survey

In 2001, the National Council for Science and Technology (CONACYT) and the National Institute of Statistics, Geography and Informatics (INEGI) conducted the second MIS. The survey is based on the Oslo Manual from the OECD and aims to compile representative data on the innovative activities undertaken by manufacturing and services enterprises in Mexico. The selection of firms was done using a random sample method, with stratification by sector of economic activity, using the OECD classification, and adjusting the representativeness of firm size by an expansion factor, but at the same time including all the firms that had 501 or more employees. [25] The questionnaire was responded by 1,712 firms operating in three industries: 64 firms in mining, 39 in construction and 1,609 in manufacturing. The MIS gathered information for the period 1999-2000 and the unit of analysis was the firm. The quantitative analysis here presented focuses only on manufacturing firms. Only 542 (33.7%) out of the 1,609 manufacturing firms interviewed claimed to have been engaged in at least one innovation project in the previous two years.[26]

Table 1 shows that 63.5% of innovative firms claimed to carry out product innovation projects using only in-firm resources, i.e. they do not collaborate with other organisations, while only 14.2% claimed to have been engaged in collaborative projects to improve or develop new products.[27] Among the latter, collaboration with other firms was the most important (11.1% of innovative firms),

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[25] The use of the expansion factor led the sample to 8,148 firms. In this paper, the rough database of 1609 manufacturing firms, without expansion factors, is used. So the participation of firms in terms of size and sectors may be biased in relation to the expanded database. It is important to mention that the sample only included firms with more than 50 employees, i.e. the sample is biased towards large firms, and this should be taken into account when the quantitative results are interpreted.

[26] To provide the reader with an international benchmark, in the fourth Community Innovation Survey (CIS) conducted among the 27 member states of the European Union with information for 2002-2004, 42% of enterprises from industry and services claimed to innovate. The highest proportion of firms with innovation activity was registered in Germany (65%) and Austria (53%) (Eurostat, 2007).

[27] The analysis includes only the 542 firms that claimed to be engaged in innovation projects (innovative firms), since the questions about cooperation were answered only by those firms.

and collaboration with research institutes and universities was scant (1.8% and 0.4% of innovative firms, respectively). A slightly higher percentage of firms (16.9%) claimed to collaborate with other organisations for process innovations. Again the most relevant partner was other firms (14.2% of innovative firms), while collaboration with universities and research institutes was limited (1.7% and 0.6%, respectively).

TABLE 1
COOPERATION FOR PROCESS AND PRODUCT INNOVATION,
INNOVATIVE FIRMS BY TYPE OF PARTNER
(Percentage of positive answers)

	Product innovation	Process innovation
No innovation projects	20.1	30.4
Does not collaborate (uses own resources)	63.5	50.6
Cooperates with research institutes	1.8	0.6
Cooperates with universities	0.4	1.7
Cooperates other firms	11.1	14.2
Developed by research centres	0.9	0.4
Others	2.2	2.2

Source: Own elaboration based on MIS.

As for overall collaboration, 76% of innovative firms do not have any type of collaboration for innovation (neither product nor process); 17% collaborate in either process and product innovation; and only 7% collaborate in both types of innovation.[28]

3.2 Econometric model

To investigate the main factors associated with cooperation for innovation, the following econometric model was constructed:

$$CI_i = \beta_0 + \beta_1 BC_{1i} + \quad + \beta_n BC_{ni} + \gamma_1 S_{1i} + ... + \gamma_m S_{mi} + \varepsilon_i \, ;$$

Where CI_i is a binary variable that denotes whether firm i cooperates or not; BC_{xi} are background characteristics of firm i (the number of characteristics ranges from 1 to n); S_{zi} are variables that assess strategies adopted by firm i (the number of strategies ranges from 1 to m); and ε_i is the error term.

It is important to mention that the econometric analysis aims to establish associations rather than causation, by examining the statistical relationships between cooperation for innovation and a set of explanatory variables.

Some authors have found simultaneity between cooperation on the one hand, and R&D intensity (Veugelers, 1997; Cassiman and Veugelers, 2002; Bönte and Keilbach, 2005) and incoming spillovers (Belderbos et al., 2004) on the other. Belderbos et al. (2004) attempt to limit the potential problems of simultaneity through a two-period dataset on innovative firms, using lagged variables. However, the results of the MIS 2001 are not comparable with those of the MIS 1998 (the first innovation survey in Mexico), given that they followed different sampling methodologies. Therefore, in this paper a two-step instrumental variables estimation procedure is used to address potential

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[28] According to the fourth CIS, 26% of all innovative enterprises claimed to have been engaged in cooperation for innovation. The highest levels of cooperation for innovation were reported in Lithuania (56% of all innovative enterprises), Slovenia (47%) and Finland (44%). Cooperation with suppliers, clients and customers was the most frequent (Eurostat, 2007).

endogeneity problems in the cross-section data set. To apply this method, a set of exogenous variables is needed. Since it was not possible to find in the survey exogenous variables, the sectoral average of the potential endogenous variable is used to construct each instrumental variable.

The first step is to run probit regressions to estimate the general model, i.e. including all independent variables. In the second stage non-significant independent variables are dropped from the regression (until a reduced model is obtained), putting particular attention to highly correlated variables in order to enable better identification of the effect of each independent variable on the dependent variable, and prevent multicollinearity. In the third and last stage the instrumental variables procedure is applied and the results are contrasted to those of the reduced model.

Estimations include only the 542 firms that claimed to be engaged in innovation projects (innovative firms). The analysis is restricted to those firms since the questions about engaging in cooperation for innovation were not responded by non-innovative firms. Therefore the analysis and econometric results are conditional, i.e. given that the firm undertakes innovation projects.[29] Table 26 summarises the second stage of the econometric results, i.e. the reduced model.

TABLE 2
ECONOMETRIC RESULTS, REDUCED MODELS
Marginal effects dF/dx (Standard errors in brackets)

Independent variables	Overall cooperation		Cooperation for product innovation		Cooperation for process innovation	
assistance	-		-		0.071 *	(0.044)
capital	-		0.065 *	(0.027)	0.060	(0.035)
client	-		-0.046	(0.028)	-0.065 **	(0.031)
cost	0.093 **	(0.043)	-		-	
financing	-		-		0.047	(0.039)
funds government	0.144	(0.112)	-			
group	-		0.072 **	(0.029)	-	
incoming spillovers	0.082 *	(0.040)	0.040	(0.029)	0.036	(0.035)
lnsize2	0.004 ***	(0.001)	0.000	(0.001)	0.003 ***	(0.001)
novelty	0.074 **	(0.033)	0.088 ***	(0.024)	-	
patents	-		-		0.121 **	(0.062)
patents granted	-		-0.044	(0.036)	-0.125 ***	(0.029)
R&D intensity	-0.006	(0.011)	-		-0.012	(0.014)
R&D internal dummy	0.097 **	(0.043)	-		-	
R&D personnel	0.020 **	(0.008)	-0.005	(0.005)	0.008	(0.005)
rights	-		-0.023	(0.049)	-0.051	(0.052)
risk	-0.071	(0.048)	0.050 *	(0.027)	0.050	(0.032)
sector	0.800 **	(0.349)	0.664 ***	(0.250)	0.121	(0.294)
technology-market	-0.070	(0.044)	-0.039	(0.033)		
No. of observations	542		542		542	
Pseudo R^2	0.119		0.096		0.082	
Prob > chi^2	0.000		0.000		0.000	

Source: Own elaboration.
Note: According to the methodology described above, the following independent variables were dropped in the second stage from all regressions: size type, lnsize, exports dummy, exports %, trademark, models, novelty2, own resources, personnel, R&D internal, R&D personnel dummy, R&D department.
*** Significant at 1%.
** Significant at 5%.
* Significant at 10%.

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[29] It is not necessary to correct for potential sample selection (two-stage Heckman correction procedure), since as said the quantitative analysis is conducted only on innovative firms and the results are conditional.

First, the results of overall cooperation are analysed. Second, the results by type of cooperation are presented.

In line with the existing literature (see Section 2 of this paper), cooperation for innovation (overall cooperation) is significantly associated with firm size: the larger the firm, the higher the propensity to cooperate. Table 2 shows that the squared of the natural logarithm of size (lnsize2) is positive and significant at the 0.01 level. Therefore, there is a non linear relationship between firm size and overall cooperation: the larger the firm the stronger the association between both variables. In average large firms have more capabilities to benefit from cooperation, as well as human and financial resources to participate in such partnerships. In Mexico this result is also related to increasing disparities and concentration in the manufacturing industry as a consequence of economic liberalization. A small number of large foreign and local firms have increased their capabilities to compete successfully in international markets, whereas the great bulk of small- and medium-sized firms have faced enormous challenges to compete (Garrido, 1998, 1999, 2001). In addition, large firms that are part of industrial conglomerates find easier to cooperate with other firms of the conglomerate in order to develop new or improved products and processes.

R&D personnel is positive and significantly associated to overall cooperation at the 0.05 level. The number of employees involved in R&D activities as a percentage of total number of employees was significant, but not the dummy variable (*R&D personnel dummy*). Therefore, to engage in innovation partnerships is important to have a minimum number of employees involved in R&D activities (depends on firm size) to carry out in-firm innovation activities and to interact with external sources of knowledge. *R&D personnel* and *size* are also variables related to absorptive capacities to benefit from cooperation. Similarly, *R&D internal dummy* is positive and significant at the 0.05 level. If the firm carries out R&D using internal financial resources, it has a stronger commitment to conduct innovation activities as well as more capabilities to participate in more complex projects.

The results of the previous paragraph illustrate that although cooperation with external sources of knowledge is a mechanism to strengthen in-firm technological capabilities, firms must develop first internal capabilities in order to take advantage of cooperation as well as to be an attractive partner to interact with. Therefore cooperation for innovation occurs when firms invest and are committed to the development of new technologies. The implication for public policy is that public initiatives to foster cooperation must come together with initiatives to strengthen in-firm capabilities.

Novelty is positive and significant at the 0.05 level. Firms whose innovations are new to the world in average cooperate more than firms whose innovations are new only to the country. In turn, the latter have a higher propensity to cooperate than those whose innovations are new only to the firm. More complex innovations are developed, in general, through interaction with external sources of knowledge, since an isolated firm hardly possesses all the necessary resources to do it. This is even more important in countries behind the technological frontier, such as Mexico, where firms find more technological constrains to develop products that are new to the world.

Incoming spillovers is positive and significant at the 0.10 level. Firms that are open to external sources of knowledge, and if those sources are highly important for their innovation activities, in average have a higher propensity to participate in cooperative agreements. At the same time, if a firm finds in the local environment agents who offer valuable technological knowledge in general is more open and interested in establishing innovation partnerships. This result illustrates the importance of having strong and active agents in the local systems of innovation, as well as having an environment prone to sharing and disseminating knowledge. Public policies to promote technology dissemination through fairs, exhibitions and conferences may be a valuable instrument to foster cooperation for innovation.

Cost is positive and significant at the 0.05 level. Firms that claimed that high cost is a significant barrier to innovate in average cooperate more. Complex innovations are expensive and the economic results often uncertain. This factor is more relevant in Mexico where private firms,

especially domestic SMEs, have had limited access to finance since 1995, when the banking system collapsed (Garrido, 2005). In addition, public support for innovation activities in Mexico is reduced, even in comparison with other Latin American countries such as Brazil and Chile (UNDP, 2008).

Lastly, *sector* is significant at the 0.5 level. Firms operating in different sectors have in general diverse strategies to access external technological knowledge and to interact with other organisations. As shown in the descriptive statistics, there are important differences among sectors in the propensity to cooperate. To understand better sectoral specificities regarding cooperation, it would be useful to have information on the motives to cooperate as well as the outcomes of doing it. However, the MIS does not offer this information.

Until this point, the econometric results are similar to those of the existing literature. The following paragraphs analyse the econometric results distinguishing between cooperation for product innovation and cooperation for process innovation, providing novel and complementary findings.

Size is not significantly associated, in any of its three forms, to cooperation for product innovation. Small, knowledge-intensive firms in the manufacturing industry in Mexico may have strong technological capabilities to develop new products and may engage in R&D cooperation. At the same time, it is common to find large manufacturing firms conducting basic assembling operations and with weak capabilities to innovate products, very isolated from the rest of the local economy (Padilla-Pérez, 2008). In contrast, *size*, in its three forms (*lnsize*, *lnsize2* and *sizetype*) is significantly associated (at the 0.01 level) with cooperation for process innovation. In general large firms have more capabilities and incentives to conduct process innovations, such as improving machinery and equipment or developing new organisation techniques. Similarly, large firms have more capabilities to interact with clients, suppliers and other agents to develop new processes and to take advantage of such partnerships. In Mexico, large manufacturing firms oriented to international markets, in sectors such as electronics, automotive and apparel, are forced to introduce state-of-the-art manufacturing processes in order to compete successfully in international markets (ECLAC, 2008).

Sector is significantly associated (at the 0.01 level) with cooperation for product innovation, but not for process innovation. Process technologies are not as sector-specific as product technologies in the manufacturing industry. The introduction of new processes or production organisation techniques, such as just in time or quality controls, is fairly common in the manufacturing industry and is not highly sector specific. In contrast, the pace of product development, as well as the need for external sources of knowledge to do it, varies importantly among manufacturing sectors. For instance, science-based sectors, such as pharmaceutics, have a higher propensity to cooperate in order to develop new products; yet cooperation for developing new processes is not highly concentrated in a few sectors.

Novelty is positively and significantly (at the 0.01 level) associated with cooperation for product innovation, but not with cooperation for process innovation since this variable assesses only the complexity of product innovations (it does not ask for the complexity of process innovations).

Group and *capital* are significantly associated (at the 0.05 and 0.10 level, respectively) with cooperation for product innovation. Firms that are part of a group have a higher propensity to cooperate to improve or develop new products. Those firms in general have more resources and are more attractive as research partners. In Mexico most cooperation agreements take place between firms, and some of them may take place between firms of the same group. Firms that are part of groups can draw on resources for innovation from other firms of their industrial conglomerate. At the same time, to be a member of an industrial group may provide the firm with better information on opportunities to cooperate with other firms outside the group to develop products and processes. Also, this subset of firms may be more able to set up cooperative arrangements for innovation with firms outside of the group, because they may be more attractive partners for other firms.

As for *capital*, locally-owned firms in average cooperate more for product innovation than foreign firms. In the manufacturing industry in Mexico (as in many other developing countries) foreign firms rely heavily on their headquarters for technological knowledge needed for their activities. Economic liberalisation broke up many production chains in Mexico and foreign firms in

general have weak backward and forward linkages with the rest of the local economy (Cordero et al., 2007). In contrast, locally-owned firms carrying out product innovations have a higher propensity to establish partnerships, mainly with other firms. In a country behind the technological frontier, like Mexico, access to external sources of knowledge is crucial to develop products, since local firms in general do not have all in-firm knowledge needed to do it.

Firms that claimed that *risk* is a significant barrier to innovate have a higher propensity to cooperate for improving or developing new products (*risk* is positive and significant at the 0.10 level). Product innovation is a risky activity and sharing this risk through a partnership is a strategy to reduce it. Yet economic risk does not have a significant effect on the decision to cooperate in order to innovate processes.

As for cooperation for process innovation, *patents* and *assistance* are positive and significant at the 0.5 and 0.10 level, respectively. Firms that have signed technical assistance and patent agreements with local or foreign firms are in average more likely to cooperate to improve or develop new processes. Those two factors are similar to incoming spillovers, in the sense that illustrate the openness to and the need for external sources of technological knowledge to conduct their innovation activities. *Patents* and *assistance* are significant for process collaboration, but not for product, and this may be the result of a higher presence of process technology-related agreements.

Patents granted is significant and negative for cooperation for process innovation (at the 0.5 level). Firms that have been granted patents have a lower propensity to cooperate to improve or develop new processes. On the one hand, firms that are awarded patents have stronger technological capabilities and may be less interested in cooperating with other firms or organisations; on the other, these firms may have a rigorous policy to appropriate the benefits of their innovations and to share their knowledge. Nevertheless, it must be taken into account that few innovative firms are granted patents.

Finally, if firms claimed that lack of client responsiveness is a barrier to innovate, they have a lower propensity to cooperate for process innovation. If clients do not demand better processes (through better quality, lower costs, faster time of response, etc.) or they are not willing to pay for them, firms in average are not willing to set up cooperation agreements to introduce or develop them. Public policies to build up or strengthen a culture of continuous improvement in the manufacturing industry may be useful to foster cooperation.

Some variables were not significant in any regression, but their analysis also offers interesting results. Export activity was not significant, either *exports dummy* or *exports %*, in any regression. The manufacturing industry in Mexico has a high presence of firms that carry out assembly operations and are strongly oriented to foreign markets, operating under the well-known maquiladora industry. Those firms in general carry out low innovation efforts (especially those related to product innovations) and have weak links with local innovation-oriented organisations. Economic reforms in Mexico during 1980s and 1990s fostered international trade as a central element of economic growth. The main assumption was that international competition and access to foreign sources of knowledge would spur productivity growth. However, the relationship between trade openness and productivity growth has been weak due to the breaking up of production chains, lack of linkages between foreign firms and the rest of the local economy and weak absorption capabilities, among other factors (Cimoli, 2000; Padilla-Pérez and Martínez-Piva, 2007).

Funds government was not significant in any regression. Public funds to support firm-level innovation activities are scant in Mexico (UNDP, 2008). As expected, most cooperation activities take place between firms, as a response to private sector needs. The Mexican government has recently launched programmes to foster cooperation, such as an award for university-industry links.[30] It may well be expected that these programmes will have a positive impact in the medium and long run.

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[30]   See www.stps.gob.mx and www.conacyt.mx.

Other variables were never significant in the regressions or were dropped in the second stage (to obtain the reduced model), since they were highly correlated with other independent variables: *RD department*, which was correlated to other variables such as *RD personnel* and *RD intensity*; *financing* and *personnel*, which were correlated to other barriers to innovate; and *trademark*, *models* and *rights*, which were correlated to other technology-related agreements.

Finally, goodness of fit for this cross-sectional model was low (below 0.12 for the three regression), but the null hypothesis that coefficients are equal to 0 is rejected at the 0.000 level.

Two-step regressions with instrumental variables were run to address potential endogeneity in three independent variables: *RD personnel*, *RD intensity* and *incoming spillovers*. Results are summarised in Table 3. The significance of *incoming spillovers* does not change in any regression; it can be concluded that either there is no endogeneity with this variable or does not affect the estimation. In contrast, the significance of *RD personnel* changes in all regressions: it becomes not significant in cooperation for innovation, and turns significant in cooperation for product innovation and process innovation. Similarly, the significance of the coefficients of RD intensity change in two regressions: it becomes significant in both cooperation for innovation and cooperation for product innovation. However, as shown in Table 3, the results are not intuitive.

TABLE 3
TWO-STEP REGRESSIONS WITH INSTRUMENTAL VARIABLES
Coefficients of selected variables (Standard errors in brackets)

	Overall cooperation		Cooperation for product innovation		Cooperation for process innovation	
incoming spillovers	-2.069 ***	0.582	1.625749	1.840	0.1537613	3.454
RD intensity	0.133	0.225	0.349 **	0.142	-0.398 ***	0.136
RD personnel	-0.152	0.126	-0.271 ***	0.063	-0.259 ***	0.058

Source: Own elaboration.
*** Significant at 1%.
** Significant at 5%.
* Significant at 10%.

Since it is a cross-section analysis and the available instruments (exogenous variables) are imperfect, it is possible to conclude that it would be better not to correct for potential endogeneity since noise maybe be introduced to the regression. Therefore, the original results are maintained, but recognising that there is a potential problem of endogeneity with two variables *RD intensity* and *RD personnel*.

4. Conclusions

Cooperation for innovation in Mexico's manufacturing industry is scant and takes place mainly among firms. Cooperation between firms on the one hand and universities and research centres on the other is almost non existent. It seems that the economic reforms that took place in Mexico in the 1980s and 1990s have not created incentives to increase innovation activities or build up links among the components of innovation systems. Weak backward and forward linkages and great disparities between large firms and SMEs do not spur cooperation.

The main factors associated with cooperation for innovation are firm size, incoming spillovers, R&D efforts and sectoral differences, in line with the existing literature. The complexity of the innovation (novelty) was also significant, i.e. firms that develop products that are new to the world have a higher propensity to cooperate. The MIS provides information to conduct an additional and original approach, distinguishing between cooperation for product innovation and cooperation for

process innovation. This distinction shows that small firm size is a barrier to cooperate for process innovations, but small, knowledge-intensive firms in average are not constrained by their size to collaborate for product innovations. By the same token, sectorial specificities are significant to explain different trends among firms to set up agreements to jointly develop products, but not processes. Product technologies are highly sector specific, whereas process technologies are more standard and widespread in the manufacturing industry. Similarly, origin of capital and type of ownership (part of a group or independent) were significant only for cooperation for product innovations, while the number of patents granted was significant only for cooperation for process innovation.

The results of this paper have various implications for public policy. First, public initiatives must take into account that the characteristics, needs and benefits of cooperation vary importantly not only among industrial sectors, but also between the object of cooperation (product vs. process innovation). Second, policies to foster cooperation should come together with policies to foster R&D activities, since firms need first to develop capabilities to take advantage of cooperation and to be attractive partners. Third, policies to strengthen systems of innovation through technology dissemination (fairs, exhibitions, conferences, etc.) may also spur cooperation, since they may help create a more open environment of knowledge exchange. Fourth, initiatives to build up a culture of continuous improvement in the manufacturing sector may foster cooperation, since they also spur demand for better and cheaper products, which in turn can be achieved through cooperation with suppliers, clients and innovation-oriented organisations.

Finally, in comparison with other innovation surveys in Latin America, for instance Chile's and Brazil's, the Mexican survey has some limitations for a richer and interesting analysis. First, although it has information on type of partners, it is not possible to conduct an analysis since the number of firms that claimed to cooperate is too small to conduct an econometric analysis. Second, regarding appropriability, the Mexican survey only inquiries about patent applications and patents granted. Other forms of appropriability such as utility models and secrecy are not included. Third, the sample is representative for firms with more than 50 employees, while in other surveys the threshold is 10 employees and therefore it is clearly biased towards large firms. Fourth, it does not have information on human capital by qualifications or position within the firm (e.g. percentage of employees with a master's degree or PhD, or percentage of blue-collar collar workers vs. white-collar workers). Human capital is a factor significantly associated with cooperation in the existing literature. Lastly, the study of cooperation for innovation would greatly enriched by including information on different types of cooperation agreements in the survey, the importance of cooperation to the innovation activities of the firm, the motives to establish such relationships and how successful the partnerships were.

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Annex

List of variables

Name	Description
Dependent variables	
overall cooperation	Cooperation agreements in innovation activities. Dummy variable that is equal to 1 if the firm claimed to have cooperation agreements.
cooperation product	Cooperation agreements for product innovation. Dummy variable that is equal to 1 if the firm claimed to innovate products in cooperation with other firms, universities or research centres, or if the innovation was developed by universities or research centres
cooperation process	Cooperation agreements for process innovation. Dummy variable that is equal to 1 if the firm claimed to innovate products in cooperation with other firms, universities or research centres, or if the innovation was developed by universities or research centres
(Independent variables	
sector	Firms were classified into 14 sectors: 1 = food, beverage and tobacco; 2 = textiles and apparel; 3 = footwear and products of leather; 4 = wood and paper; 5 = editing and printing; 6 = oil and oil derivatives; 7 = chemicals; 8 = pharmaceutical products; 9 = non metallic minerals; 10 = metallic products; 11 machinery and equipment; 12 = electronic machinery and appliances; 13 = transport equipment; 14 = other manufactures. The variable *sector* corresponds to the sectoral average of overall cooperation, i.e. the number of firms that cooperate in each sector divided by the number of firms in that sector.
	Dummy variable that is equal to 1 if the firm is part of a group and to 0 if it is an independent enterprise
group	Dummy variable that is equal to 1 if it is a locally-owned firm and to 0 if it is foreign. If foreign capital is higher that 10% of total capital, the firm is considered foreign.
capital	Ordinal variable that takes five possible values depending on total number of employees: 1 if the firms has between 10 and 49 employees; 2 between 50 and 99; 3 between 100 and 249; 4 between 250 and 499; and 5 if it has 500 or more
sizetype	Natural logarithm of total number of employees Squared of *size num*
lnsize	Dummy variable that is equal to one if the firm exports some of its production (more than 1%)
lnsize2	Exports as a percentage of total sales
exports dummy	Dummy variable that is equal to 1 if the firm signed trade mark agreements with either national or foreign firms; 0 otherwise
exports %	Dummy variable that is equal to 1 if the firm signed patent agreements with either national or foreign firms; 0 otherwise
	Dummy variable that is equal to 1 if the firm signed technical assistance agreements with either

	national or foreign firms; 0 otherwise
trademark	
	Dummy variable that is equal to 1 if the firm signed industrial models agreements with either national or foreign firms; 0 otherwise
patents	
	Dummy variable that is equal to 1 if the firm signed property rights agreements with either national or foreign firms; 0 otherwise
assistance	
	Ordinal variable that is equal to 0 if new products were only new to the firm; 1 if at least one product was new to the country, but none was new to the world; and 2 if at least one product was new to the world
models	
	Expenditure on R&D investment as a percentage of total sales
rights	
	Dummy variable that is equal to 1 if the firm used its own resources to fund innovation projects, 0 otherwise
novelty	
	Dummy variable that is equal to 1 if the firm received public resources to fund its innovation projects, 0 otherwise
	Dummy variable that is equal to 1 if the firm was granted at least one patent, 0 otherwise
RD intensity	
	Dummy variable that is equal to 1 if the firm claimed that high economic risk was a (highly significant) barrier to innovate, 0 otherwise
own resources	
	Dummy variable that is equal to 1 if the firm claimed that high cost was a (highly significant) barrier to innovate, 0 otherwise
funds government	
	Dummy variable that is equal to 1 if the firm claimed that lack of qualified personnel was a (highly significant) barrier to innovate, 0 otherwise
patents granted	
	Dummy variable that is equal to 1 if the firm claimed that low client's receptiveness was a (highly significant) barrier to innovate, 0 otherwise
risk	
	Dummy variable that is equal to 1 if the firm claimed that lack of financing sources was a (highly significant) barrier to innovate, 0 otherwise
cost	
	Dummy variable that is equal to 1 if the firm claimed that lack of access to sources of technological AND market knowledge were a (highly significant) barrier to innovate, 0 otherwise
personnel	
	Dummy variable that is equal to 1 if the firm claimed that external sources of knowledge were highly or moderately significant to innovate (conferences, seminars, fairs, digital information networks or exhibitions)
client	
	Expenditures on technological R&D as a percentage of total sales, carried out within the firm
financing	
	Dummy variable that is equal to 1 if the firm carries out in-firm technological R&D activities, 0 otherwise
technology- market	
	Personnel in technological R&D activities as a percentage of total personnel
	Dummy variable that is equal to 1 if the firm has one employee or more involved in technological R&D, 0 otherwise
	Dummy variable that is equal to 1 if the firm possess a technological R&D unit, 0 otherwise

V. The determinants of firms' distant collaboration. Evidence from Argentina 1998-2001

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Abstract

In this paper we explore the determinants of the probability of cooperating for innovation with partners located at different distances in Argentina. Our hypothesis is that international cooperation requires stronger technological capabilities and firms' openness. Our findings largely confirm the hypotheses. Firstly, foreign firms or those that trade intensively are more likely to cooperate abroad. Secondly, skilled labour intensive firms and firms that allocate more resources to innovation activities show higher probability of forming international partnerships.

1. Introduction

Scientific and technological novelties are increasingly the result of joint efforts of a network of innovators, who interact formally or informally, purposely or without awareness as part of their normal social behaviour. The mad and inventive scientist who created path-breaking inventions in isolation is more than ever a stereotype. The rapid pace of development of new scientific and technological knowledge together with technological and market uncertainty associated to developing new products and process, has pulled the demand for collaboration.

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Innovation is increasingly the result of a combination of a multiplicity of disciplines, actors and locations. Especially in those fields of fast technological progress, the sources of knowledge are widely spread and no single actor could gather the necessary competences for creating something novel (Hagedoorn and Duysters, 2002, Powell, et al., 2005, Powell and Grodal, 2005).

In fact, the literature has posed many arguments claiming that collaboration is a positive sum game in innovation performance (see Pittaway, et al., 2004 for a review).

Collaboration allows actors to access a wider stock of knowledge and to some extent promotes knowledge spillovers, since collaborating partners would be more open to share knowledge and they would also develop a common language through which they could become more explicit about their tacit knowledge. This is particularly important since it is more likely that tacit (rather than codified) knowledge conveyed novelty (Maskell and Malmberg, 1999). In other words, collaboration contributes to the diffusion of novelties that are relevant to the partners, even if they only interact to solve very specific problems. In this vein, some authors have claimed that firms need to collaborate in order to stay updated, especially in technologically dynamic sectors (Powell, et al., 1996) and also that organisations lacking of interaction capacity would fall behind in (Powell, et al., 2005).

Moreover, collaboration it is not just about diffusion; the combination of existent knowledge may create novelty in itself (Fleming and Sorenson, 2001), since actors would acquire more experience and different competences. It is believed that collaboration creates a virtuous cycle since firms learn how to interact, developing strategic network capabilities, which in due time increases their chances of becoming innovators and facilitates the formation of new linkages (e.g. Hagedoorn, et al., 2006, Pittaway, et al., 2004, Powell and Grodal, 2005).

Partners may contribute with similar or different capabilities to collaborative arrangements. Since collaboration opens up the opportunity to exploit complementary assets, networks will perform better when different capabilities are being complemented, promoting the technological specialisation of partners (e.g. Dussauge, et al., 2000, Mowery, et al., 1996). In any case, collaboration would reduce duplication efforts.

Moreover, in rapidly changing contexts strategic alliances could be instrumental for risk sharing (Sarkar, et al., 2001) and some studies have claimed that collaboration increases the chances of survival (and growth) of small and newly founded firms (e.g. Bruderl, et al., 1992, Larson, 1992, Sarkar, et al., 2001, Shan, et al., 1994).

However, too close collaboration may also create a lock-in effect, by means of reducing possible lines of research and by making actors too focused into their own community. This is particularly important when collaboration is only locally conceived. Nowadays innovations are generated and diffused not only locally and regionally but globally, therefore the network of innovators should not be constrained geographically.[33] Linkages may well be international.

This proves to be most important for innovation systems of developing countries, where promoting local linkages may come at the expense of achieving novelty and updated knowledge. In these countries strictly local collaborations may perpetuate the innovation systems backwardness and their lack of diversification, rather than promoting technological dynamism. Marin and Arza (2009, forthcoming) have discussed the importance for developing countries of promoting the system's "international involvement", or in other words creating the mechanisms for making the system involved in the international processes of knowledge creation and diffusion. One way of opening-up the system, would be via international collaborations.

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[33] See Archibugi, et al., 1999, Archibugi and Michie, 1995 for a discussion on the literature on innovation systems and globalization and the implications for each other. See also Cooke, et al., 1997 for a discussion on how globalization strengthens regional innovation systems.

In this paper, we aim at identifying factors that drive firms to establish international linkages. In particular, we shed some light on the extent to which determinants of international linkages differ from national linkages through the study of the case of the manufacturing sector of Argentina. Departing from the premise that firms' international collaboration is positive for technology development and innovation, the paper policy goal is promoting firms forming international partnerships. To this end, we need to identify the main drivers of such collaboration.

The paper is structured as follows: section two presents the literature on distant interactions, their main drivers and their role in innovation systems: section three presents the data and the methodology employed. Section 4 discusses the results and section 5 concludes.

2. International collaboration and innovation systems

One of the key contributions of the innovation systems literature has been to highlight the importance of complex relations amongst different actors for achieving innovative outcomes. This literature has rejected the idea that innovative outcomes are the results of isolated actors. Innovation occurs in systems, which include economic, social, political, and other factors that influence innovation. It is believed that this common framework would affect actors' trust and entrepreneurship, affecting the way they behave and interact with each other.

In particular, there is one strand of literature on innovation systems that more explicitly studies causes and consequences of the formation of linkages. This literature includes clusters studies, regional studies, industrial districts, industrial geography, etc. and we will encompass it altogether under the name of local systems of innovation (LIS) literature. Their premise is that interactions work as channels for transmitting tacit knowledge, which demands face-to-face communication for efficient transmission since tacit knowledge cannot be isolated from the knowing person. It is also believed that this type of knowledge conveys more novelty than explicit/codified knowledge, since the latter is less costly and therefore diffuses widely. As a consequence, geographical proximity appears as a highly important pre-requisite for knowledge transfer and innovation (e.g. Fischer, et al., 2006, Ivarsson and Alvstam, 2005, Maskell and Malmberg, 1999). The drawback of this conception is to neglect the possibility of learning through distant cooperation. This is particularly restrictive in an era when the diffusion and production of technologies have become global.[34]

Bell and Albu (1999) discussed the LIS literature studying developing countries and argued that most of the studies examined the internal characteristics of the local environment (e.g. market and production structure, local linkages, local institutions, culture identity, etc.) despite the fact that there was a number of case-studies that had already highlighted the importance of external linkages for the technological dynamism of clusters in these countries (they quoted three doctoral theses: Nadvi, 1996, Sandee, 1995, Visser, 1996). Moreover, they questioned the importance of spatial proximity for the performance of local innovation systems and they argued, instead, that developing countries should aim at being connected to knowledge from outside their local systems.

In fact, we believe that one reason why geographical proximity was given such level of importance in LIS literature is that most research in that field was done based on innovation systems of developed countries. Developing countries, instead, have very limited access to knowledge and technologies close to the international frontier. Sources of updated knowledge in these countries usually come from abroad. Therefore, agents in developing countries might be more susceptible to be trapped in technological lock-in effects if they only interact locally.

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[34] In contrast, the literature on *sectoral* systems of innovation has stressed the global factors affecting the development of particular technologies (e.g. Malerba, 2002), but this literature downplays the importance of macroeconomic, institutional and local factors in learning and innovation.

Besides, LIS literature has somehow overplayed the importance of tacit knowledge while downplaying the likelihood of knowledge codification.[35] Moreover, as other have claimed LIS literature has fallen short in examining the actual ways in which knowledge is appropriated, many of which may not be associated to co-location.[36] As a result, the probability of transferring knowledge has been (misleadingly) associated to geographical proximity.[37]

Although the importance of external linkages was somehow understated by the literature vis à vis the relevance of internal linkages, since Bell and Albu (1999) research on the characteristics and roles of external linkages in LIS in developing countries has grown. . To name just a few, firms absorptive capabilities were found as important drivers for forming both internal and external linkages, as found by Giuliani and Bell (2005) studying a wine cluster in Chile. In turn, Saxenian (2005) pointed out to reverse brain-drain flows of US-educated Indian and Chinese-born engineers, as an increasingly important source of external knowledge in information technology industries in India and China. Looking at the performance side, Nadvi and Halder (2005) analysed external linkages of two clusters one in Germany —developed country— and another one in Pakistan —developing country— of the global surgical instrument industry and concluded that external linkages together with internal ones were important in both clusters to raise competitiveness as well as to respond to global challenges. More specifically and studying Latin America, Giuliani et al (2005) used primary and secondary sources to study 40 clusters in several countries. They argued that governance of global value chains and collective efficiency[38] of the cluster matter for firms' innovativeness.[39] They also pointed out to the fact that sectors specificities mediate such relationships.

Most of the existing LIS literature that does study external linkages studies them in relation to global value chains. The role of global value chains in upgrading industrial clusters in developing countries was put forward by Humphrey and Schmitz (2002). The authors claimed that global value chains are quasi-hierarchical in developing countries. This implied an asymmetry of competence and power in favor of global buyers who set product and process parameters. On the one hand, this type of governance creates incentives for local firms' fast upgrading, but on the other hand local firms might found themselves locked-in in low value added activities that are functional to global buyers' interests. The authors recognized the fragility of these types of governance of global value chain which predominates in developing countries and suggests ways in which local firms move forward.

This study will also analyse firms' external linkages. In particular we will compare drivers of external linkages with those of local and national linkages. However, we will not restrict the analysis to vertical linkages. The partnerships to be assessed here include suppliers, clients, other organisations

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[35] There is knowledge that although being articulable remains unvoiced because the costs of codification are too high. Therefore, some authors have aimed at understanding the conditions that will encourage codification (see for example Ancori, et al., 2000, Cohendet and Steinmueller, 2000, Cowan, et al., 2000, Cowan and Foray, 1997).

[36] Breschi and Lissoni, 2001 pointed out those network specific technologies are developed within a system of production transactions, and these interactions usually occur at distance. Moreover, they argue that certain knowledge might be embodied in the organization and its cooperation practices, thus face-to-face interactions might not be a requirement for knowledge transmission.

[37] Torre and Rallett, 2005 claim proximity is a concept much more ambiguous than localization. They divide the concept in *organized proximity* and *geographical proximity*. The former is based on the *logic of belonging* and the *logic of similarity* (e.g. two researchers from the same organization will tend to cooperate more between each other than with outsiders), while the other is based on co-localization. Their contention is that the former offers mechanisms for distant collaboration and therefore the search for geographical proximity is not at the core of firms' strategies anymore.

[38] The authors take Schmitz, 1995's definition of collective efficiency: "comparative advantage derived from local external economies and joint actions" p. 530.

[39] However, there is also a need to analyse the types of international linkages that are being established, since it could well be that these international linkages do not open up new opportunities for learning but they just substitute the opportunities that are available within the NSI (see some of the articles published in a book about the Mexican NSI edited by Cimoli, 2000, for example the articles by Capdevielle, et al., 2000, Casas, et al., 2000, Unger and Orlariz, 2000).

within corporations and the scientific community. By dealing with so heterogeneous actors, we could assume that power relations would not interfere in a single direction. Thus, we will assume that by cooperating with the international community firms will have better access to updated technological information which would contribute to their upgrading and competitiveness. In this paper, however, we will not test for the validity of such statement. Instead our goal is to evaluate the determinants of firms' propensities to cooperate with national and international actors, assuming that proximity aids the likelihood of cooperating (i.e. ceteris paribus firms will find easier to cooperate with national partners than with Latin-American partner than with other international partners) but the further away the cooperation is established the greater the opportunities for accessing updated technology.

Our methodological approach also differs from most of the existing literature, which has been mainly confined to qualitative methodologies based on specific LIS. Instead, we will estimate a multinomial logit model which will jointly identify the determinants of connecting at different levels of proximity for a sample of firms which is representative of the Argentinean manufacturing sector.

All in all, our object of study fits better with the interests of the literature on national system of innovation (NSI) rather than with those of the LSI literature. This makes our contribution more noticeably, since openness has not been thoroughly conceptualised in the NSI literature. Although some authors reasonably pointed out to the need for policy makers to remain alert to technologies developed in other systems (e.g. Liu and White, 2001, Lundvall, et al., 2002), the internationalization of the NSI was never a key aspect of research in that area, neither conceptually nor empirically. As a matter of fact, Archibugi et al. (1999) claimed that the debate within NSI literature –although having originated at the surge of the globalization era- was surprisingly disconnected from the international business literature that studied globalized innovative activities of business corporations. Similarly, Carlsson (2006) argued that very few papers within NSI literature have empirically addressed the internationalization of activities[40] while no single paper on internationalization of corporate R&D has dealt with components or relations of the system that remain nationally-bounded. Marin and Arza (2009, forthcoming) also highlighted the scarce research done in relation to innovation systems' international involvement and have joined the call for more research analysing the role and characteristics of external linkages of innovation systems. This paper aims to partially fulfil this goal.

In particular, our hypotheses are the following:

(i) The system's openness is self-enforcing: there is a higher probability that exporting, importing and foreign firms cooperate with distant partners.

As the literature has largely testified, global value chains open opportunities for further collaboration that could influence on firms' innovativeness. Therefore, firms that are commercially integrated (i.e. exporting and importing firms) and/or are part of a multinational corporation (MNC) (i.e. foreign owned firms) would be more likely to establish collaborations with distant partners than firms that operate mostly within the national boundaries. Instead, international integration might not be necessarily conducive to establish local or national linkages. Even more, if one assumes —as we do here- that international cooperation implies better access to updated technologies, and therefore, ceteris paribus, would be preferable vis à vis national linkages, we could hypothesise that firms that have the chance to contact distant partners would do so. In sum, our hypothesis is that subsidiaries of MNCs and firms that trade internationally enjoy better chances to cooperate internationally (and they would take advantage of them) than other firms, relatively to cooperating locally.

(ii) The system's openness is self-selective: there is higher probability that firms with higher absorptive capacities cooperate with partners further away.

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[40] In fact, Carlsson, 2006 found only five studies that examine empirically internationalization at system level, those are: Bartholomew, 1997, Fransman, 1999, Niosi and Bellon, 1994, Niosi and Bellon, 1996, Niosi, et al., 2000.

Similarly, if connecting with international partners involves higher sophistication in knowledge transfer, it would be important to have acquired absorptive capabilities to be able to cooperate efficiently with technologically dynamic partners. The literature has been highlighting the role of absorptive capabilities as drivers of collaboration. However, our hypothesis is, instead, that there is a differential impact of absorptive capabilities on the probability of collaborating at different levels of proximity. Since it is technologically more demanding to collaborate with international partners, capabilities are more of requisite there than to collaborate only with national partners.

3. Methodology

3.1. Data and definition of variables

We aim at characterising firms' international linkages with different partners in an attempt to identify the main differences between determinants of national linkages –about which the literature has been traditionally concerned with- and two types of international linkages classified according to the cultural and geographical proximity of Argentinean partners (i.e. Latin-America and other parts of the world).

To this end we used information from the National Innovation Survey 1998-2001.[41] The sampling methodology for that Survey makes it representative of the national manufacturing sector. It includes information for 1337 firms (response rate 76%) which are both innovative and non innovative. Their sales represent around 30% of total sales of the manufacturing sector for the period 1998-2001.

Firms in the sample were requested to answer whether they have cooperated with other partners. Cooperation could take place amongst different partners, and we define four types of partnerships as can be seen in the Table 1A. Besides, firms were asked to identify the geographical location of their partners, which could be: Local (<100km), National, Regional (i.e. MERCOSUR), Latin-America, European Union, United States and Canada, East Asia, or others. We re-classified these categories in three groups as can be seen in Table 1B. As defined by the Survey form, cooperation was broadly understood; it could follow objectives as different as information requirements, funding, training, consultant, organisational change, R&D, tests, design, or technical assistance.

TABLE 1
DEFINITION OF DEPENDENT VARIABLES

(A) Partners		
Variable Label	Variable Name	Firms declared cooperation with:
Cooperation with Science and Technology (S&T) partners	COOP_ST	Universities, technology centres, technical training institutes, laboratories, R&D consultants, institutes for technology linkages or Government agencies for S&T projects
Intra-corporation cooperation	COOP_IC	Headquarters or other firms within the corporation
Vertical cooperation	COOP_VERT	Clients and suppliers
Cooperation with any partner	COOP	Any of the above or consultants or other firms (competitors)

(continued)

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[41] Unfortunately, it is impossible to compare firms' collaborating activities across different innovation surveys in Argentina, since the definition of cooperation has changed for every edition of the Survey. In the National Innovation Survey 1992-1996, there was information only for year 1996 and in relation to R&D. There was no information on location, either. Innovation Surveys for subsequent years do not inform about localization of partners.

Table 1 (concluded)

(B) Location		
The furthest location of partners was	Location value	Variable suffix
None	0	NO
Local or national	1	NAT
Regional or Latin-America	2	LA
European Union, United States and Canada, East Asia, or others	3	INT

Source: Own elaboration.

Therefore, four categorical variables were defined (COOP_ST, COOP_IC, COOP_VERT, COOP); each of them could adopt four values, 0 if no cooperation exists, 1 if the furthest partners were within the national frontier (NAT), 2 if the furthest partner were within Latin-America (LA) and 3 if the partners were from other international location (INT).

The literature analysing drivers for the likelihood of cooperation, has usually found firms' size, absorptive capacity, information opportunities and sectoral affiliation as important determinants of firms' cooperation (e.g. Cassiman and Veugelers, 2002, Giuliani, et al., 2005, Koschatzky and Sternberg, 2000, Veugelers and Cassiman, 2005). As can be seen in Table 2, we include employment in a quadratic form to account firms size, firms' expenditures in innovative activities and workforce' skills to proxy firms absorptive capacity, the use of internal and external sources of information to proxy for information opportunities and a variable that account for the sectoral weighted-intensity of cooperation with every type of partners to account for unobserved sectoral specificities that may affect the probability to cooperate. Moreover, we also add firms' trade integration and a dummy for foreign firms to test for our first hypothesis. The second hypothesis will be based on analysing the differential impacts of workforce skills and innovative expenditures on collaborating nationally and abroad.

TABLE 2
INDEPENDENT VARIABLES, CALCULATED IN AVERAGE
FOR THE PERIOD 1998-2001

Variable	Definition
SIZE	Employment in natural logarithms
EXPORT	Export intensity: Export/Sales
IMPORT	Import intensity: Import/Sales
INNOV_ACT	Innovative activities: Average expenditures in R&D (in-house and external), in engineering and industrial design, hardware, software, capital goods , licences, management, consultants and training over Sales. All expenditures are strictly related to firms' innovative activities.
SKILLS	Workforce skills: Professionals / Employment
FOREIGN	Dummy variable that adopts the value 1 if at least 10% of capital belong to foreigners
INFO_EXT	Information opportunities or incoming spillovers: Importance of public information (i.e. expositions, conferences, journals, catalogues, databases, internet) as sources of information for innovative activities. Normalized in a 0-1 scale
INFO_INT	Internal (to the firm) sources of information, normalised in a 0-1 scale
SECTOR	Control for sector specificity. It is construct as the sector propensity to cooperate (i.e. firms that cooperate over total firms in the sector ISIC Rev3, 2 digits) weighted by the number of firms sampled in each sector. This variable changes over the different definition of cooperation

Source: Own elaboration.

3.2. Model specification and estimation methods

From the discussion on how we defined the dependent variables, firms' cooperation decisions drop in four mutually exclusive categories: either they did not cooperate (NO) or they cooperate and the furthest partner they reach was national (NAT), or it was Latin-American (REG) or it was from the rest of the world (INT). Therefore, a multinomial logit was chosen to test for our research hypotheses.

We shall assume that

(1) $Y_{tj}^{*} = \beta_j^{'} X_t + \varepsilon_{tj}$

where Y_{tj}^{*} is the level of indirect preference of firm t to j types of collaboration, which are four (NO, NAT, REG, INT). X_t is the vector of firms-specific variables (i.e. the values of our independent variables).

Then, the probability that the tth individual makes the choice j is:

(2) $P_{tj}(Y_{tj} = 1) = e^{\beta_j^{'} X_t} / \sum_{k=0}^{3} e^{\beta_k^{'} X_t}$

As normally in multinomial logit models, to carry out the estimation one category must be used as a benchmark, which is normalised to 0. We chose NO (i.e. firms that do not cooperate) as the base category.

Then, formally, if k=0

(3) $\ln(P_{tj} / P_{tk}) = X_t^{'} \beta_j$

The coefficient then represents the effect of a change in the independent variable on the probability of cooperation j relative to the probability of not cooperating. Therefore, in order to determine the direct effect of each independent variable on the probability to cooperate as far as each category (and also in order to be able to compare the influence of each independent variable across categories) we estimate and report the marginal effects evaluated at the mean of the independent variables.[42] All estimations were done with robust standard errors.

Given our research hypotheses we expect the coefficient for EXPORT, IMPORT, FOREIGN, SKILLS and INNOV_ACT to increase for longer distance collaborations.

Finally, since the decision to collaborate could also influence the amount invested in innovative activities, we control for the endogeneity of INNOV_ACT using a two-step procedure. However, deciding about the first step of the estimation was not simple. On the one hand, the variable INNOV_ACT is censored: more than 40% of firms report zero expenditures in innovative activities. On the other hand, it was difficult to find instruments, since most of the available information that relate to INNOV_ACT also related to the different definitions of COOP. We discuss the details of the procedure used when we present the econometric results.

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[42] This was done with the command dmlogit2, created by Bill Sribney from StataCorp.

4. Results

4.1. Main characteristics of the sample

As mentioned above, we use data from the National Innovation Survey 1998-2001. After controlling for extreme observations in nominal variables we kept around 1200 firms that inform valid data for all the variables used in the econometric estimations.

Table 3 shows mean values for the control variables across cooperation categories. As we defined localisation (i.e. the furthest located partner) columns reflect exclusive categories (i.e. per row, every firm falls in one single column -therefore per row, columns sum up to 100%) while the rows reflect cooperation with different partners, which are not exclusive (e.g. a single firm could cooperate with international suppliers and with international scientific institutions, thus it will turn up in COOP_VERT_INT and in COOP_ST_INT, and also in COOP_INT –therefore per column, rows sum more than 100%).

Most firms (69%) declared to have cooperated with some partner in some location; 39% have reached international partners (30% reached partners beyond Latin-America) and 30.6% reached only national partners. The probability of reaching international partners is larger for cooperation with suppliers and clients, than with cooperation with scientific and technological institutions. In the latter case, most linkages remain within the national boundaries. As expected, the majority of firms do not cooperate with other firms within the corporation, since the majority of firms are independent units. However, among those that do cooperate, they do it mostly with international partners, which reflects the incidence of foreign firms on this type of cooperation.

It is important to highlight at this point, that although we estimate models for cooperation with different types of partners, the only hypothesis we had was in relation to the level of proximity and not in relation to types of actors. Moreover, as could be seen in Table 3, for linkages with science and technology (S&T) organizations and also for intra-corporative linkages, there are no critical number of firms in each category. Therefore in the analysis of the empirical results, we will focus mostly in cooperation broadly defined (with any partner, COOP).

In terms of size, firms that cooperate with international partners tend to be bigger in average than those that cooperate only nationally (almost 3 times larger) and also bigger than those that do not cooperate.[43] This is not surprising since cooperating abroad is demanding in infrastructure, especially in countries that are further apart and where international collaboration is not publicly promoted. Another interesting finding related to size, is that at any level of proximity firms that cooperate with S&T institutions are larger than those that cooperate with other partners.

The last two variables in Table 3 show the importance of external and internal sources of information for innovation activities across groups of firms that cooperate at different proximity. One reason for cooperating is to get access to information, so, it is to be expected that cooperative firms give more value to information in general than those that do not. This is exactly what we find when we compare the importance allocated to both sources of information between firms that do and do not cooperate. However, when we compare the importance of sources of information for firms with partners located at different distances, the results depend on the type of partners. Briefly, it seems that sources of information are always important for firms that cooperate with S&T institutions and with the corporation, while among firms that cooperate vertically those that cooperate internationally are more interested in internal and external sources of information.[44]

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[43]   Anova tests indicate that differences are significant at 1% across location categories for all cooperation variables.
[44]   This statement is based on results of ANOVA tests.

TABLE 3
MEAN VALUES OF CONTROL VARIABLES ACROSS
COOPERATION CATEGORIES, 1998-2001

	Proportion of firms (%)			
	NO	NAT	REG	INT
COOP	31%	31%	9%	30%
COOP_VERT	45%	28%	6%	21%
COOP_ST	55%	34%	5%	6%
COOP_IC	77%	9%	4%	11%
	Employment (n° employees)			
	NO	NAT	REG	INT
COOP	100.3	130.2	198.8	336.9
COOP_VERT	141.3	162.3	218.8	320.1
COOP_ST	125.1	222.1	244.0	523.9
COOP_IC	133.4	301.0	340.9	437.5
	Incoming spillovers (normalized 0-1 scale) INFO_EXT			
	NO	NAT	REG	INT
COOP	0.12	0.31	0.36	0.40
COOP_VERT	0.18	0.34	0.38	0.41
COOP_ST	0.19	0.38	0.39	0.47
COOP_IC	0.25	0.39	0.43	0.38
	Internal sources of info (normalized 0-1 scale) INFO_INT			
	NO	NAT	REG	INT
COOP	0.24	0.60	0.75	0.73
COOP_VERT	0.36	0.63	0.76	0.73
COOP_ST	0.39	0.71	0.74	0.77
COOP_IC	0.49	0.64	0.81	0.72

Source: Own elaboration based on the National Innovation Survey 1998-2001.

In sum, Table 3 suggests that firms that reach international partners are bigger and also those that collaborate with international suppliers and clients tend to give more importance to internal and external sources of information for innovative activities than those that reach national partners exclusively.

Our real concern is related to openness and absorptive capabilities. We claim that relatively to firms that cooperate only nationally, firms that cooperate internationally tend to be those that are already integrated globally (hypothesis I) and also those with the necessary innovative capabilities so as to face technologically more sophisticated partners (hypothesis II).

To illustrate the validity of this proposition, we drew Figures 1 to 5 in which we compared, respectively, export intensity, import intensity, proportion of foreign firms, skills of the workforce and innovative expenditure intensity across different levels of proximity (NO, NAT, REG, INT) and for the four categorical variables (COOP, COOP_VERT, COOP_ST, COOP_IC).

The first three figures illustrate the validity of Hypothesis I. As can be seen, in average firms that cooperate internationally export (as a proportion of sales) average more than three times more than firms that cooperate just nationally. Imports (over sales) are also larger (almost double) and the proportion of foreign firms among international collaborators is more than four times the proportion of foreign firms within the pure-national collaborators.

FIGURE 1
EXPORTS AS A PROPORTION OF SALES ACROSS TYPES OF
COLLABORATING FIRMS, ARGENTINA 1998-2001
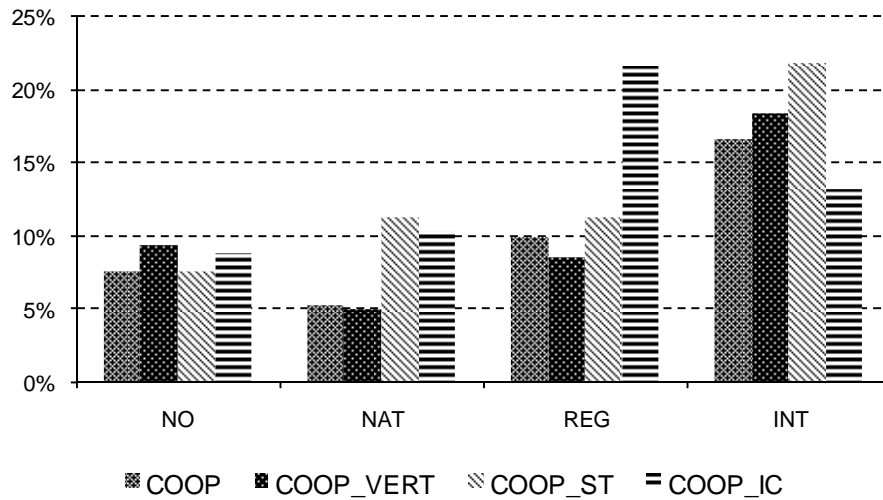
Source: Own elaboration based on the National Innovation Survey 1998-2001.

FIGURE 2
IMPORTS AS A PROPORTION OF SALES ACROSS TYPES OF COLLABORATING FIRMS,
ARGENTINA 1998-2001
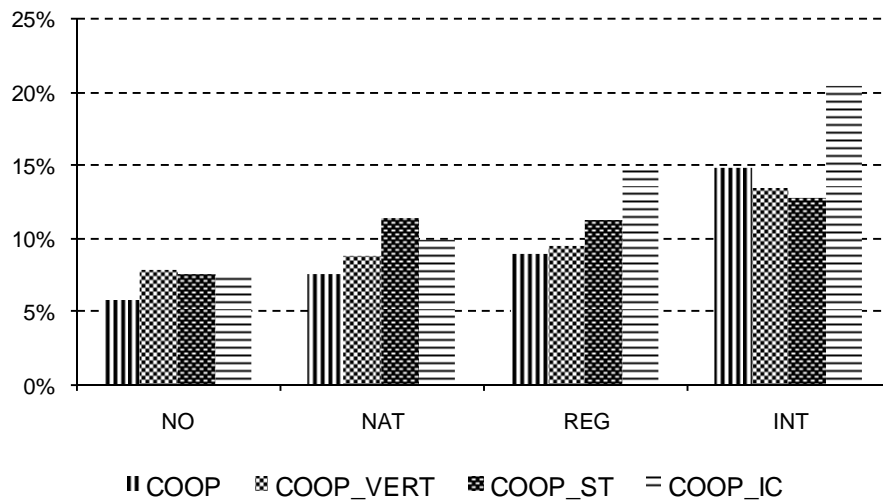
Source: Own elaboration based on the National Innovation Survey 1998-2001.

As expected, the differences between international collaborators and pure-national collaborators in terms of foreign trade are particularly marked for those that cooperate vertically; while differences in terms of the proportion of foreign firms are especially large in the case of intra-corporative collaboration. On the other hand, the differences are not as large in the case of collaborators with S&T partners, although international collaborators in S&T export significantly more than pure national collaborators in S&T (and also the proportion of foreign firms is significantly larger), differences are not as marked as for the other variables (COOP, COOP_VERT, and

COOP_IC). Moreover, imports are fairly the same between international and national collaborators in S&T.

FIGURE 3
FOREIGN FIRMS AS A PROPORTION OF TOTAL FIRMS ACROSS TYPES OF COLLABORATING FIRMS, ARGENTINA 1998-2001
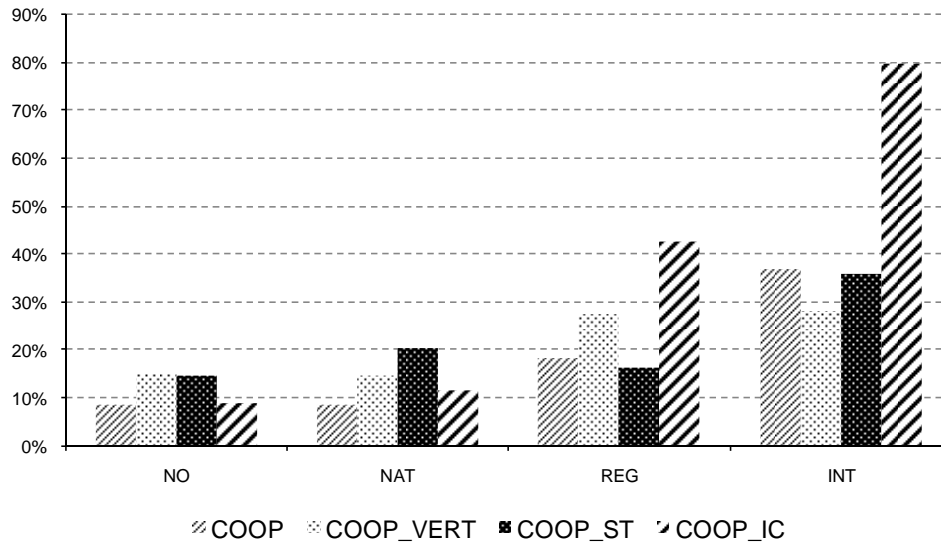
Source: Own elaboration based on the National Innovation Survey 1998-2001.

Figure 4 and 5 illustrate the validity of hypothesis II. It is fairly noticeable that absorptive capabilities -proxied by the intensity of investment in innovative activities and by the proportion of skilled workers in total workforce- are higher for the group of firms that reach international partners. Firms that collaborate with any type of international partners, invest almost a double proportion of their sales in innovative activities than firms that reach only national partners (Figure 4, first column). The professionals also represent more than double of the total workforce in the former than in the latter group (Figure 5, first column).

If one compares collaboration with different types of partners, one concludes that the differences in innovative expenditures between international and national are the highest in those firms that collaborate with clients and suppliers, while differences in skills are the highest for those that collaborate with other actors within the corporation. In this latter case, there are not significant differences in expenditures in innovation as a proportion of sales between international and national collaborators (Figure 4).

FIGURE 4
**INVESTMENT IN INNOVATIVE EXPENDITURES AS A PROPORTION OF SALES ACROSS TYPES OF COLLABORATING FIRMS, ARGENTINA 1998-2001**
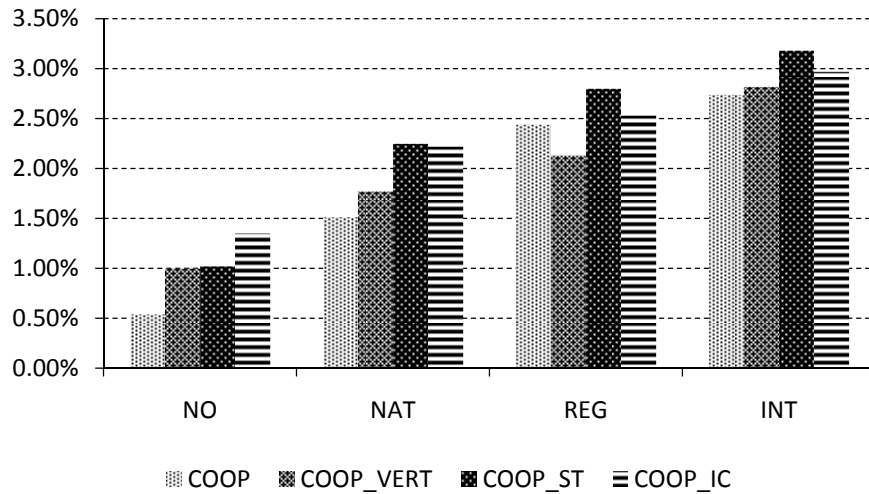
Source: Own elaboration based on the National Innovation Survey 1998-2001.

FIGURE 5
SILLS OF THE WORKREFERENCE ACROSS TYPES OF COLLABORATING FIRMS, ARGENTINA 1998-2001
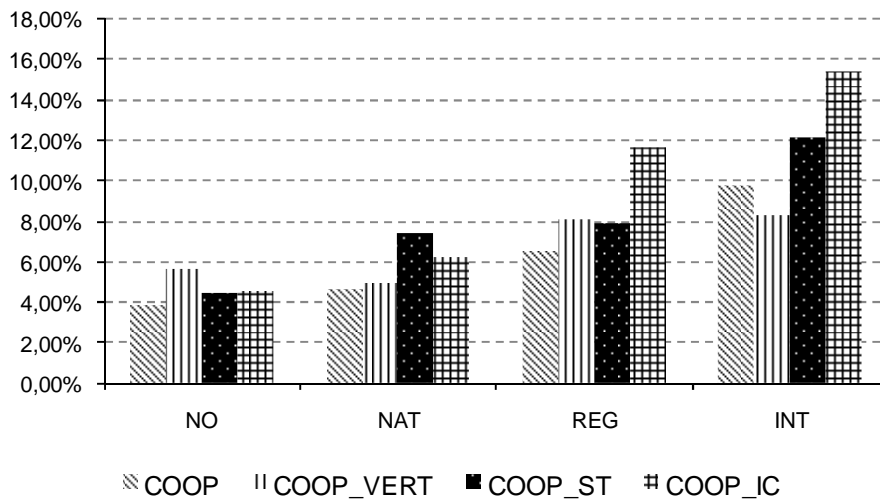
Source: Own elaboration based on the National Innovation Survey 1998-2001.

4.2. Econometric results

The econometric results on the multinomial model for our main variable (COOP) are presented in Table 4. We report the marginal effects evaluated at the mean of the independent variables. The second set of columns corrects for endogeneity of the variable INNOV_ACT. The correction is done in two-steps.

Since the variable INNOV_ACT is censored, we estimate a Tobit model (presented in Table A1 in Appendix) and we calculate the expected value of INNOV_ACT conditional on being within the interval (0,1). These predicted values were used in the second step.[45] As we mentioned before, we experienced difficulties in finding the right instruments, since most available data that relate to expenditure in innovation also relate to our main variable COOP. Our strategy was to increase the explanatory power of the Tobit model (1st step) as long as we did not create multicolinearity between the predicted-INNOV_ACT and the other regressors in the second step. The definition of instruments is presented in Table A2 in Appendix.

Confirming our descriptive findings respect to the control variables, we can see that firm size more largely affect the probability of collaborating internationally than nationally only. Moreover, it seems that firms' size decreases the probability of collaborating only nationally. In terms of sources of information, firms that allocate high importance to internal sources of information, have also higher chances to be collaborative, both nationally and internationally, while being interested in external sources of information increases the chances of collaborating internationally.

The econometric exercise also replicates the descriptive findings in what respect to the main explanatory variables. Exporting and importing increase the probability to cooperate international and being foreign also increases the likelihood to cooperate internationally. Oppositely, exports and foreign ownership reduce the probability to interact solely with national partners. Similarly, absorptive capability, proxied by the proportion of sales devoted to innovative activities and the proportion of professional within the workforce, increases the chances of cooperating internationally while it does not affect the probability of cooperating nationally. In other words, these results suggest that while openness and absorptive capabilities are significant determinants of international collaboration they are not significant determinants of national collaboration (as a matter of fact, being open reduces the probability of cooperating just nationally). All these results are independent on whether the estimation is done in one or two steps.[46]

TABLE 4
MULTINOMIAL LOGIT MARGINAL PROBABILITIES ON COLLABORATION AT DIFFERENT DISTANCES, ARGENTINA 1998-2001

	1-step			2-steps		
	NAT	REG	INT	NAT	REG	INT
SIZE	-0.027*	0.001	0.087***	-0.022	0.000	0.078***
	[0.053]	[0.919]	[0.000]	[0.118]	[0.972]	[0.000]
EXPORT	-0.449***	0.026	0.413***	-0.453***	0.027	0.425***
	[0.000]	[0.567]	[0.000]	[0.000]	[0.547]	[0.000]
IMPORT	-0.121	-0.054	0.435***	-0.140	-0.034	0.486***
	[0.377]	[0.573]	[0.000]	[0.301]	[0.717]	[0.000]
INNOV_ACT	-0.070	0.760**	2.476***	-4.402	2.252	10.827***
	[0.928]	[0.023]	[0.000]	[0.158]	[0.179]	[0.000]
FOREIGN	-0.158***	0.024	0.196***	-0.118**	0.013	0.137***
	[0.003]	[0.374]	[0.000]	[0.033]	[0.660]	[0.001]

(continued)

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[45] The spearman correlation coefficient between the INNOV_ACT and predicted-INNOV_ACT was 0.58.

[46] As can be seen by comparing the coefficients of INNOV_ACT and predicted-INNOV_ACT, there are differences in scale between these two variables. As a matter of fact, although the median for the original INNOV_ACT was just less than 0.02, the smallest estimated value for predicted-INNOV_ACT was larger than 0.02 and the median was 0.03. The predicted values of INNOV_ACT were very sensible on the restriction of the lower limit. If unrestricted, it would adopt negative values and the median value would be 0.0005. Coefficients for all the other variables remained fairly unchanged.

Table 4 (concluded)

	1-step			2-steps		
	NAT	REG	INT	NAT	REG	INT
SKILLS	-0.330	0.087	0.572***	-0.261	0.068	0.469***
	[0.205]	[0.467]	[0.002]	[0.281]	[0.566]	[0.004]
INFO_INT	0.086*	0.096***	0.108***	0.132**	0.083***	0.012
	[0.050]	[0.000]	[0.010]	[0.019]	[0.008]	[0.823]
INFO_EXT	0.056	0.023	0.237***	0.073	0.022	0.230***
	[0.413]	[0.500]	[0.000]	[0.287]	[0.518]	[0.000]
SECTOR_COOP	-0.462	-0.371	0.590	-0.439	-0.374	0.587
	[0.258]	[0.178]	[0.135]	[0.281]	[0.178]	[0.142]
CONSTANT	0.308***	-0.161***	-0.736***	0.377***	-0.206***	-0.928***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	1198	1198	1198	1198	1198	1198
Pseudo-R2	0.20			0.12		

Source: Own elaboration based on the National Innovation Survey 1998-2001.
Note: p values in brackets.
*** significant at 1%.
** significant at 5%.
* significant at 10%.

   Similarly, Table 5 presents the marginal coefficients for models on cooperation with different types of partners.

   In the case of cooperation with suppliers and clients (COOP_VERT), foreign trade, as expected, increases the chances of cooperating internationally and decreases the chances of cooperating only nationally. Ownership, in turn, has no effect on the probability of cooperating vertically at any distance. Finally, absorptive capabilities seem to have some positive effect on the probability of cooperating internationally but affect negatively the probability of cooperating just nationally (coefficient for skill is negative).

   Cooperating with S&T organisations (COOP_ST) has its own particularities. On the one hand, it is to be expected that firms that collaborate for this purpose with partners in every location are particularly interested in innovative activities[47]. Thus we would expect skills and innovative activities to positively affect the probability of cooperation at every distance. This is what we find for skills and innovative activity when endogeneity is not being controlled for. When estimation is done in two steps, the variable loses its significance in the case of cooperating just nationally. On the other hand, there are very few firms that cooperate internationally with S&T partners (only 6% of firms in the sample plus another 5% that cooperate regionally); in other words, this type of cooperation remains very much nationally bounded. This might be explained by the incidence of public institutes as partners in COOP_SC. Therefore, foreign ownership does not significantly increase the probability of cooperating with S&T partners. Trade, in turn seems to have an ambiguous effect: on the one hand, importing affects the probability of cooperating nationally and exporting the probability of cooperating internationally. These results could be spurious due to the scarce number of observation in S&T collaboration with international partners.

   Finally, cooperating with other partners within the corporation (COOP_IC) also constitutes an especial case of partnerships. Firms that cooperate in this category are basically national

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[47] It is worth remembering that the definition of collaboration from the Survey is very broad and include collaboration in any activity associated to production, thus it is not clear that the collaboration done with other partners (e.g. suppliers & clients) also has innovation as the preliminary aim.

conglomerates or foreign firms. As expected, there is a high incidence of foreign firms on the probability of cooperating internationally. Exporting increases the probability of cooperating regionally and importing the probability of cooperating internationally. Respect to variables related to absorptive capabilities, skills affect the probability of cooperating internationally, while expenditures on innovation changes its significance when endogeneity is being controlled for; with no controls, the variable is only significant to explain international partnerships, when controls are established, it is also significant to explain merely national collaborations.

Results on Table 5 largely replicate results on Table 4; especially for cooperation with vertical partners. The other two types of collaboration show some particularities. On the one hand, there is a high incidence of technologically able firms that cooperate with S&T organisations. On the other hand, there is bias towards size and ownership among firms that cooperate with other partners within the corporation. Therefore, absorptive capabilities are important determinants of collaborating with S&T organisations at any distance, and openness (and size) significantly affect the likelihood of cooperating within the corporation.

In order to validate our hypotheses, we need to compare coefficients across distances. Results on this exercise are presented in Table 6. For each of the regressions in Tables 4 and 5 we test the hypotheses that coefficients for international collaboration were the same than coefficient for national collaboration. P-values are presented in Table 6. When these coefficients are lower than 10%, we claim that differences are significant. Significant differences are shaded, but when the difference sign does not go in the hypothesised direction cells are also dotted.

As can be seen, the hypotheses are totally validated in the case of cooperation with any partners. On the one hand, the difference in openness is significant, meaning firms that cooperate internationally are open while those that cooperate just nationally are closed. On the other hand, absorptive capabilities exert significantly higher influence on the probability of collaborating internationally than on the probability of cooperating just nationally. As a matter of fact, we have seen in Table 4 that absorptive capabilities did not affect the probability of collaborating just nationally. These are important results. This means collaboration at national level only might not aid knowledge diffusion at its best. This is because skills and innovative behaviour make firms more likely to collaborate regionally or internationally rather than only nationally.

Although less significantly, these findings are also confirmed for cooperation with clients and suppliers. For cooperation within the corporation, only ownership exerts a larger influence on the probability to cooperate internationally. As we said above, since the characteristics of these types of collaborators are already quite specific (they would basically be either big national conglomerates or foreign firms) we could not find significant differences on the determinants of cooperating nationally and internationally besides ownership.

In the case of cooperation with S&T partners, although we have seen in Figures 1 to 5 that in average firms that cooperate internationally have higher absorptive capabilities and are more open than firms that cooperate just nationally, we see in Table 6 that absorptive capabilities and importing exert larger influence on the probability of cooperating just nationally than on the probability of reaching international partners. Thus, results for COOP_ST go in the opposite direction as hypothesised. One possible speculation for this could be the quality filter imposed to firms collaborating with (national) public institutions. Thus, it might be more important as a pre-requisite to access national S&T partners to have high absorptive capabilities than it is to collaborate internationally. It is worth noting, however, that there are very few firms that reach international partners in S&T, and around 90% of them also reach national partners in S&T. The main difference that we could find among those groups is that while in international partnerships laboratories predominate, in national partnership universities and technology centres do. This justifies our speculation, public research institutions might select their partners based on their quality —and therefore the chances to collaborate with them largely increase with skills and innovative expenditures— while collaborating with private laboratories and R&D firms might be more responsive to market demand.

TABLE 5
MULTINOMIAL LOGIT MARGINAL PROBABILITIES COLLABORATION WITH DIFFERENT TYPES OF PARTNERS AT DIFFERENT DISTANCES, ARGENTINA 1998-2001

	COOP_VERT						COOP_ST						COOP_IC					
	1-step			2-steps			1-step			2-steps			1-step			2-steps		
	NAT	REG	INT	NAT	REG	INT	NAT	REG	INT	NAT	REG	INT	NAT	REG	INT	NAT	REG	INT
SIZE	-0.003	0.002	0.047***	-0.003	-0.001	0.051***	0.045***	0.007	0.022***	0.044***	0.006	0.021***	0.030***	0.007**	0.017***	0.028***	0.006*	0.011**
	[0.833]	[0.751]	[0.000]	[0.791]	[0.903]	[0.000]	[0.001]	[0.306]	[0.000]	[0.002]	[0.368]	[0.000]	[0.000]	[0.030]	[0.000]	[0.002]	[0.065]	[0.018]
EXPORT	-0.498***	-0.032	0.302***	-0.499***	-0.032	0.300***	0.075	0.011	0.063***	0.081	0.012	0.067***	-0.013	0.034***	-0.003	-0.012	0.036**	0.001
	[0.000]	[0.319]	[0.000]	[0.000]	[0.323]	[0.000]	[0.318]	[0.702]	[0.000]	[0.288]	[0.673]	[0.000]	[0.778]	[0.010]	[0.895]	[0.797]	[0.010]	[0.939]
IMPORT	-0.009	-0.044	0.190**	-0.010	-0.049	0.227***	0.217*	0.028	-0.025	0.255**	0.039	-0.027	0.025	0.026	0.070**	0.033	0.027	0.066**
	[0.939]	[0.544]	[0.033]	[0.935]	[0.500]	[0.009]	[0.051]	[0.553]	[0.334]	[0.021]	[0.407]	[0.344]	[0.738]	[0.224]	[0.012]	[0.676]	[0.223]	[0.010]
INNOV_ACT	0.154	0.090	1.324***	1.122	1.712*	-2.336	1.474**	0.414**	0.329***	2.440	0.925	1.457**	0.423	0.078	0.287***	7.495***	2.012***	.989***
	[0.789]	[0.721]	[0.002]	[0.643]	[0.088]	[0.217]	[0.014]	[0.014]	[0.006]	[0.381]	[0.277]	[0.023]	[0.180]	[0.415]	[0.004]	[0.000]	[0.005]	[0.000]
FOREIGN	-0.007	0.027	0.004	-0.014	0.013	0.026	-0.068	-0.027	0.000	-0.077	-0.034*	-0.012	-0.011	0.030***	0.093***	-0.035	0.025**	.066***
	[0.860]	[0.156]	[0.905]	[0.749]	[0.570]	[0.442]	[0.131]	[0.143]	[0.999]	[0.116]	[0.087]	[0.325]	[0.713]	[0.001]	[0.000]	[0.269]	[0.010]	[0.000]
SKILLS	-0.578***	0.057	0.150	-0.600***	0.032	0.199*	0.484**	0.095	0.134***	0.448**	0.085	0.123***	0.142	0.092***	0.139***	0.075	0.077**	0.083**
	[0.001]	[0.416]	[0.192]	[0.001]	[0.698]	[0.082]	[0.016]	[0.177]	[0.000]	[0.020]	[0.254]	[0.000]	[0.124]	[0.005]	[0.001]	[0.427]	[0.018]	[0.010]
INFO_INT	0.132***	0.069***	0.063*	0.120**	0.047**	0.117***	0.216***	0.033**	0.004	0.209***	0.030	-0.010	-0.004	0.024***	0.014	-0.084**	0.002	.057***
	[0.000]	[0.000]	[0.069]	[0.011]	[0.035]	[0.003]	[0.000]	[0.038]	[0.699]	[0.000]	[0.125]	[0.502]	[0.893]	[0.006]	[0.209]	[0.015]	[0.906]	[0.001]
INFO_EXT	0.184***	0.036	0.190***	0.184***	0.030	0.210***	0.254***	0.040	0.056***	0.257***	0.040*	0.053***	0.100***	0.020	0.012	0.081**	0.014	-0.011
	[0.002]	[0.151]	[0.000]	[0.002]	[0.238]	[0.000]	[0.000]	[0.103]	[0.000]	[0.000]	[0.099]	[0.000]	[0.005]	[0.137]	[0.486]	[0.035]	[0.323]	[0.558]
SECTOR_COOP_VERT	-1.418***	0.174	0.571	-1.400***	0.178	0.532												
	[0.007]	[0.529]	[0.203]	[0.008]	[0.519]	[0.230]												
SECTOR_COOP_ST							0.528	0.136	0.013	0.502	0.125	-0.009						
							[0.317]	[0.521]	[0.923]	[0.340]	[0.558]	[0.950]						
SECTOR_COOP_IC													-0.219	-0.216	0.325*	-0.308	-0.241	0.238
													[0.614]	[0.201]	[0.054]	[0.512]	[0.205]	[0.216]
CONSTANT	0.023	-0.163***	-0.493***	0.000	-0.187***	-0.456***	-0.515***	-0.176***	-0.212***	-0.557***	-0.192***	-0.238***	-0.339***	-0.135***	-0.222***	-0.505***	-0.180***	).289***
	[0.674]	[0.000]	[0.000]	[0.995]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	1198	1198	1198	1198	1198	1198	1210	1210	1210	1210	1210	1210	1209	1209	1209	1209	1209	1209
Pseudo-R2	0.13			0.12			0.15			0.15			0.26			0.30		

Source: Own elaboration based on the National Innovation Survey 1998-2001
Note: p values in brackets
*** significant at 1%.
** significant at 5%.
* significant at 10%.

TABLE 6:
P-VALUES FOR TEST ON MARGINAL COEFFICIENTS FROM TABLE 4 AND 5. NULL
HYPOTHESES: COEFFICIENT FOR COOPERATING SOLELY NATIONALLY =COEFFICIENT
FOR REACHING INTERNATIONAL PARTNERS.

	1-steps models				
	INNOV_ACT	SKILLS	FOREIGN	EXPORTS	IMPORTS
COOP	0.008	0.015	0.000	0.000	0.010
COOP_VERT	0.081	0.002	0.847	0.000	0.227
COOP_ST	0.051	0.066	0.135	0.878	0.030
COOP_IC	0.667	0.968	0.002	0.839	0.565
	2-steps models				
	predicted-INNOV_ACT	SKILLS	FOREIGN	EXPORTS	IMPORTS
COOP	0.001	0.032	0.002	0.000	0.004
COOP_VERT	0.295	0.001	0.508	0.000	0.147
COOP_ST	0.723	0.077	0.190	0.859	0.012
COOP_IC	0.189	0.927	0.003	0.794	0.674

When hypotheses are confirmed, significant differences and correct signs

When hypotheses are rejected, significant differences and incorrect signs

Source: Own elaboration based on the National Innovation Survey 1998-2001.

Once again we want to highlight that our hypotheses on the reinforcing effect of firms' absorptive capabilities and international involvement on the probability to collaborate internationally were developed for cooperation broadly defined. Thus, our discussion was on the determinants to reach distant partners, whoever they were. We were interested in analysing the determinants of going international in general and in particular whether it was necessary to be already "capable" and "open" to reach international partners, more than it was to reach national partners.

5. Conclusions

As it is widely acknowledged in the received theoretical and empirical literature, firms do not innovate in isolation and cooperation is key for technological activities. The NSI literature has stressed the value of cooperation among partners located within the national boundaries (firms, universities, S&T institutions, etc.) and the role of cooperating with partners abroad has received less attention. However, in the globalization era cooperation with foreign partners could be more relevant than in the past. Furthermore, in the case of developing countries, this kind of cooperation could be more important than cooperation with national partners, since knowledge and capabilities available within the country's frontiers could be not enough for firms wishing to develop ambitious innovative activities.

In this paper we do not explore the relevance of different kinds of cooperation, but the determinants of the probability of cooperating with partners located at different distances. We do so through the study of the Argentina's manufacturing firms' cooperation behaviour. Our hypotheses were that internationally integrated firms (through trade or through foreign investment) and technologically able firms (those with high absorption capabilities, measured through the availability of skilled workforce and the development of innovation activities), could be more prone to cooperating with international partners, rather than with just national partners.

Our findings largely confirm these hypotheses. Firms that export, import and/or have foreign ownership show higher probabilities of establishing cooperation linkages with international partners. The same goes for skilled labour intensive firms and for firms that allocate more resources to innovation

activities. Larger firms and firms that assign higher importance to external sources of information are also more prone to collaborating with international partners. These findings go in line with our arguments that international cooperation is self-enforcing (to be internationally integrated demands and/or induces cooperation with distant partners) and self-selective (to cooperate abroad demands higher capabilities than national or regional collaboration).

When disaggregating cooperation with different kind of partners these finding are mostly confirmed in the case of cooperation with clients and suppliers. When analyzing intra-firm cooperation the only significant determinant of international cooperation is foreign ownership. This is not surprising since very few domestically owned firms have affiliates abroad, hence observations for the variable intra-firm cooperation corresponds almost exclusively to foreign owned firms. Local affiliates of foreign firms by default establish cooperation linkages with their headquarters and/or with other affiliates of the corporation, since their technological behaviour is mostly dependant on the innovations they receive from those partners. Hence, it could be expected that independently of the characteristics of those affiliates, they establish international cooperation linkages insofar as their production activities depends, to a large extent, on information received from other partners within the corporation.

When dealing with cooperation with S&T institutions, our hypotheses are rejected. We found that absorptive capabilities and imports exert higher influence on the probability to cooperate nationally only than internationally. Our speculation for this is related to the pre-requisites for accessing collaborative agreements. Given that the majority of international scientific and technological partners are private labs and R&D firms while in the case of national partners they are universities and research centers, it could be argued that the latter implement an institutional selection process based on 'quality' to select partners among firms wishing to collaborate, while the former accept partnerships on a market demand basis.

We have found that openness and absorption capabilities are key determinants of international cooperation in general (while they are not for cooperation done within the national boundaries). To some extent, this means that promoting only domestic interaction might not be the best policy action if technology diffusion is aimed at, because collaboration agreements among only national partners are predominantly established by technologically less able firms. Instead, technologically more able firms establish international cooperation. Therefore, if one is ready to assume that the opportunities for accessing novel knowledge increase for a firm that establishes international collaboration agreements, one is ready to claim that international collaboration is self-enforcing. Under these assumptions, from a policy point of view, international agreements should be promoted so as to avoid the trap of interacting within a community of firms with low technological capabilities.

However, some of the drivers for international cooperation are beyond the scope of public policy actions (e.g. foreign ownership —in fact, it would not be wise to recommend domestic firms selling their equity to foreign hands in order to increase the chances of establishing international linkages). But not all of them:

On the one hand, there could be a virtuous circle between trade and international cooperation. Firms engaged in foreign trade could be more prone to cooperating internationally and, in turn, this cooperation might increase their competitiveness. Hence, promoting firms to engage in export activities could not only have a positive impact in terms of trade balance, but also on the firms' competitiveness levels through learning and innovation, an argument that has been suggested in the received literature.

On the other hand, employing skilled labor and allocating more resources to innovation activities also increases the chances of cooperating internationally with a broad range of partners. Another virtuous circle emerges in this case, since cooperation could further increase absorption and innovative capabilities.

This paper was set within specific limits, both empirically and conceptually. Firstly, we have been limited by the lack of panel data. It would have been more convenient to perform panel data analysis to better control for firms' fixed effects.

Secondly, although we have controlled for sectoral specificities on the probability to cooperate, we have not tested whether the determinants of cooperation affect the probability to cooperate

nationally/internationally differently for different sectors. For example, firms that belong to sectors that are far behind the technological international frontier might need to compensate for this with higher internal capabilities than firms from sectors in which there is a national advantage. Similarly, technological specificities could make absorptive capabilities more necessary in some sectors and less in others. We did not have enough data to disaggregate the estimations per sector, thus it is left for further research. Particularly, it would be interesting to assess whether the determinants of international collaboration change for different sectors.

Thirdly, based on our review of the literature we have departed from the assumption that international cooperation is more relevant for learning in developing countries and even more so in the globalization era. Some scholars within the NSI literature might dispute this assumption. On the one hand, NSI scholars might believe in the existence of learning economies associated to interacting, even if only nationally. On the other hand, the international specialization of many developing countries might make national firms technologically subordinated to international partners. A sort of vicious circle could thus arise insofar those countries are specialized in activities with low opportunities for endogenous technological learning which in turn would reinforce their dependence on foreign partners. We believe that more empirical research should be done aiming at assessing the difference in technological upgrading and economic performance between firms that cooperate nationally against those that do so internationally. For example, are the latter technologically more dynamic and more productive than the former?

Finally, the data available did not allow us to distinguish different modes of collaboration and we believe this is an important drawback to be overcome when more data is made available. While some modes of collaboration might result in very little knowledge involved (e.g. funding, tests, etc.) or knowledge transfer in a single direction (e.g. training, consultancy, etc.), there is much more to gain in terms of capability improvement with other modes of collaboration (e.g. joint R&D projects).

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Annex

TABLE A.1
TOBIT REGRESSION ON INNOVATIVE EXPENDITURE OVER SALES, ARGENTINA 1998-2001

	INNOV_ACT
EMPLOY	0.000*
	[0.051]
EMPLOY_2	-0.000*
	[0.078]
PATENTS	0.008*
	[0.075]
INFO_CORP	0.081***
	[0.000]
BASICNESS	0.000***
	[0.003]
PUBLIC_SUPPORT	0.012
	[0.131]
INNOV_ACT_SECTOR	0.112**
	[0.048]
PATENTS_SECTOR	0
	[0.347]
CONSTANT	-0.030***
	[0.000]
Observations	1323
Df	8
Log likelihood	1132.376
Pseudo R3	-0.198
LR chi2(8)	374.41
Prob > chi2	0.000
N of observations	1323
p values in brackets	

Source: Own elaboration based on the National Innovation Survey 1998-2001
*** significant at 1%
** significant at 5%
* significant at 10%

TABLE A2
DEFINITION OF REGRESSORS OF TABLE A1

EMPLOY	Employment
EMPLOY_2	Squared employment
PATENTS	Dummy variable that adopts the value 1 if the firm obtained at least one patent.
INFO_CORP	Internal (to the corporation) sources of information, normalized in a 0-1 scale.
BASICNESS	Ratio of (1) importance of universities, research centers or technological centers (national or international, public or private) as sources of information for innovative activities (normalized in a 0-1 scale) and (2) importance of market partners (clients, suppliers and competitors) as sources of information (also normalized in 0-1 scale)
PUBLIC_SUPPORT	Dummy variable that adopts the value 1 if the firm utilized public funding for innovative activities.
INNOV_ACT_SECTOR	Innovative activities: Average expenditures in R&D (in-house and external), in engineering and industrial design, hardware, software, capital goods , licenses, management, consultants and training over Sales, by sector ISIC 2 digits.
PATENTS_SECTOR	Dummy variable that adopts the value 1 if the firm obtained at least one patent, by sector ISIC 2 digits.

Source: Own elaboration.

VI. Make, buy and cooperate in innovation: evidence from Uruguayan manufacturing surveys and other innovation studies

Carlos Bianchi[48]
Natalia Gras
Judith Sutz

Abstract

The paper analyses the cooperative behaviour of firms in innovative activities from several data sources and using such data in different ways. Our main assumption is that cooperation for innovation is a knowledge exchange process, driven by people. This leads to stressing the importance of knowing who knows what -and does what- in firms. The results obtained demonstrate that "scientifically and technically trained employees" are among the most relevant variables to understanding the cooperation for innovation within the Uruguayan industry. We posit that our approach helps to improve the usefulness of innovation statistics for public policy design.

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1. Introduction

The cooperation between firms and different types of organizations with the aim of improving their capacity to innovate has been unanimously signalled as important. This has been especially notorious in appreciative theory with a neo-schumpeterian turn. (Nelson and Winter, 1982, Johnson, 1992) Moreover, research on innovation concerned with the commercial success of innovations, or the usefulness of innovations for specific social actors, insists on cooperation as a main explanatory factor in the observed results (Rothwell, 1972; Lundvall, 1985; von Hippel, 1986). Cooperation for innovation is undertaken with various types of "external" actors: other firms, universities and different kinds of scientific and technical service providers, clients and users. Survey-type empirical research has seldom included users as partners for cooperation, even though early in innovation research they were recognized as a powerful source of innovation (von Hippel, 1986), and recent research as well as policy making is highlighting the role of users to such an extent that the expression "user-driven innovation" has become fashionable. (Jepessen and Molin, 2003; Lett et al, 2006).

The identification of the factors that can foster or hamper the propensity of business firms to cooperate for innovation is far from simple, particularly because they are highly context dependent, as any factor embedded in the cultural milieu in which it operates. However, some assumptions can be made to give an a priori framework for empirical work, both to propose indicators and to interpret results. These assumptions are as follows:

Cooperation with external actors with the aim to better innovate is related to knowledge exchanges.[49] If the firm has all the knowledge it needs, or can access the information it needs and transform it into knowledge without further interactions with external actors, or can develop internally in a profitable way the knowledge it needs without cooperation, or it does not care about knowledge, cooperation for innovation would probably not take place.

Knowledge exchanges are embedded in people, and therefore what people know (in the firm) is important to assessing the scope of such exchanges, that depend on the recognition of sources of useful knowledge, the understanding of the ways in which such knowledge can be turned into a useful tool for business purposes and the capacity to establish fruitful dialogues with people belonging to different organizational and institutional cultures.[50]

Knowledge exchanges involve a good deal of tacit knowledge ("The things that we know in this way include problems and hunches, physiognomies and skills, the use of tools, probes and denotative language…" Polanyi, 1983: 29).[51] So, such exchanges are mostly exchanges between people in different organizations and not between organizations as such, even when such exchanges result from institutional agreements.

This framework leads to understanding cooperation as a substantively "people-driven activity", even if it can be performed through formally institutionalized agreements. From an empirical point of view, this leads to understanding the factors related to the firms' propensity to cooperate looking with particular care to the different types of knowledgeable people within the firm, to what they know, to the efforts done to update and upgrade what they know and, last but not least, to the opportunities they are given to exploit their creativity while developing their organized

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[49] Even cooperation to access financial support for innovation can be considered a knowledge exchange to some extent, because the questions to be answered by the firm to get that support may help it to better understand the processes involved and its consequences.

[50] Nelson and Winter have stressed this point forcefully, first by distinguishing between "knowing how to do X" and "knowing how to get X accomplished", and second by noting that the latter involves not only the ability to name the skill involved in getting X accomplished but some level of familiarity with such skill too. (Nelson and Winter, 1982:87)

[51] This is forcefully explained, among others, by Keith Pavitt (1996).

work. The latter has been included in some innovation-related empirical work, (Lund and Gjerding, 1996; Arundel, et al, 2006) but has not yet entered into the main recommendations for comparative research on innovation.

The more cooperation is seen as important for innovation and for better exploiting the pool of knowledge available at national and international level, the more it enters the realm of science, technology and innovation policies. Innovation surveys should provide policy guidance for policies aiming at fostering cooperation for innovation between firms and other actors. This, however, is not always the case. A series of interviews conducted by MERIT staff with members of the European policy community in the spring of 2005 found that econometric results (stemming from CIS surveys) rarely influenced policy making. Instead, the policy community preferred detailed descriptive analysis, particularly when combined with case studies. This conflicts with the perspective of the academic community, which focuses on econometrics. This has also increased over time, with a decrease in academic reports that contain careful descriptive analyses and a trend towards increasingly complex econometrics in academic publications" (Arundel, 2005: 9). However, Arundel indicates that one of the subjects in which innovation surveys analyze have had more political impact was precisely cooperation. Cooperation seems also to be one of the issues that policy makers would most like to get well acquainted with: "The main type of new indicators that the interviewed would like to have concerns the process of commercialization and collaborative activities involving innovation. The latter has the higher political interest, cited by all the interviewed but two from the 19 countries" (Arundel, 2006: 3). We do not know for sure what Latin America's science, technology and innovation policy makers, both at governmental and academic levels, would like to know about the real innovation processes. But we can be sure that the assertion that the primary audience for innovation indicators is the policy community is equally valid for Latin America as it is for Europe. Making the best of available data and presenting sound arguments to back alternatives for its recollection seems to be a valuable exercise. This is what we attempt to do in this paper for the Uruguayan case.

In section two, we explore the factors that better explain the propensity to cooperate for innovation in Uruguayan industrial firms: our findings confirm the role played by knowledgeable people, even in a weak innovative environment. In Section three, we organize the empirical data differently, which allow us to criticize the accuracy of the innovation survey results taken at face value. Nevertheless, the importance of knowledgeable people for cooperation is reassured. In section four, we briefly discuss some recent empirical studies that address innovation industrial surveys with the kind of framework sketched above: our main point is that nothing forbiddingly complex can be found that would stop Latin American surveys from following that path. In Section five, we present some conclusions and suggestions for future work.

2. The Uruguayan Innovation Survey 2001-2003: descriptive statistics and econometric analysis

The results of the Uruguayan industrial innovation survey (IAS), conducted by the Science, Technology and Innovation Directory of the Ministry of Education and Culture and the National Institute of Statistics and covering the period 2001-2003, was released in 2006. [52]

From the surveyed firms, 36.1% declared having undertaken some kind of innovation activities[53], 34.6% declared having introduced some type of innovation, and 31.1% declared having introduced

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[52] The utilized sample is representative of the whole Uruguayan manufacturing industry (Chapter D, Divisions 15 to 36 of the International Industrial Standard Classification (IISC), Revision 3, adapted for Uruguay (http://www.ine.gub.uy).

[53] Innovation activities include: internal or external R&D, the acquisition of capital goods, hardware and software for innovation purposes, technology transfer, industrial design, management and training improvements; oriented to processes or product development or to organizational or trading innovations.

technologically improved products or processes (innovative TPP) during the given period. The difference between firms that undertook innovative activities and those that effectively introduced some innovation in the market is negligible: almost all firms that tried to innovate appeared to be successful. This success shall be discussed later on. The following three tables show the distribution of innovative TPP firms by size, by sector and in relation to characteristics of particular interest. Given our concern about the knowledgeable people in the firm, each of these tables includes columns indicating whether or not such firms have or not university graduates in their staff and whether or not they have scientifically or technically higher education trainees (STT) in their staff. [54]

TABLE 1
INNOVATIVE TPP FIRMS BY SIZE (NUMBER OF EMPLOYEES)

Size	Percentage	Innovative TPP firms have professionals (%)		Innovative TPP firms have STT professionals (%)	
		Yes	No	Yes	No
5 to 9	24.1	25.7	74.3	3.7	96.3
10 to 49	54.7	43.9	56.1	30.6	69.4
50 to 99	9.6	83.9	16.1	78.2	21.8
100 to 249	7.3	89.4	10.6	86.4	13.6
250 to 499	3.0	92.6	7.4	80.8	19.2
500 or more	1.3	100.0	0.0	100.0	0.0
Total	100.0	48.8	51.2	35.0	65.0

Source: Own elaboration based on IAS 2003.

TABLE 2
INNOVATIVE TPP FIRMS BY SECTOR

Activity sector	Weight on the whole industry	Innovative TPP firms have professionals		Innovative TPP firms have STT professionals	
	%	Yes	No	Yes	No
Food, beverages and tobacco	34.1	45.5	54.5	37.9	62.1
Textiles and garments	5.5	52.9	47.1	22.0	78.0
Shoes and leather products	2.4	42.9	57.1	33.3	66.7
Wood and paper	3.1	35.7	64.3	32.1	67.9
Edition and impression	8.8	57.5	42.5	16.3	83.7
Oil and derivatives [a]	0.1	100	0	100.0	0.0
Chemistry	8.7	77.5	22.5	75.0	25.0
Pharmaceutical products	2.7	100.0	0	95.8	4.2
Non metallic minerals and basic metals	2.9	36	64	28.0	72.0
Metallic products	0.8	85.7	14.3	85.7	14.3
Machinery and equipment	13.0	11.0	89.0	11.0	89.0
Electrical machinery and equipment	2.9	61.5	38.5	50.0	50.0
Transport material	2.8	64	36	44.0	56.0
Other manufactures (non specified)	12.2	56.9	43.1	24.5	75.5
TOTAL	100	48.8	51.2	35.2	64.8

Source: Own elaboration based on IAS 2003.
[a] There is only one big public firm in this sector.

[54] Professionals with Scientific or Technical Training (STT) are considered those with training in physics, chemistry, mathematics, statistics, medicine, biology and biochemistry, engineering, architecture or agricultural sciences.

As we could expect, the proportion of firms that have professionals and STT professionals varies with the size of the firm. The drop from having professionals to having STT professionals for the small and very small firms is particularly dramatic. The majority of university trained personnel engaged in innovative activities in the Uruguayan industry (88.6% total) are STT. This implies that a small proportion of the smallest firms have university trainees performing innovation related activities.

The relationship between the presence of STT professionals and the firm's sector of activity is expectedly high in the chemical and pharmaceutical sectors, but for other supposedly technologically intensive sectors. Within, machinery and equipment, for example, the presence of these professionals is quite low. This result is in tune with research findings pointing to the historically very high intra sectoral heterogeneity of the Uruguayan industry. (Argenti et al, 1988; Bianchi, 2007)

TABLE 3
INNOVATIVE TPP FIRMS BY SEVERAL CHARACTERISTICS OF INTEREST

	% in total innovative TPP firms		% of innovative TPP firms that have professionals		% of innovative TPP firms that have STT professionals	
	Yes	No	Yes	No	Yes	No
Foreign capital	6.8	93.2	93.4	6.6	80.6	19.4
Spend in R&D	35.6	64.4	62.7	37.3	45.0	55.0
Perform internal R&D	39.3	60.7	60.6	39.4	46.8	53.2
Receive public financial support for innovation	0.6	99.4	100.0	0.0	100.0	0.0
Cooperate for innovation	82.4	17.6	49.9	51.1	37.9	62.1
Cooperate with S&T institutions	55.1	44.9	64.5	35.5	48.7	51.3
Cooperate with other firms (clients, suppliers, other firms outside their group)	58.2	41.8	42.9	57.1	35.4	64.6
Cooperate with firms within their group	19.7	80.3	38.2	61.8	34.1	65.9
Cooperate with S&T governmental programs	6.7	93.3	71.7	28.3	48.3	51.7
Cooperate for R&D [a]	11.5	88.5	74.0	26.0	71.2	28.8
Cooperate for R&D with S&T institutions[a]	9.1	90.9	70.7	29.3	68.3	31.7
Cooperate for R&D with other firms (clients, suppliers, other firms outside their group) [a]	3.4	96.6	60.0	40.0	60.0	40.0
Cooperate for R&D with firms within their group [a]	3.4	96.6	58.1	41.9	54.8	45.2
Cooperate for R&D with S&T governmental programs [a]	1.2	98.8	100.0	0.0	100.0	0.0
Cooperate for other innovation activities [a]	65.0	35.0	52.7	47.3	41.8	58.2
Cooperate for training [a]	39.7	60.3	61.5	38.5	46.0	54.0
Use external sources for scientific information	41.3	58.7	60.9	39.1	45.6	54.4
Obstacle for innovate with high rating: scarcity of qualified personnel	19.0	89.0	38.0	62.0	12.8	87.2
Obstacle for innovate with high rating: risk of innovation	13.0	87.0	50.8	49.2	32.2	67.8
Obstacle for innovate with high rating: insufficient information about markets and technology	15.5	84.5	47.5	52.5	16.4	83.6
Obstacle for innovate with high rating: insufficient access to financing	33.3	66.7	42.7	57.3	27.4	72.6
With professionals in R&D	18.5	81.5	93.4	6.6	100.0	0.0
Ask and/or obtain patents (Uruguay)	6.0	97.0	89.1	10.9	53.7	46.3
Ask and/or obtain patents (MERCOSUR, rest of the world)	1.0	99.0	100	0	88.9	11.1
Novelty of innovation of TPP firm: firm	57.0	----	40.1	59.9	30.8	69.2
Novelty of innovation of TPP firm: national, regional or international market	43.0	----	60.8	39.2	40.9	59.1
Novelty of innovation in products: firm	44.5	----	47.3	52.7	35.6	64.4
Novelty of innovation in products: national, regional or international market	30.5	----	57.2	42.8	32.7	67.3
Novelty of innovation in processes: firm	57.9	----	40.3	59.7	34.4	65.6
Novelty of innovation in processes: national, regional or international market	27.3	----	64.0	36.0	48.2	51.8

Source: Own elaboration based on IAS 2003.

[a] The Uruguayan survey asks about linkages with agents of the National System of Innovation to develop innovation activities. It did not ask specifically about cooperation. "Linkages for R&D" is considered thus the best possible proxy for cooperation activities. It is worth stressing that it is not possible to assimilate "linkages" to "cooperation" because this would lead to a too loose definition of cooperation. In fact, for the whole sample of innovative TPP firms, the proportion of firms

indicating that they have linkages with the purpose of innovation amounts to 82.4%, leading to an almost non discriminatory situation for "cooperate" or "does not cooperate". Moreover, linkages are mostly related to relatively unspecific activities, as shown by the fact that the bulk of cooperation, 65%, is for "other innovative activities".

Table three summarizes the relation between the variables used as a proxy for "innovation as a people embedded process" and the different variables that will be used in the econometric model as independent and dependent variables.

The latter refers to the cooperation propensity of the firms. "Cooperate for R&D" in its different modalities seems to imply the need of having not only professionals but STT professionals as well: between 60% and 70% of the innovative TPP firms declaring this type of cooperation have both types of professionals. It is also interesting to observe that passing from novelty at firm level to novelty at national, regional or international implies a jump in the proportion of firms that have professionals and STT professionals.

In Table 4 some activities related to performing R&D and cooperating for innovation and for R&D were selected "negatively", that is, the focus is in not performing the activity. The results confirm that not performing an activity distinguishes between those firms having or not having professionals: more than 60% of the firms that do not perform each of the selected activities do not have professionals.

TABLE 4
NOT PERFORMING ACTIVITIES AND HAVING OR NOT PROFESSIONALS

	Innovative TPP firms have STT professionals	
	Yes	No
Do not spend on R&D	29.7	70.3
Do not perform internal R&D	27.5	72.5
Do not receive public financial support for innovation	34.7	65.3
Do not cooperate for R&D with S&T institutions	35.4	64.6
Do not cooperate for R&D with other firms (clients. suppliers. other firms outside their group)	34.1	65.9

Source: Own elaboration based on IAS 2003.

We present now the results of the econometric model, which variables are defined in Annex 1. This model was built following a common methodology for all the participants in the ECLAC-IDRC project, with the aim of analyzing in depth the determinants of co-operation for innovation. It is possible as well to compare the results obtained from the model with those stemming from the descriptive analysis.

When taking into account the real sample (that is, the sample without expansion) of TPP innovative firms that engage in collaborative agreements for R&D, the Uruguayan survey indicates that 17.8% of all innovative firms have been engaged in co-operative arrangements related to R&D.[55] To have some clue about the likeliness of such a figure, we take the paper of Abramovsky et al (2005) which uses a very similar methodology in order to analyze the co-operative R&D activities in four European countries. The paper indicates that the corresponding figure for Spain is 14%, taking a population of firms of more than 20 employees and considering as innovative firms those that introduced innovation and also those that undertook innovative activities during the period of analysis. The corresponding figure for Germany is 18%. The figure for Uruguay can then be considered plausible. The results of the econometric model are presented in Table 5.

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[55]   With the already mentioned caution note about how co-operation is defined in the questionnaire.

TABLE 5
CHARACTERISTICS OF FIRMS THAT UNDERTAKE
CO-OPERATIVE ACTIVITIES FOR R&D

Dependent variable = 1 if firm has a co-operative for R&D Probit Estimates

	(1)	(2)	(3)	(4)
	Cooperation with any organization	Cooperate with S&T institutions	Cooperate with other firms	Cooperate with Group's firm
Size	0.001	0.001	0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Foreign Capital	0.158***	-0.011	0.011	0.083***
	(0.048)	(0.043)	(0.013)	(0.025)
Skills	1.501**	1.388**	0.092	0.143
	(0.737)	(0.587)	(0.165)	(0.238)
R&D Intensity	-0.547	-0.378	-0.017	-0.033
	(0.679)	(0.574)	(0.114)	(0.18)
Public Support	0.186	0.149*	0.038*	
	(0.117)	(0.089)	(0.029)	
Technological Opportunities	0.2***	0.148***	0.029*	0.037
	(0.071)	(0.057)	(0.021)	(0.028)
Novelty of innovation	0.113***	0.069**	0.035**	0.0237
	(0.039)	(0.031)	(0.013)	(0.015)
Legal Protection	-0.068	-0.016		
	(0.084)	(0.057)		
Lack of access to finance	-0.097**			-0.014
	(0.046)			(0.018)
Lack of access to information on market	0.128*		0.035***	0.022
	(0.07)		(0.019)	(0.026)
Lack of access to information on technology		0.099*		
		(0.051)		
Lack of qualified personnel				-0.015
				(0.023)
Industry level cooperation	0.649***	0.387***	0.073*	0.066
	(0.169)	(0.135)	(0.05)	(0.05)
Pseudo R2	0.214	0.158	0.228	0.312
LL	-130.31	-106.79	-43.02	-54.78
Chi – square	72.54	43.82	18.62	45.76
Observations	354	354	354	354

Source: Own elaboration based on IAS 2003
Note: Robust Standard Error in parentheses
***significant at 1% level.
**significant at 5% level.
* significant at 10% level.
The numbers reported are the marginal effect of the independent variable on the probability of cooperation.

Abramovsky et al (2005:5) indicate: "As in Cassiman and Veugelers (2002) we find that firms' ability to take advantage of incoming spillovers in the form of publicly available knowledge (their absorptive capacity), and firms' ability to limit outgoing spillovers and appropriate the returns to their innovative efforts both have a positive effect on the likelihood of firms undertaking co-operative R&D agreements. Moreover, absorptive capacity is found to be a more important factor in determining collaborative agreements with research institutions. As might be expected given the orientation of public support for R&D we find a positive relationship between receipt of financial public support for innovative activities and the probability of cooperating with the research base, and to a lesser extent with the probability of co-operating with other firms. Finally, we find some evidence, particularly for firms in Spain, that cooperative R&D is motivated by a need to overcome financial constraints, potentially reflecting differences in capital markets". The Uruguayan results go in the same direction:

(i)   incoming spillovers, approximated by the variable "technological opportunities" (which takes into account the importance given by firms to external sources of knowledge), have a significantly positive effect on the likelihood of firms undertaking co-operative R&D agreements;

(ii)   absorptive capacities, approximated by the variable "skills" (measured by the proportion of professionals working on R&D in total number of employees) have also significant positive effect on the likelihood of firms undertaking co-operative R&D agreements, this is also the case for collaboration with S&T institutions;

(iii)   a positive relationship can be found between receiving public support and the probability of cooperating with the research base; in the Uruguayan case this also true for cooperating with other firms, an expected result given that public support for innovation at firm level is usually stronger if collaborative arrangement between firms are present;

(iv)   cooperative R&D seems to be motivated by a need to overcome financial constraints;

(v)   differently from the conclusion of Abramovsky et al (2005), the limitation of outgoing spillovers is not significant in Uruguay, a result related to the lack of importance of patents in general.

Moreover, other interesting characteristics are:

(vi)   Skills are a significant variable at 5% of confidence and it is the most important variable explaining the probability to cooperate on R&D, particularly to cooperate with S&T institutions. This result is aligned with the literature on innovation, especially that which is concerned with absorptive capacities. It is interesting to note the importance of this variable in a developing country like Uruguay. It is interesting to note that this variable has not been extensively used as a proxy for absorptive capacities: our framework, as well as our results, suggest that it should be.

(vii)   Technological opportunities (used as a proxy for incoming spillovers) is a variable that shows a positive and significant relationship with the likelihood to co-operate. This result is not surprising; in order to be aware of technological opportunities as well as of who could be a partner for interactive innovation activities, co-operative arrangements can be particularly useful. Cooperation with S&T institutions and other firms (vertical cooperation) seem to be affected in a smaller magnitude by the existence of technological opportunities.

(viii) Foreign capital is a variable that shows positive and significant relationship with the likelihood to co-operate, including firms of the same group. This result confirms that foreign firms tend to co-operate with their headquarters or other branches of the firm. Given the importance of the current discussion on foreign firms' local spillovers in developing countries, it is worth being cautious with this result in terms of generalizing it to all firms at the national level.

(ix)   The novelty level of innovation seems to be a "good" variable in terms of its explicative power related to co-operation for R&D. This result seems to be of "common sense" to some extent: the more the novelty, the more the complexity, the more the need for assessment on technical information, for instance about standards, etc. In the same vein as in the case of skills, this is a variable seldom used in other empirical analyses of co-operation for R&D.

(x)   Public support is a variable that shows positive and significant relationship with the likelihood to co-operate, particularly with S&T institutions and with other firms (vertical co-operation). This result suggests that co-operation for R&D is an activity that implies costs to the firms, which tend to incur more in such co-operations when they are supported by public resources.

(xi)   Variables related to obstacles to innovate show different behaviors, with lack of skilled personnel not showing any significant relationship with the probability of co-operating for R&D. Lack of information about markets is significant to foster vertical cooperation while lack of access to information on technologies seems to foster co-operation with S&T institutions. Lack of finance seems to be an un-differentiated problem: not having access to finance hamper co-operation with any organization. This result is in line with the suggestion made above.

(xii) Patents are not significant, but not just for co-operation but in absolute terms. The proportion of Uruguayan firms that ask for or obtain patents are negligible.

(xiii) R&D intensity, approximated by the proportion of R&D expenditures on total sales, is a non significant explanatory variable. [56]

(xiv) Size is not significant as an explanatory variable. We have tried different ways of taking this variable into account, with no significant variations in results. The mean of employees for the total sample of innovative TPP co-operative firms is 106 (any firm with more than 100 employees is considered as a "big firm" in the national statistical conventions of Uruguay). This shows that cooperation for R&D is weakly present in small and medium firms.[57] This is not such a surprising result according to the previous analysis of the Uruguayans Innovations Surveys (Pittaluga et al, 2005. Bianchi, 2007). Also, for the Canadian innovation survey of 1999, a similar situation is reported. (Arundel and Mohen, 2003: 47)

(xv)   Industry level co-operation is, expectedly, a significant variable, showing that the probability of co-operating for R&D is associated to the firm's sector.

3. Looking critically into data

The main results of the econometric model presented and analyzed in Section two exhibits two types of results. Some of them are arguably predictable in the light of the background knowledge we have about the Uruguayan industry; however, these results make it possible to discuss some dimensions that are specially useful for the analysis of the innovation process. Other results are of a more general nature. Among the latter, we would like to insist on issues related to the "innovation as people driven activity" approach to innovation, encouraged by the good correlation the model shows between

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[56]   Some additional measures were made to test the explanatory capacity of the considered variables. The measures of the mean value of the considered variables show different outcomes. No significant differences were found across cooperative and non-cooperative firms in the case of R&D intensity.

[57]   The measure of the mean value of the variable "size" does not show significant differences across cooperative and non-cooperative firms.

"skills" at firm level and the likelihood to co-operate on R&D. It is particularly interesting to link the information from the innovation survey presented so far and the results of the model, to the additional empirical evidence presented in this section, where we work with the same data set but look differently into it, as well as referring to other sources of information. The section ends referring to these links and what they imply.

The Uruguayan industry's innovative behaviour is, in general terms, weak. The proportion of innovative firms is low, that endogenous innovation efforts account for a small part of the budget devoted to innovative activities, and spending in R&D is extremely low. Industry constitutes a weak market for higher education scientific and technically trained personnel, a trend that was observed systematically for the first time in 1986 and has not changed until today.

TABLE 6
COMPARISONS BETWEEN FIRMS WITHOUT SCIENTIFICALLY OR TECHNICALLY
HIGHER EDUCATION TRAINED STAFF IN 1985-1987 AND 2001-2003

Size of firms	% of firms without scientifically or technically higher education trained (STT) staff [a]	
	1985-1987 (1)	2001-2003 (2)
Small 20-49 for (1) <20 for (2)	73.8	87.4
Medium 50-99 for (1) 20-100 for (2)	50.3	63.2
Large > 100	22.5	21.9

Source: Argenti et al, 1988; Bianchi and Gras, 2006.
[a] Life science trainees did not exist in industry in 1985-1986; they account for 1% of all trainees in 2000-2003.
This result contrasts with the weight of life science researchers in the Uruguayan academic milieu, where they are by far the best represented group.

Table 6 deserves some attention for three reasons. First, it gives information about a specific type of staff: that with higher education in science or technology. This type of information is gathered in both Latin American and European surveys. In the Uruguayan case it has been collected in 1986, 2001 and 2003[58], even if with different methodologies. We posit that this is a positive feature of Uruguayan surveys that should be maintained and improved.[59] Second, it depicts information for "not having staff with S&T higher education training". The important issue here is that "having" and "not having" this type of staff is not symmetrical in substantive terms for the whole population of firms, particularly regarding size but regarding sector too. The case of size is particularly clear: a firm of 500 people does not need to have 25 S&T trained employees to be able to absorb and interact on knowledge matters in a similar way than a firm of 20 people that have one such employee: there is no linear relationship between size and number of S&T trainees in terms of capacity to relate usefully

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[58] It has also been collected in the latest innovation survey, 2006-2007.

[59] The 2001-2003 Uruguayan survey, for instance, contains a full block of questions related to the introduction of information and communication technologies in the firms. However, there are not questions concerning trained personnel in ICTs at firm level. The impact, sophistication and scope of ICTs depend to some extent on the internal capacities of the firms to interact with the purchased hardware and software: without information about specific skills on ICTs, important differences are blurred and interpretation of data can be misleading.

with knowledge. On the contrary, "not having" is a clear cut indicator of a capacity that is missing.[60] An indicator of this type has been taken into account in recent empirical work on small firms in Denmark where it has been shown that a population of firms without any university-trained employee at time t exhibited a differentiated behaviour related to innovation at time t+1 depending on the hiring or not of a first university trained employee: those firms that did hire a first university trained employee exhibited a higher propensity to introduce innovations. (Nielsen, 2007)

Finally, this way of depicting information is useful for policy design. If the first university trainee in a small or medium firm seems to be able to make a difference in terms of its ability to interact with knowledge sources, then having a map of firms without such personnel allows for the identification of what can be called a "knowledge-vulnerable" population of firms. Specific policies for such population with special pro-active features can then be designed and tried.

Table 7 shows the distribution of professionals in Uruguayan industry by type of knowledge and activity within the firm: this type of information is also useful to have a better picture of the relationship of industry with knowledge.

TABLE 7
PROFESSIONALS BY FIELD OF KNOWLEDGE AND TYPE OF ACTIVITY
(Uruguay, 2001-2003)

Field of knowledge (as asked in the survey)	% of each type of professional in total professional staff	% of each type of professional engaged in R&D activities (1)	% of each type of professional engaged in other innovation activities (2)	(1) + (2)	% of each type of professional not engaged in any innovative activity	Total
Exact sciences (physics and chemistry)	17.0	29.5	50.1	79.6	20.4	100
Exact sciences (mathematics and statistics)	4.3	6.1	14.4	20.5	79.5	100
Natural sciences (biology, biochemistry, biophysics)	1.1	21.2	42.4	65.6	36.4	100
Medical sciences	5.8	5.1	11.4	16.6	83.4	100
Technology (engineering and architecture)	27.4	20.3	45.1	65.4	34.6	100
Agrarian sciences	11.8	17.8	28.6	46.5	53.5	100
Social sciences	28.5	3.0	10.3	13.3	86.7	100
Humanities	4.1	0	4.8	4.8	95.2	100

Source: Own elaboration.

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[60] The importance given to this type of staff does not imply diminishing the importance of very different types of knowledge within the firm, from the knowledge about doing gained by experience, to the formal knowledge of people trained in diverse branches of the social sciences when they work in organizational issues.

We will not undertake a thorough analysis of this table, but make brief comments related to the fields of knowledge with high scores in the column "% of each type of professional not engaged in any innovative activity", mathematics and statistics, medical sciences, social sciences and humanities. In the first case, it can be inferred that this type of professionals is engaged mainly in production and management; in the second case, such professionals are mainly hired to perform certification of personnel on leave for health reasons. The case of social sciences and humanities is more difficult to tackle. They could have been associated to "soft" innovations, but only one third of firms declared having performed innovation in organizational change and related issues, which may explain the very low attachment of such professionals to innovative activities. The main explanation seems to stem, then, from a general trend of the labor market present in Latin America during the so called neo-liberal reforms: "Firms have used educational and skills levels to select personnel not so much because they needed workers with higher schooling as because the overabundance of workers allows them to be more selective in hiring" (Reygadas, 2006: 137).

Uruguayan industry concentrates in traditional sectors food and beverage, clothing and textile, basic chemical products. Industrial exports concentrate in sectors and sub-sectors mainly based on static comparative advantages, particularly the good endowment of natural resources for agriculture, forestry and husbandry, favoring the competitiveness of agro-industries. Exports with middle or high value-added are a small portion of total exports. The overall results stemming from innovation surveys are, thus, not surprising. Uruguayan industry does not demonstrate homogeneous behaviour regarding innovation. The careful understanding of heterogeneity and the identification of the roots of differentiated innovative behaviour among firms is important for policy purposes.

Working with micro data from the 2003 IAS, Bianchi and Gras (2006) conducted an exercise with the aim of clustering firms around a set of characteristics related to the "cognitive base" of its innovative behaviour. For this exercise, "innovation activities" include R&D, design, quality control and engineering. With such aim in mind, a set of 20 variables were defined, associated with three features:

The internal capabilities of the firm, understood as the capabilities of its personnel to identify and solve production problems through generating and applying knowledge. Eight variables were included in this feature, all of them taken as a percentage of each characteristic in total employment.[61]

The links that the firm maintains with its environment to undertake innovative activities. Four variables enter here, all of them giving account of the number of agents of the National Innovation System with whom the firm established linkages for different type of activities.[62]

The firm's innovation experience, understood as the firm's specific learning trajectory. As a proxy to this feature a series of items were selected, expressed as a percentage of the investment made on them over total sales or as a percentage of sales of novel products over total sales.[63]

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[61] The variables used as a proxy indicator of *internal capabilities of the firm* were (in % of total employees): (1) personnel receiving training; (2) personnel working on innovation in formal units; (3) personnel working on innovation informally; (4) technicians employed; (5) TTS professionals working on R&D; (6) TTS professionals working on other innovation activities; (7) TTS professionals; (8) no-TTS professionals.

[62] The variables used as a proxy indicator of *the links that the firm maintains with its environment to undertake innovative activities* were*:* number of agents of the NIS with whom the firm established linkages for: (9) R&D activities; (10) other innovation activities; (11) training activity; (12) financing

[63] The variables used as a proxy indicator of *firm's innovation experience* were % of different types of investments in total sales: (13) capital goods; (14) technology transfer; (15) design; 16 management improvements; (17) investment in training; (18) R&D; (19) computing. The last variable, (20), refers to sales of novel products on total sales.

TABLE 8
INNOVATIVE BEHAVIOR PATTERNS IN THE URUGUAYAN MANUFACTURING INDUSTRY

Definition of the pattern	% of cases [a]
Low or null innovative intensity	73.4
Innovation based on exogenous knowledge (Mainly through purchasing capital goods).	13.7
Innovation based on the endogenous competences of the firm.	7.1

Source: Adapted from: Bianchi and Gras 2006.
[a] 5.8% of the cases could not be analyzed based in the multivariate analysis.

Based on these variables,[64] and performing first a multivariate analysis process —principal component analysis, followed by a cluster analysis— three patterns of innovative behaviour in the Uruguayan manufacturing industry are proposed. In terms of knowledge for innovation, one of such patterns, covering almost three quarters of all firms, is a "very weak demander"; the second one can be sketched as a "buy" pattern and the third as a "make" pattern.

The first pattern, characterized by low or null innovative intensity, includes 83% of firms that did not engage in any innovation activity. The remaining 17% of firms exhibiting this pattern did declare having carried out some innovative activity, and given, that almost all firms declaring innovative activities declared as also declared having been successful in introducing innovations. We have here a "data mismatch": 34.6% of firms counted as innovative by the survey belongs to the pattern of low or null innovative intensity. [65]

The second pattern identifies firms whose innovative processes are based on the incorporation of exogenous knowledge. The innovation activities of these firms are basically oriented towards investments in hardware, software and capital goods. Both the first and the second pattern exhibit as a characteristically low number of firms with engineers or scientifically trained personnel.

The firms characterized by the third pattern exhibit a higher proportion that have TTS personnel as well as stronger linkages with agents of the NIS. They are a fair minority in the Uruguayan industrial landscape.

To explore the usefulness of the clustering of firms around these patterns and, moreover, to evaluate to what extent these clusters give account for what we believe ex-ante should happen, we analyze the behaviour of the three groups of firms in relation to cooperation, understood as links with NIS agents quite broadly defined. This is done in two steps. First, as shown in Table 9, cooperation is taken as a broad concept; second, as shown in Table 10, cooperation is taken in a more detailed way. In both cases each pattern behaves as it is reasonable to expect it would: the low intensity pattern has very little cooperation, diminishing as the type of cooperation is more knowledge intensive, and the endogenous innovative pattern has relatively high cooperation in comparison to the other patterns, the difference widening as the type of cooperation is more knowledge intensive.

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[64] Four other variables were added to characterize the firms: size (number of employees); foreign capital; proportion of exports on total sales and apparent productivity (sales/employees).

[65] The mismatch for firms that declare being technologically innovative in product and processes are only slightly smaller: 33.9% of them belong to the first pattern of low or null innovative intensity.

TABLE 9
INNOVATIVE BEHAVIOR PATTERNS AND LINKS WITH NIS AGENTS*
(% of firms)

Links with NSI institutions	Low or null innovative intensity	Innovation based on exogenous knowledge	Innovation based on the endogenous competences of the firm	Total
No	42.46	22.00	8.78	36.96
Yes	57.54	78.00	91.22	63.04
	100.00	100.00	100.00	100.00

Source: Adapted from Bianchi and Gras, 2006.
* NIS agents include universities, technological centers, technical training institutes, laboratories, technological-related units, financial bodies, suppliers, customers, related enterprises, other enterprises, consultants, S&T government agencies and the firm's headquarters.

TABLE 10
INNOVATIVE BEHAVIOR PATTERNS AND DETAILED LINKS WITH NIS AGENTS
(in % of firms)

		Low or null innovative intensity	Innovation based on exogenous knowledge	Innovation based on endogenous competence of the firm	Total
Links for R&D	No links	98.59	93.25	67.80	95.51
	Links with one institution	1.41	2.50	17.56	2.77
	Links with more than one institution	0.00	4.25	14.63	1.72
Links for other innovation activities*	No links	70.40	42.50	27.18	63.08
	Links with one institution	16.58	9.50	12.14	15.21
	Links with more than one institution	13.02	48.00	60.68	21.71
Links for training	No links	90.91	51.88	51.96	82.32
	Links with one institution	6.00	24.06	23.04	9.90
	Links with more than one institution	3.09	24.06	25.00	7.78
Links for financing	No links	78.37	71.93	67.80	76.64
	Links with one institution	16.15	22.81	14.63	17.01
	Links with more than one institution	5.48	5.26	17.56	6.35

Source: Adapted from: Bianchi and Gras 2006.
Other innovation activities include organizational change; testing; technical support; and design.

The consistence of these patterns underline the seriousness of the above mentioned "data mismatch", by which one third of all supposedly innovative firms should not have been considered thus. Before sketching an explanation, it is worth presenting a last piece of data stemming from the IAS 2003 survey. How many of the firms declaring performing R&D did not have any TTS employee? The figure is high indeed: 54.5%. It is compelling, then, to criticize the data, trying to

understand how it can be that almost one third of all firms declaring being innovative are in fact not innovative, and more than half of the firms declaring performing R&D have not a single employee with some training at university level in sciences or engineering.[66]

The problem lies with the concepts used and with the questionnaires utilized. We are not alone in criticizing the concepts used in innovation surveys. Referring to the European innovation surveys and its estimation of innovative firms, it was recently said: "…these estimates are usually based on a very broad definition of what constitutes innovation, which includes both intensive in-house R&D to develop a new for the market product or process and minimal effort to introduce manufacturing equipment purchased from a supplier. Such a broad definition of innovation is both misleading in international comparisons and also fails to provide a clear picture of the structure of innovation capabilities within individual countries" (Arundel et al, 2006: 13). If this is true for Europe, it is even more so in reference to a developing country. In such a context, both concepts and the way of making questions need to be carefully revisited to obtain meaningful results. Elsewhere (Sutz, 2006) some of these issues have been discussed. It is worth recalling here that firms that declare being innovative while they are not, can do that not only because the concept of innovation is not well understood as it is described, but because they want to be seen in a better light. Innovation is a value added concept: to innovating is good and not innovating is not good, and so answers to this question should not be taken at face value. This suggests that innovation surveys should be prepared with the assistance of sociologists and political scientists with expertise in phrasing questions and introducing control questions to assess the correspondence of answers to the questions asked.

The suggestion is more demanding. The very comprehension of innovation as a complex social process leads to revisiting the articulation between the theory of innovation, particularly "political economy" theories of innovation, and the tools designed to measure innovation. Such approach, focusing in developing countries, can be found in Cassiolato et al, 2003. A proposal in this direction, centered in developed countries, has been made recently, stressing that competence building and organizational change aimed at promoting creativity at work are main features of an innovative firm. Empirical work has been done, showing that firms that combined two modes of learning, one more biased towards science and the other more biased towards experience (approached by organizational practices such as 'interdisciplinary workgroups' and 'integration of functions' together with 'closer interaction with customers') have a much better innovative performance that firms concentrated in only one mode of learning. (Jensen et al, 2007) There is a long road to go in fine-tuning the theory of innovation and the way we measure innovation, particularly so in developing countries.

Coming back to other puzzling feature of the Uruguayan innovation survey, namely that almost all firms declaring innovative activities were successful in innovation, we present evidence now of how this situation changes when a broader definition of innovation activity is allowed. The evidence stem from a case study of more than 50 Uruguayan firms, mostly small firms, concentrated in an industrial park housed in the premises of an old and out of use slaughter (Technology and Industrial Park Cerro). (Bendelman, 2007) The questionnaire used for analyzing innovative activities added to the classical definitions the following one: "Recycling of machinery. This mean recycling or adaptation of machinery and devices, old or advanced, specifically directed to the introduction of changes, betterments and/or innovations in products, processes, organizational techniques and/or commercialization". The results obtained are net, even if not surprising for anyone acquainted with the industrial reality of countries in which innovation is performed in scarcity conditions (Srinivas and

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[66] We are not implying here that innovation requires necessarily TTS personnel. But in any "common sense" understanding of what R&D means (moreover if we take the Frascatti definition of R&D) the concept is linked to scientifically trained people. If more than half of the population of firms that declare performing R&D does not have scientifically trained people, it is legitimate to wonder if this data is comparable in any sensible sense with that of other surveys were the understanding of what R&D means can be more strict.

Sutz, 2008): the proportion of firms indicating this activity is slightly higher than the most mentioned activity in the Industrial Survey, which was purchase of capital goods. (Bendelman, 2007)

Table 11 shows how the difference between firms undertaking innovative activities and innovative firms change dramatically when asking in the "official" way and when asking in the broader, more contextual way.

TABLE 11
DIFFERENCES BETWEEN FIRMS PERFORMING INNOVATIVE ACTIVITIES AND INNOVATIVE FIRMS IN VARIOUS INNOVATION SURVEYS IN URUGUAY
*(% of total firms)*

	% of firms performing innovative activities	% of innovative firms
Technology and Industrial Park Cerro	81	27
National Innovation Survey 1998-2000	32	32
National Innovation Survey 2001-2003	36	34

Source: Based on Bendelman, 2007.

The result for the Technology and Industrial Park Cerro is more in tune with what intuition suggests that the difference between efforts to innovate and success at innovating should be significant in a developing country. In any case, with all due caution, these results back the claim that what is asked and how it is asked around industrial innovation, at least in Uruguay, needs revision. [67]

Regarding the overall picture on innovation that can be gathered linking the different exercises made with the sources of information available, it can be determined that knowledgeable people and what they know at firm level is key for cooperation. An engineer talks to another engineer, in another firm, at the university, at the technical regulatory body; a biochemist talks to other biochemists, and so on. They share a specialized knowledge that allows them to recognize each other in the first place, to set a common agenda of exchanges in the second place, and finally to establish cooperation relationships. We knew that beforehand, less from theory than from common sense. However, the powerful confirmation stemming from the econometric model suggests that digging further in this direction is of value, not only because of the weight of skills as such but because several of the variables strongly related to the likelihood to cooperate can be seen as "skill-related". The Figure 1 tries to capture the picture that comes out when some of the different exercises made are linked.

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[67] The need for revision is not only centered around concepts and ways of asking; revision is needed too for achieving a better articulation between different surveys at national level, liberating innovation surveys from the burden of asking questions that have been already asked elsewhere. See Baptista 2003 for a critique of this aspect in the Uruguayan case.

FIGURE 1
RELATIONSHIPS BETWEEN INNOVATION PATTERNS
AND COOPERATION LIKELIHOOD
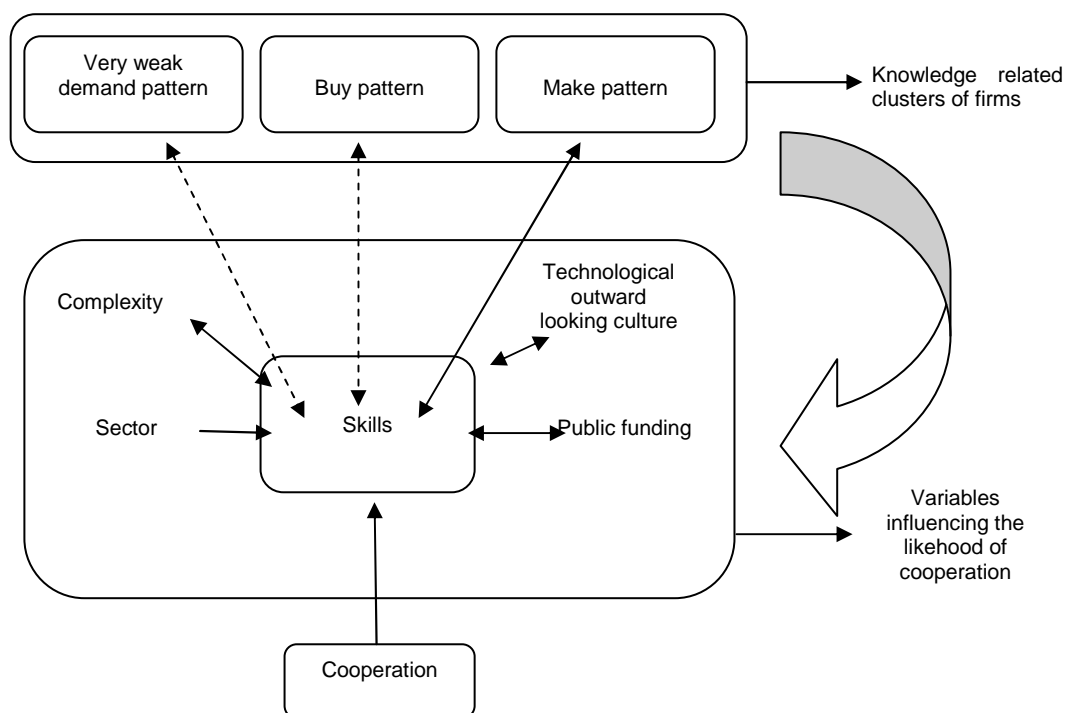
Source: Own elaboration.

The descriptive statistics, the econometric model, the cluster analysis, the case study and the general knowledge about the Uruguayan economy, help to formulate questions to data from different perspectives, making that way the best possible use of the wealth of information that innovation surveys usually convey. They help too to realize which questions that appear as important are not answerable due to weaknesses in the way innovation surveys are conceived, which helps to advocate for changes in such conceptions.

4. A survey example to take into account

We will take the European Commission Flash Eurobarometer 2004 as an example for two main reasons: the type of questions included and the factorial analysis made, leading to a taxonomy that can be compared with the one presented in this paper. The methodology of the Eurbarometer survey is different in various respects from the classical innovation surveys, but there is no reason why several of the questions asked in the former cannot be included in the latter.

Flash Eurobarometer (FE) is particularly useful as an example to take into account because it gives high importance to co-operation and to the knowledgeable people in the firms, the cognitive background of such people and the willingness of firms to hire more people of this kind as an

innovation strategy.[68] "The human dimension is a key element for companies investing in innovation activities. At this stage of our analysis, we will focus on the hiring of new university graduates specifically in support of innovation activities" (FE, 2004: 39). The analysis of the last point stems from the following question: "In the last two years, in support of your innovation activities, did your firm hire one or more new university graduates from the following countries?" The alternatives were own country, other EU member countries, USA and other countries. Around one third of the firms in countries at EU 25 level had hired a new university graduate from their own country.[69]

The typology of firms developed by FE applying a factorial analysis to 11 variables taken from the questionnaire led to 5 categories or patterns:

1. "small, local, static" (30% of the sample): "do not invest in efforts to support (innovation) activity through hiring new graduates, training their staff or participating in an innovation network."

2. "local dynamic" (13% of the sample) "can be considered to be innovative...When it comes to supporting their innovative activities, this group looks to experts for advice on innovation, they hire new national graduates, train their personnel and participate in an innovation network."

3. "exporting, non-innovative" (24% of the sample) "are equally inactive in terms of efforts to support innovation activities including engaging the services of experts in the matter, hiring new graduates and training staff."

4. "successful, innovative" (20% of the sample) "This group of companies shines in all aspects of the innovative process and support this activity through the requesting of advice from experts as well as hiring new graduates from universities at home and abroad."

5. "secure, public sector clients" (13% of the sample) "Their distinguishing characteristic is that they sell to a number of government agencies".

Patterns 2 and 4 have successfully introduced new products and new processes clearly above of the rest. These two groups are also distinguished by being well above in giving a positive answer to the following questions: Carry out in-house research; Contract out research; Sales outside the EU; Advice services obtained; Hire new graduates from country; Participate in innovation networks. [70]

It is interesting to note that three out of these six questions can be considered related to co-operation for innovation: contracting out research, obtaining services advice and participating in innovation networks. The linkages between innovative behaviour and (i) co-operation, (ii) endogenous knowledge efforts and (iii) concern about the "absorptive capacities" of the firm understood as the knowledgeable people the firms incorporates, can be considered strong. It would have been possible to argue the other way around: co-operation for innovation should be undertaken more by those firms which weakness in terms of internal knowledge push them to rely on external support. However, as common sense indicates and literature underlines (Cohen and Levinthal, 1990), recognizing the need for knowledge, and finding ways for satisfying such need, can hardly be accomplished without some internal strength in terms of knowledge.

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[68] Regarding intellectual propriety protection, that is one of the features of interest for ECLAC's comparative analysis, Flash Eurobarometer states: "Only a small minority of innovative enterprises in the EU have taken measures to protect their intellectual property through patenting or the registration of international trademarks" (FE; 2004:12)

[69] This information, combined with the results of the question around outsourcing R&D from universities, suggests that the two strategies can be alternatives for the same aim: get acquainted with fresh knowledge. Finland, that shows the highest proportion of firms outsourcing R&D to universities (51%) has the lowest rate of new university graduates hiring (8%); Sweden, with a much lower rate of outsourcing R&D to universities (21%) has the highest proportion of new university graduates hiring (48%).

[70] The question is formulated as follows: "In the last two years, did your firm participate in an innovation network including other firms, universities, or research institutes?"

Other questions of interest in FE include the field of knowledge of the new hired employees, the degree of satisfaction with the qualification of such newly matriculated university graduates, the efforts aimed at training for better performing innovations, the public support received for "knowledge-related" activities and the opinion about the importance of such support, in different activities for the firm's performance. Table 12, where answers to some selected question along the typology are shown, gives an idea of the kind of picture focused on skills, co-operation and public support that could be possible and useful to obtain for Latin America. Table 13 presents an attempt to reproduce as far as possible such exercise for the Uruguayan case.

TABLE 12
SELECTED INFORMATION FROM FLASH EUROBAROMETER N° 164
(% of firms of each type that answered yes)

Questions	1 "small, local, static"	2 "local dynamic"	3 "exporting, non-innovative"	4 "successful, innovative"	5 "secure, public sector clients"
Successfully introduce new or significantly improved products or services.	60.5	84.5	74.1	88.4	75.8
Carry out in-house research	33.2	74.6	50.4	70.9	51.4
Contract out research to other firms, universities or research institutes..	6.4	26.8	11.3	46.1	17.2
In the last two years, did you obtain public support for R & D within your firm or for R & D contracted out to other organizations?	6.4	14.1	10.2	28.5	12.3
In the last two years, did you obtain advice services for your innovation activities e.g. with business plans, market research, patenting, finding innovation partners, or adopting new manufacturing technology?	5.9	63.4	15.3	45.1	26.1
In the last two years, in support of your innovation activities, did any of your staff attend formal training courses?	46.2	90.1	54.9	73.7	65.5
In the last two years, did your firm participate in an innovation network including other firms, universities, or research institutes	3.4	18.5	2.8	35.9	11.5
Was public support in the last two years crucial to any of your innovation projects, such that the innovation would not have been developed without the support? (for those receiving public support)*	19.0	22.4	19.3	32.9	13.8
In the last two years, in support of your innovation activities, did your firm hire one or more new university graduates from the following countries? Your country	16.3	44.4	28.1	55.8	26.1
(for those that answered yes to the question about hiring new graduates) In which of the following fields did one or more of these new employees have degrees in ?					
Engineering	40.0	41.4	49.7	45.9	43.7
Sciences	10.5	14.4	14.7	32.2	16.7
Economics or business administration	45.2	50.5	42.9	37.4	35.3
How satisfied were you with the level of qualifications of the graduates you hired? Satisfied	87.3	91.9	89.2	88.6	86.8
In the last two years, did you receive a public subsidy to hire new university graduates?	3.6	10.8	6.7	11.0	12.7

Source: Own elaboration.
Note: Referring to this question, Antony Arundel indicates that from the 8 activities between which to choose for acknowledging public support, the first rated was collaboration and the second programs to support research. (Arundel; 2006).

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TABLE 13
INNOVATIVE BEHAVIOR PATTERNS IN THE URUGUAYAN MANUFACTURING INDUSTRY
BY SEVERAL CHARACTERISTICS OF INTEREST
(Plus comparison with Type for FE)

	Low or null innovative intensity	Innovation based on exogenous knowledge	Innovation based on endogenous competence of the firm	Total in each row	Type 4 for FE
All sample	73.4	13.7	7.1	100	
For Innovative TPP					
Innovative TPP	33.9 (13.0)[a]	43.6 (89.0)	22.5 (89.8)	100	88.4
Internal R&D	8.8 (10.5)	55.3 (51.1)	35.9 (64.1)	100	70.9
Public support for innovation(only 3 innovative TPP firms)	0.0	66.7 (0.6)	33.3 (0.5)	100	28.5
Links for R&D with S&T institutions	2.6 (0.7)	30.3 (6.5)	67.1 (27.7)	100	
Links for R&D with other firms	0.0	13.8 (1.1)	86.2 (13.6)	100	
With professionals	24.8 (33.9)	39.3 (41.8)	35.9 (73.2)	100	
With STT professionals	19.6 (18.4)	30.0 (21.9)	50.4 (70.8)	100	
Obstacle for innovate with high rating: scarcity of qualified personnel	18.5	56.7	24.8	100	

Source: Own elaboration based on IAS 2003.
[a] Indicates the proportion of firms in each pattern that have the characteristic indicated in the row.

        This serves as an example of an approach to asking about innovation that places issues associated to how firms relate to knowledge at the center by getting advice, hiring new graduates, training their staff formally, and networking. There are other types of innovation-related surveys where the accent is placed on organizational forms, particularly in relation to work and the deployment of creativity. It is time to explore these approached in Latin America as well.

5. Ideas for the future based on the main results

We will summarize the main results of the paper following the logical steps in our analysis. We proposed, as a point of departure, that cooperation for innovation may be understood as a knowledge exchange. This implies that it is a process mainly driven by people through interaction, which involves a good deal of tacit knowledge. In this sense, it is key to know who knows and does what in the firms.

        Following this approach, we highlighted why some aspects of the innovation surveys are unsatisfactory for analyzing the cooperation activities of firms. These aspects are related to (i) the ways of taking into account and of analyzing "absorptive capacities" and (ii) the ways of asking for innovation and for R&D activities. Arguably, however, the main unsatisfactory aspect relates to the usefulness of innovation surveys for STI policy design.

        We analyzed the absorptive capacities of the firms by inquiring who knows and does what, using the available data in the IAS 2003 and in other innovation databases for the inquiry. The best available proxies for that aim are (i) the presence of professionals in the firms' staff and (ii) the kind

of professionals that are hired by the firms. Based on that, we tried to answer several questions using different methods for "interrogating" data. We applied an econometric model, multivariate analysis as well as a thorough revision of descriptive results. Additionally, we checked our results with other international sources.

The convergent results were as follows:

(i) The proportion of professionals in R&D in total number of employees is the most important variable explaining the probability of a firm cooperating on R&D, particularly to with S&T institutions (econometric model);

(ii) Descriptive analyses show that having knowledgeable people discriminates clearly between firms that cooperate for innovation and are involved in relatively complex innovation tasks and those that do not;

TABLE 14
COMPARING FIRMS' BEHAVIOR WITH AND WITHOUT PROFESSIONALS

More than 60% of firms that do have professionals	More than 60% of firms that do not have professionals
Spend on R&D	Do not spend on R&D
Perform R&D	Do not perform R&D
Cooperate for R&D	Do not cooperate for R&D with S&T institutions
Cooperate for R&D with S&T institutions	Do not cooperate for R&D with other firms
Cooperate for R&D with other firms	
Cooperate for training	

Source: Own elaboration from IAS 2003.

Principal component analysis, followed by a cluster analysis, lead to three groups of firms: the group that cooperate the most for innovation is the one where the density of STT staff is higher;

The comparisons that are possible to make between the Uruguayan innovative firms and the European ones (FE), show two key similarities (see again Table 13); however, the difference in public support for innovation is striking. This aspect is a clear result of the different weights that public support for innovation counts on in the UE and in Uruguay.

The exercise, allows for getting a better grasp the limits of what we can do with the data at hand, that is, with the data collected through actual innovation surveys. In this sense, our questions outweigh the answers we got as far.

We need to be better acquainted with the universe of innovative firms by taking into account innovative activities in very diverse forms and by making sure that the answers are accurate. In order to achieve this, it is necessary not to treat innovation as a free-value concept; a multidisciplinary approach is needed in order to build more perceptive questionnaires.

Given that cooperative behaviour for innovation is positively associated with having university trained employees, we need to improve the way to ask about who knows what and do what at firm level in order to assess present and future cooperative behaviour. In this sense, we highlight the relevance of knowing the opportunities that people have to apply their knowledge. We suggest that new questions about organizational topics are important in order to understand what kinds of tasks undertake the technicians and professionals.

In terms not of data gathering but of analysis of the data, it is particularly important to look carefully into the "knowledge weak" actors, those with bad prospects of innovative and cooperative behaviour.

Importance should be placed on innovation surveys for policy purposes for policy design. In countries like Uruguay, the "scarcity context" reinforces the relevance of improving innovation survey as tools for innovation policy design. However, it seems that nowhere is this goal easy to achieve.

Arundel (2006) indicates that for Europe, one of the reasons why innovation surveys are not used by policy makers is that they are designed at arms-length from the innovation policy community. In a paper suggestively entitled "Innovation policy in the knowledge-based economy - Can theory guide policy making?" innovation survey approaches are criticized for not being sufficiently oriented by evolutionary theories. (Nyholm et al, 2001) In Latin America, we can add that the comparative imperative has overshadowed the need for context dependent indicators, able to say meaningful things about the reality they are trying to capture. Moreover, beyond evolutionary theory, a truly holistic development theory is needed to better understand how the renewed power of knowledge re-shapes social relations and productive structures.

There is a point of unfairness, however, in reclaiming innovation surveys to follow too closely what policy makers may think they need to know: a certain level of autonomy in the design is not as much a researcher's right as it is a necessary widening of scope. Perhaps a better approach is to ask what the realms where innovation policy can really make a difference are and devise indicators to better know how firms behave in relation to such issues and how they value them. A good example is co-operation, because it is critically important and because it is a field where significant improvements in the ambience where actors interact and take decisions can be induced by policy action. If co-operation is a main focus of attention, the issue of who co-operates with whom follows as a fundamental concern. Knowledgeable people in the organization (knowledgeable at all levels and types of knowledge) appear as a main piece of the needed information, followed by a detailed description of what they know today, key to understanding both the scope of what they can absorb today and what they can arrive to know tomorrow. Interactions with research and academic institutions are important to fine-tuning life-long learning associated with changing demands in the productive sector, so questions about how they are deployed should be devised. Following this type of reasoning can continue until an almost full-fledged innovation survey questionnaire is developed. The suggestion here is not to put innovation surveys up-side-down and exclusively take these factors into account, but to assure that some room is made to integrate them.

The task is not easy. Almost forty years ago, Amílcar Herrera, a well known thinker in Latin America development for his thinking on science and technology policy, undertook the task of turning the model used by the report to the Club of Rome "The limits of growth" upside down. Along with his team at Fundación Bariloche, in Argentina, he built what came to be known as the "counter world-model Bariloche". The statistical tools were not the problem, but rather the equations used and moreover, the assumptions that were behind the equations. He gathered a truly interdisciplinary team to face such challenge. At almost the same time, Christopher Freeman strongly criticizes the Club of Rome report, accusing it of "computational fetishism" (Freeman, 1973, reprinted 1977: 85), along the same lines as Herrera did. Freeman makes there a strong plea for interdisciplinary work, particularly to understand the role of science and technology in social change: "Neither sociologists, economists, nor political scientists have satisfactory theories of social change and it is unlikely that they will develop them unless they overcome their fragmentation into separate jealously guarded kingdoms and learn to cooperate with one another and with natural scientists…" (Ibid: 84). We posit that everywhere, but particularly in developing countries, Freeman's recommendation should be seriously taken into account. The next generation of innovation surveys should then be the result of cooperative efforts between different people, knowing different things and willing to help change to happen.

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Annex

Definition of the variables of the econometric model

- Dependent variable: cooperation for R&D

(1) Cooperate with any organization for R&D: Dummy variable that takes the value 1 if the firm had at least one linkage in order to develop R&D activities with S&T institutions or with other firms or with firms within their group, and 0 otherwise.

(2) Cooperate for R&D with S&T institutions (universities, laboratories and other technological units, technological linkage units, technical training institutes, consultants and experts): Dummy variable that takes the value 1 if the firm had at least one linkage with any of those institutions in order to develop R&D activities, and 0 otherwise.

(3) Cooperate for R&D with other firms: Dummy variable that takes the value 1 if the firm had at least one linkage in order to develop R&D activities with customers, suppliers or other firms outside their group (vertical cooperation). The variable takes value 0 otherwise.

(4) Cooperate for R&D with firms within their group: Dummy variable that takes the value 1 if the firm had at least one linkage in order to develop R&D activities with headquarters and other firms related to the group. The variable takes value 0 otherwise.

- Independent variables

Skills: Proportion of professionals in R&D in total number of employees

Technological Opportunities: Sum of the scores of importance given to the following information sources for TPP innovation processes: professional conferences, scientific data bases and, Internet. Scores between 0 (not used) and 3 (high). Re-scaled between 0 (not used or irrelevant)and 1 (high).

Foreign Capital: Dummy variable that takes the value 1 if the firm has more than 10% of foreign capital, and 0 otherwise.

Novelty of innovation: Dummy variable that takes the value 1 if the firm has obtained innovative results novel for the market (local, regional or international). It takes the value 0 if the firm obtained results novel only for the firm.

Public Support for innovation: Dummy variable that takes the value 1 if the firm has received public financial support for innovation activities, and 0 otherwise.

Lack of access to finance: Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of availability of financial resources, and 0 otherwise.

Lack of access to information on markets: Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of availability of information about markets and 0 otherwise.

Lack of access to inform on technology: Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of availability of information about technologies, and 0 otherwise.

Lack of qualified personnel: Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of qualified personnel, and 0 otherwise.

R&D Intensity: Proportion of R&D expenditure in 2003 over turnover in 2003.

Legal Protection: Dummy variable that takes the value 1 if the firm asks and/or obtains patents in Uruguay or in the rest of the world.

Size: Number of employees.

Industry level cooperation: Mean of cooperative firms at sectoral level. (Food, beverages and tobacco; Textiles and garments; Shoes and leather products; Wood and paper; Edition and impression; Oil and derivatives; Chemistry; Pharmaceutical products; Non metallic minerals and basic metals; Metallic products; Machinery and equipment; Electrical machinery and equipment; Transport material; Other manufactures (non specified)).

VII. Innovation and cooperation in Latin America: Evidence from National Innovation Surveys in a comparative perspective

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Abstract

This paper analyzes the determinants of cooperation for innovation in the manufacturing industry in five Latin American Countries (Argentina, Brazil Chile, Mexico and Uruguay) from a comparative perspective. An analysis by type of partner is included, differentiating between: a) cooperation with (S&T) scientific and technological infrastructure, such as universities and other research centers; b) cooperation with other firms, including cooperation with suppliers, clients and other institutions that are not part of the group, and c) cooperation with firms of the group. In Latin America, on average, the percentage of firms engaged in cooperative activities for innovation is residual, ranging from 5.7% of total firms in Chile to 13.9% in Argentina. In Chile, Brazil and Mexico, innovative firms tend to cooperate more with other firms (client and/or suppliers) rather than with science and technology institutes or other firms of the group. In Argentina and Uruguay, the preferred partners of innovative firms are, on the contrary, the S&T research centers and institutions. In terms of capital ownership,

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foreign firms cooperate more than domestic ones. As for size, bigger firms show a higher propensity to cooperation with respect to small ones. The paper highlights the difficulties in comparability between the different surveys and calls for improving the comparability of data across countries, developing surveys which allow tracking the dynamic changes in the behaviour of firms, and matching firm-level analysis with case studies. The advantage of innovation surveys is to show differences in the behaviour of a heterogeneous set of agents in order to help policy makers understanding the type of reality in which policies are going to be implemented. How to do it is an open and urgent question that will require a collective effort in the region between experts, policy makers and national statistical offices.

1. Introduction

The rise of new technological paradigms such as biotech and nanotech increased the need for organizing the innovation process in a more horizontal and systemic way considering that industrial application and scientific discoveries in those areas usually occur at the margin between different scientific and production sectors, thus requiring collaboration and interaction between different agents and diverse competences (namely, firms, academic institutions, R&D labs).

Globalization, multiplied the set of potential partners for innovators, which as a result of information and communication technologies are also more easily reachable. However, the complexity for screening potential partners and for managing collaborative relationships with geographically and culturally distant partners is on the rise. In the case of Latin America, and developing countries in general, the impact of globalization on collaborative and open approaches to innovation is mixed. On the one hand, globalisation broadens the sets of partners and it facilitates collaboration with foreign, usually more technologically advanced partners. On the other hand, globalization, if not matched with public and private efforts to strengthen or build domestic capabilities in given production and scientific areas, will not induce per se increased collaboration and innovative performance, but could simply amplify the gap between advanced and lagging production agents.

Actually, in Latin America the management of globalization and the structural reforms of the late 80s had truncating and often disruptive effects on the processes of accumulation of endogenous scientific and technological capabilities, thus undermining the potential positive effect of increased opportunities for collaboration of global economies. The open economy setting, the renewed role of innovation as an engine of growth after the financial crisis and the new forms of innovation increase the complexity of the architecture of collaborative arrangements for innovation, calling for a deeper understanding of the mechanisms and the relevance of collaboration for innovation and on which policies can be implemented to support it.

The innovation policy debate in Latin America focused on public-private partnership for innovation and on measures supporting the interaction between science and business for innovation, as well as on mechanisms favouring the establishment of different forms of interaction between the agents of the innovation system (science parks, research consortia, collaborative research programs, etc.), since the end of the 90s. In the post Washington consensus period, policies supporting innovation shifted towards a more "public-private partnership model for innovation", privileging the support of networks and collaboration in the array of policy tools to foster innovation. However, in many cases, policies seemed to frame the debate from a simplified point of view. Policies focused more on creating the mechanisms to facilitate cooperation in R&D (science parks, technology transfer offices, etc.), rather than supporting the creation of capabilities in the scientific and the in the industrial sector to carry out R&D and to innovate. This fragility of innovation policy in the region requires a more integrated approach to policies for innovation which mixes demand and supply side polices.

Recently, innovation policy became a topic of rising relevance in the agenda of several countries in the region (ECLAC, 2008). The increasing attention towards innovation as a domain of action for public policy increases the demand for empirical evidence on innovative behaviour both for policy design and follow up. The growing attention towards the measurement of innovation has been a response to the need of increasing the understanding of the dynamics of innovation and innovative agents' behaviour in Latin American countries in order to support the design and implementation of evidence-based and reality-tailored policies.

In this respect, there has been a growing interest towards national innovation surveys, following the trend in more advanced countries in which a growing series of studies analyzes cooperation and innovation in the manufacturing sector on the basis of innovation surveys (Veuguelers and Cassiman, 1999; Arundel and Hollanders, 2005; Laursen and Salter, 2005; Knell and Srholec, 2005, among others). In fact, European countries pioneered the effort of measuring innovative conduct at the firm level. The CIS (Community Innovation Surveys) represent an almost consolidated set of data and procedures for mapping innovative behaviour at the firm level. In the last decade, recognizing that innovation surveys offer an interesting data base for exploring innovative conducts, a group of Latin American countries devoted significant efforts to develop a methodology for mapping and describing innovative behaviour at the firm level, in accordance, even though not always in line, with the methodology followed by more advanced countries. However, the process of collecting those data in Latin America is recent, and it requires validation.

This paper represents the first effort to conduct a "cross-country reading" of national innovation surveys in Latin America. It presents a comparative analysis of the determinants of collaborative innovation in 5 countries: Argentina, Brazil, Chile, Mexico and Uruguay. Clearly, there are drawbacks in the comparative analysis, especially due to the fact that not all the surveys follow a similar methodology, and that there is an inter-country response variation which might derive from cultural or specific local conditions and attitudes. This paper is a first step in a longer-term effort of building a system of indicators in the region to monitor innovation dynamics at the firm level in order to improve innovation metrics in the region and to improve the capacity of monitoring and evaluating the implementation of innovation policies.

The first section briefly reviews the literature on innovation and cooperation, with specific focus placed on studies based on national innovation surveys. The second section presents an overview of the peculiarities of innovation patterns in Latin America; the third section presents the empirical analysis of the determinants of cooperative behaviour in innovation in the region. The section includes an overview of innovation surveys in Latin America, it presents comparative descriptive statistics and it shows the results of the probit estimation of the determinants of cooperation for innovation in the Latin American manufacturing industry. The forth section concludes and presents the policy implications.

2. Cooperation and innovation, some introductory notes

Firms are not monads in their search for innovation and technological opportunities. They rely on multiple capabilities and sources for innovation generation and adoption of novelty. The theoretical and empirical literature shows that: (i) innovation arises when enterprises —which act by reason of market mechanisms— and institutions —whose behaviour is determined by non-market incentives— collaborate and interact; (ii) this collaboration is mediated by norms, institutions and policies which regulate and create incentives which shape cooperative behaviour; and that (iii) there is no optimal collaborative strategy; in fact, some firms carry out in-house R&D, others externalize R&D functions and some others combine the two strategies. (Nelson and Winter, 1982; Freeman, 1982; Cimoli and

Dosi, 1995 Schumpeter 1942; Rosenberg 1982; Kline and Rosenberg, 1986; Freeman, 1987; Dosi, 1988; Nelson and Winter, 1982; Nelson, 1993; Freeman and Soete, 1997).

Both innovation theory, managerial studies and empirical analysis based on firm-level data show that innovation is the result of a combination of technology push and demand pull forces, and that different sectors and production activities require different combinations of scientific, technical and managerial inputs for innovation (Nelson, 1959; Dosi, 1988; Pisano and Verganti, 2008; Cassiman and Veugelers, 2002).

Collaboration and relationship with external agents have always been crucial factors in explaining innovative trajectories of firms, group of firms and research centers. Recently, globalization, ICT and the emergence of new paradigms such as biotechnology and nanotechnology transformed the scenario in which collaborations take place transforming cooperative behaviour into an increasingly relevant and strategic feature of the innovation process. The ICT revolution, increased connectivity and new actors allow for more opportunities, but also for increased difficulties in the governance and in the selection of best options. Collaboration and external sources of ideas matter, however the key issue is "with whom to collaborate" for innovation and through "which channels" —open collaborations, research consortia, formal or informal agreements, etc.— (Pisano and Verganti, 2008).

The body of literature on empirical evidence on collaborative arrangements for innovation is varied and it is capturing rising attention. Innovation surveys offer interesting data sets to provide insights on cooperative behaviour in innovation. Since mid 90s, several studies, mostly based on the European Community Innovation Survey (CIS), analyzed the determinants of cooperative behaviour in industrial innovation (Arora and Gambardella, 1994; Colombo and Gerrone, 1996; Veuguelers 1997; Veuguelers and Cassiman, 1999; Hall, Link and Scott, 2000; Belderbos et al., 2004; Knell and Srholec, 2005; Laursen and Salter, 2005). Firm size, the capacity to appropriate returns form innovation (the use of appropriability mechanisms), internal capacities in R&D (i.e. absorptive capacity) and the importance assigned to costs and risks as obstacles for innovation are among the factors that result, in general, significant in determining the probability of firms to be engaged in R&D cooperation. Sectorial specialization and differences in types of cooperation according to the degree of novelty of innovation and type of partners are also determining factors in the definition of collaborative behaviour.

Existing studies focus on different aspects of the determinants of cooperative behaviour. For example, Veuguelers and Cassiman (1999) analyze the decision to make or buy in innovation strategies. In their analysis of the Belgian manufacturing sector they find that high costs and risks and low appropriability affect firms' cooperative behaviour. Small firms are more likely to choose one strategy, make or buy, while larger firms are more likely to combine different strategies. Firms that identify internal sources as relevant are more likely to mix the outsourcing with the direct carrying out of R&D.

Belderbos et al. (2004) explore the determinants of different types of R&D cooperation for Dutch innovative firms: bigger firms are more likely to be engaged in what they call "institutional cooperation", i.e. cooperation with universities and research labs. Absorptive capacity, measured through R&D intensity, the perception of innovation risks and costs as obstacles to innovation, and being beneficiaries of R&D subsides are additional variables influencing the likelihood of cooperating with the scientific sector.

Abramovsky et al. (2005) analyze the determinants of R&D cooperation in a group of European countries (France, Germany, Spain and the UK) on the basis of the third CIS. The capacity of firms to appropriate returns from innovation (the usage of appropriability mechanisms) positively influences the probability of engaging in cooperative R&D. Receiving public support also affects R&D cooperation especially with the research base. Risks and costs of innovation are perceived as

factors affecting the decision to cooperate, i.e. cooperation can be seen as a mechanism to overcome those obstacles.

Laursen and Salter (2005) study the relevance of external sources of innovation using the UK Innovation Survey and focus on the role of appropriability mechanisms in shaping firms' openness in R&D. According to their results, the relationship between the degree of openness to external sources and the strength of the firms' appropriability strategy takes the form of an inverted U shape, i.e. the probability of a firm to be engaged in cooperative agreements with external agents increases when the firm makes use of appropriability mechanisms, but beyond a certain threshold an aggressive appropriability strategy might reduce the willingness to cooperate with external sources.

Knell and Srholec (2005) stress the relevance of innovation for countries that are willing to catch up. In their study on innovation cooperation in the Czech Republic they find that international cooperative agreements are relevant for the domestic economy but they demonstrate that foreign ownership does not imply knowledge spillovers to the local economy.

There is a lack of similar studies in Latin America. This paper collects the first efforts to analyze cooperative behaviour in innovation in the region; and in particular, explores the potentialities and the limitations of carrying out comparative analysis on the basis of innovation surveys as they are structured nowadays in the region.

Analyzing cooperative behaviour in Latin America, and in developing economies in general, requires taking into account a set of features that are, obviously, different from that of industrialized countries. In general, firms in the countries of the region lack a technologically dynamic domestic environment that stimulates their willingness to interact. At the same time, the prevalent technological static behaviour of firms' negatively influences the (innovative) dynamisms of the environment engendering a sort of vicious circle.

In Latin America, enterprises do not innovate as much, the specialization pattern is oriented towards low technology intensive sectors and the environment is not so attractive in terms of technological opportunities. Most of innovations are novel to the domestic market, but are already available in foreign economies. At the same time, R&D is not a priority for regional universities, nor for firm's which in general suffer from budget and human resources constraints. Even though islands of excellence in R&D exist, research centers and firms are likely to search for international cooperative agreements and projects, rather than domestic ones (Cimoli, Ferraz, and Primi, 2009). In this scenario, it is quite reasonable to expect scant collaborative links in the economies of the region. In parallel terms, however, the countries have shifted towards innovation policy models that foster collaboration and interaction between the agents of the innovation system. Considering the relevance of this topic in current public policy priorities it is worth exploring the collaborative behaviour of firms in Latin America to increase our knowledge regarding the micro-behaviour of agents and to support the process of design, implementation and follow up of policies.

3. Innovation patterns in Latin American countries, an overview

Recently, innovation studies in Latin America, focused on analyzing industrial and technological development at sectoral level, in the light of development and catching up theories (Reinhardt and Peres, 2000; ECLAC, 2002; Cimoli, 2005). The countries of the region show different production structures and specialization patterns; however, they all lag behind in terms of technological and production capabilities, with respect to frontier economies. Latin American countries invest scant resources in R&D and the propensity of the private sector to invest in R&D is lower than that of most advanced and industrialized economies. These trends, which to different extents apply to all the

countries of the region, with the only exception of Brazil, are deeply related with production specialization, which is basically oriented towards natural resources and labor-intensive activities that per se express a limited demand for knowledge, and with the set of prevailing incentives in open economies (Cimoli, Ferraz and Primi, 2005: 2009; ECLAC, 2008; Cimoli and Rovira, 2009).

In this context, cooperation and innovation have been analyzed at the aggregate and sectoral level, on the basis of innovation system and network analysis approach. How do innovation systems perform in the region? To what extent universities and firms cooperate? How do firms collaborate with clients and suppliers in the organization of production? The literature on production, innovation and networks in the countries of the region pointed the weaknesses in articulation and linkages between firms, universities and public institutions, mainly through aggregate studies (Cimoli, 2000; Tigre, Cassiolato, De Souza, Szapiro, Ferraz, 2000).

Innovation surveys are a new experience in the countries of the region. Scholars have started to explore those data only recently. Available analysis tend to focus on providing descriptive analysis of innovation patterns (De Negri et al., 2005; López and Orliki, 2005; Viotti 2006) and on exploring the determinants of innovative efforts and on the impact of innovation on productivity and export performance (Benavente, 2002; 2005; Chudnovsky et al., 2006; Kuramoto and Torero, 2004; Arza, 2005; Crespi and Patel, 2006).

For example, Chudnovsky, Lopez and Pupato (2006) use panel data from Argentinean innovation surveys, for the period 1992-2001, to analyze the determinants of innovation and the impact on productivity. According to their estimates, in-house R&D and technology acquisitions increase the probability of firms to innovate. Innovative firms are in general, more productive than non-innovative ones. Big firms are more likely to engage in innovation activities and to obtain positive results than smaller ones.

Benavente (2005) estimates the impact of R&D on productivity in Chile, finding a positive relationship. For each dollar received from public support and assigned to R&D, productivity rises, on average, by 5 dollars. In a cross-country comparative study, Crespi and Patel (2006) find a positive non-linear relationship between competition and innovation, which varies according to industry specific characteristics. According to their estimates, competition usually has a positive impact on innovation in sectors like information technologies, energy and aerospace; while, for example, it could hamper innovation in the case of food, chemicals, machinery and textiles. When testing for technology gap, the authors find that increasing competition may increase the rate of innovation only in frontier countries.

National innovation surveys give further details on innovation performance. (i) On average, less than 50% of sampled firms in each country qualify as innovative. (ii) Bigger firms are more likely to be innovative than smaller ones; however according to estimates the relationship is not linear. There is a threshold beyond which further increases in size reduce the probability to innovate. [73] (iii) Firms with higher internal R&D capacities (R&D expenditures and personnel) are more likely to be in the innovative pool than those with less internal capabilities. (iv) Innovative firms tend to concentrate in

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[73] This is coherent with findings of similar studies carried out in advanced economies. Using data from CSI some authors find that there is a positive, non-linear relationship between firm size and the probability to be innovative (Crépon et al., 1998; Veuglers and Cassiman, 1999; and Lööf et al., 2001). The relationship between firm size and innovative conduct is quite vast and controversial. It is possible to find two different stances in the same Schumpeter (1912; 1942). According to Levin and Reiss (1984) review, the relation between innovation and firm size is not conclusive, and although the economies of scale and scope may exists, they may be exhausted only in the medium-size firm.

traditionally more technology intensive sectors, such as pharmaceuticals and chemical products, electronics and transport equipment.

Those figures do not portray an optimistic scenario. Latin America is clearly not yet the "place to be" for innovation and for establishing collaborative partnership for innovation at least on aggregate terms. However, there is high heterogeneity between and within countries and innovation surveys allow for monitoring firms' behaviour with more detail.

This study goes a step further with respect to existing analysis and uses micro data from innovation surveys of five countries (Argentina, Brazil, Chile, Mexico and Uruguay) to analyze the determinants of cooperation for innovation. Those five countries account for more than the 70% of total regional manufacturing value added and for almost 80% of regional R&D expenditure. In terms of production specialization, in 2007 the manufacturing sector accounts for 21% of GDP in Argentina, 17% in Brazil, 14% in Chile, 19% in Mexico. and 17% in Uruguay. Those countries are mainly exporters of natural resource based products. [74] Natural resource based sectors account for a major share in total manufacturing value added, 60% in Argentina, 43% in Brazil, 72% in Chile, 43% in Mexico and 50% in Uruguay. Labor-intensive activities account for 16% of total value added in Mexico, 17% in Brazil and Chile, 23% in Argentina and 30% in Uruguay. Technology intensive sectors represent 40% of manufacturing value added in Brazil, 41% in Mexico, 17% in Argentina, 11% in Chile and 9% in Uruguay. [75] In terms of R&D expenditures, in line with the relative technological intensity of their specialization patterns, Brazil is the only country that invests in R&D more than the regional average. In 2008, Brazil spent in R&D 1.11% of GDP, Argentina 0.51%, Uruguay 0.44%, while Chile and Mexico invested 0.67% and 0.44%, respectively, in 2004. [76] In addition, beyond similarities, those countries have diverse technological capabilities and market size, allowing analyzing cooperative behaviour in different contexts.

4. The determinants of cooperation for innovation in the Latin American manufacturing industry

This section, presents the results of the effort to harmonize data from innovation surveys of the 5 Latin American countries. [77]

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[74] Animal food, soya and maize in the case of Argentina; bovine, rice, milk and leather in Uruguay; cooper, fuits and fishes in Chile; petroleum oils, television, automotives and telecommunication equipments in Mexico; and iron, petroleum oils and airplanes in the case of Brazil.

[75] With the exception of Uruguay which data refers to 2003, data refer to 2007 and are authors' calculations based on the ECLAC-UN-DDPE-PADI database.

[76] Data refer to R&D expenditure as a percentage of GDP, RICYT estimates for the year 2007 or closest year available.

[77] The results presented in this section are the result of a collective effort. We have worked together with a group of country experts in order to identify the common set of variables which determine the probability of a firm to engage in a collaborative arrangement for innovation and to estimate the model country by country. Valeria Arza and Andrés López were responsible for the case of Argentina; Ana Paula Avelar and David Kupfer for Brazil, José Miguel Benavente and Carmen Contreras for Chile, Celso Garrido and Ramón Padilla for Mexico and Carlos Bianchi, Natalia Gras and Judith Sutz for Uruguay.

4.1 Innovation Surveys in Latin America: an overview

Collection of firm level data on innovation is a recent phenomenon in Latin America. Few countries regularly carry out innovation surveys and analyze the results as part of a monitoring effort of the micro behaviour of agents and their response to policies. In Latin America only Argentina, Brazil, Chile and Uruguay have been carring out innovation surveys systematically in the last decade. Colombia and Mexico have collected this information but more sporadically. Other countries have just started this process, such as Costa Rica; while Peru Panama and Venezuela only carried out one survey, and the rest of the countries in the region are not involved in measuring innovation at micro level.

Innovation surveys matter, not simply because they are carried out, but because they are "used" and countries develop the capacity to analyze the data, interpret them and use them for informing the policy debate. OECD countries accumulated relevant experience in this respect and pioneer creative work in developing new metrics and new models for analyzing innovation conduct (OECD, 2009: OECD, 2010). Latin America needs to advance in this respect. The only country which seem to be most advanced in using information from national innovation surveys to think, evaluate and design innovation policy is Brazil. In Brazil there is a strong articulation between institutions in charge of policy design, policy execution and data collection, which guarantees that the efforts of data collection support the policy making process. This interaction also supports a reality-check for micro-level data thus not only contributing to extract information from the surveys, but to improve the quality of the survey itself. The regular feedback between policy and analyst actors allows smoother information flows and contributes to improve policy design (De Negri, Araujo and Moreira, 2009). The case of policies supporting ICT and the rising measurement effort in those domain is another example (Grazzi, Rovira and Vergara, 2009).

Comparability between innovation surveys of different countries is not an easy task, and it requires serious harmonization efforts (OECD, 2009). In Latin America this is even more relevant considering that innovation surveys follow different approaches, formats and modalities (i.e. while the Brazilian, Chilean and Mexican surveys follow the Oslo Manual, the Uruguayan and Argentinean one are base on the Bogotá Manual). Table 1 provides information about the sources of information for the comparative study.

TABLE 1
SOURCES OF INFORMATION FOR THE COMPARATIVE STUDY

Country	Survey
Argentina	2nd National Survey on Innovation and Technology (1998-2001)
Brazil	3rd Industrial Technological Innovation Survey (PINTEC, 2005)
Chile	4th Innovation Survey (2005)
Mexico	2nd Innovation Survey (2001)
Uruguay	2nd Innovation Survey (2001-2003)

Source: Own elaboration.

The reference for Argentina is the 1998-2001 National Survey on Innovation and Technology (ENIT), carried out by the National Statistical Office (INDEC). The survey follows the Bogotá Manual[78,]

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[78] The Bogotá Manual draws its inspiration from the Oslo Manual and derives from regional efforts to account for specificities in innovation conducts in the countries of the region (RICYT, 2001).

and adopts a broad definition of innovation which includes product, process, organizational and commercialization innovations. The ENIT is a compulsory survey. The survey, which is also the same of the Industrial Survey, was sent to 2229 firms, having a response rate of 76%. The sample is representative in terms of sectoral distribution, size and geographic location of the Argentinean manufacturing industry. The survey includes questions regarding innovation activities, R&D expenditures, efforts and obstacles to innovation, and quality and the training of personnel. With respect to appropriability mechanisms, this survey only allows checking for field and obtained patents. The survey also gathers information regarding the relationship between agents of the innovation system.

In the case of Brazil, the analysis is based on data from the 2005 PINTEC (Pesquisa Industrial de Inovação Tecnológica /Industrial Technological Innovation Survey), carried out by the IBGE (Brazilian Institute of Geography and Statistics). The PINTEC follows the Oslo Manual. It adopts a strict definition of innovation, which considers technological innovation the introduction of a new or substantially improved product and the adoption of a new or substantially improved process. The survey collects information on innovation activities between 2003 and 2005. It includes innovative and non-innovative firms. The survey is carried out through in-person interviews for firms with more than 500 employees located in federal districts with more than 15 sampled firms, and computer assisted telephone interview (CATI) in the other cases. The survey contains information about the characteristics of firms and the innovative conduct (expenditures for innovative activities, expenditure of internal and external R&D, acquisition of R&D, if the firm has R&D department, the qualification of the employees, etc.), the collaborative partnerships for innovation, the impact of public policy, and the use of different appropriability mechanisms.

The reference for Chile is the fourth Innovation Survey, carried out in 2005[79], and covering innovative activities in 2003 and/or 2004. The survey follows the Oslo manual. The survey is compulsory, and it collects information on performance, sources of technical information, types of cooperation and obstacles for innovation. The survey is designed to capture qualitative variations in innovation activities of firms and to evaluate the efficacy and efficiency of innovation policies. The survey defines cooperation as the existence of any formal cooperation agreement for any innovative activity performed by the firm. The sample is representative of the total Chilean firms with annual sales above 2400 UF (i.e. approximately 90'000 dollars). The response rate is 85%.

The source of information for Mexico is the 2001 National Innovation Survey, conducted by the National Council for Science and Technology (CONACYT) and the National Institute of Statistics, Geography and Informatics (INEGI). The survey is based on the Oslo Manual and it covers both the manufacturing and the service sector. The selection of firms was done using a random sample method, with stratification by sector of economic activity, and adjusting the representativeness of firm size by an expansion factor, but at the same time including all the firms that had 501 or more employees[80]. The questionnaire was responded by 1,712 firms operating in three industries: 64 firms in mining, 39 in construction and 1,609 in manufacturing. The Mexican Innovation Survey (MIS) gathered information for the period 1999-2000.

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[79] The fourth version performed during 2005 has considered firms from the manufacturing, mining, energy and services sectors.

[80] The use of the expansion factor led the sample to 8,148 firms. In this paper, the rough database of 1609 manufacturing firms, without expansion factors, is used. So the participation of firms in terms of size and sectors may be biased in relation to the expanded database. It is important to mention that the sample only included firms with more than 50 employees, i.e. the sample is biased towards large firms, and this should be taken into account when the quantitative results are interpreted.

In the case of Uruguay, the reference is the 2006 Uruguayan Industrial Innovation Survey (Encuesta de Actividades de Innovación en la Industria), conducted by the Directorate for Innovation, Science and Technology for Development (DICyT) and the National Statistical Office (INE). The survey follows the Bogotá Manual and adopts a broad definition of innovation, including organizational and commercialization innovations. This second survey covers the period 2001-2003. The sample is representative of the manufacturing industry; the sampling method followed a mixed approach: random selection, representative for sector, for firms with 5 to 19 and 20 to 49 employees and automatic inclusion of firms with more than 50 employees, or with sales above 1,000,000 US$. The sample included 828 firms, and the response rate was 98.3%. The survey aims at collecting information on innovation efforts and results, as well enabling conditions for innovation. The survey is carried out through in-person interviews by university students trained by the National Statistical Office.

TABLE 2
PROVIDES AN OVERVIEW OF THE MAIN CHARACTERISTICS OF INNOVATION SURVEYS IN ARGENTINA, BRAZIL, CHILE, MEXICO AND URUGUAY

Variable	Argentina	Brazil	Chile	Mexico	Uruguay
Status	Compulsory	Compulsory	Compulsory	Compulsory	Compulsory
Collecting Agency	National Statistical Office (INDEC)	National Statistical Office (IBGE)	National Statistical Office (INE)	National Statistical Office (INEGI) and CONACYT	National Statistical Office (INE)
Method of Collection	Postal	Face to face interviews + pone	Postal	Face to face	Face to face interviews
Frequency	Yearly (a)	Every 2 years (d)	Every 3 years (e)	Every 5 years	Every 3 years
Framework	Manufacturing Survey (b)	Mining and quarrying Manufacturing, telecommunication, Software and R&D registers	All sectors excluding trade, hotels and restaurants, housing and public sector	Manufacturing Services	Manufacturing register
Reporting Unit	Firm	Firm	Firm	Firm	Firm
Minimum size cut-off point	10 employees	10 employees	10 employees for manufacturing US$65,000 the rest	50 employees	5 employees
Panel	No manufacturing Yes services	No	No	Manufacturing Services	No
Sample size	2,333 (total) 2,133 (manuf) 200 (panel services)	14,400 (total) 13,500 (manuf) 900 (services)	3,298 (total) 1,022 (manuf) 161 (electricity) 65 (mining) 2,050 (rest)	1,712 (total) 1,609 (manuf) 64 minning 39 construction 542 (innovative firms in manufacturing)	828
Response rate	78%	91%	85%	n.i	98%
Number of variables (c)	189 (100)	208 (67)	170 (95)	?	339 (138)
Combined with other surveys	Yes (ICT)	No	No	No	Yes (ICT)

Source: Own elaboration.

Note: (a) quantitative questions asked on annual basis. Innovation outputs asked over the last three years. It will also rotate modules between surveys. (b) Starting work with a census of large service firms. (c) Number of quantitative variables. (d) From 2003, before it was done every 3 years. (e) Years of the survey were 1995, 1998, 2001, 2005 and 2007. From 2005 the Survey will be made every 2 years.

4.2 Micro-behaviour of firms: descriptive statistics

Innovation surveys in Latin America define cooperation in different ways. The Brazilian and Chilean surveys adopt a similar definition of cooperation in innovation which considers as cooperative a firm which participates in R&D and/or innovation projects in cooperation with other organizations, enterprises or institutions. In the case of Argentina and Uruguay the surveys do not ask explicitly about cooperation; firms are asked to specify their relationship with the other agents of the national innovation system. This is a broader definition of cooperative innovation which yields to not comparable results (i.e. it overestimates the probability to cooperate in Argentina and Uruguay with respect to Brazil and Chile). To allow comparability, in this study, we have then redefined cooperation for Argentina and Uruguay including only firms that have declared to be involved in a R&D relationship with other agent. The case of Mexico is a peculiar one, since the survey asks if the firm is involved in a cooperation agreement for innovation with other firms or institutions, thus opting for a more restrictive approach which includes only formalized agreements for cooperation. In all cases, we have included in the definition of cooperation the collaboration with customers, suppliers, competitors, universities and research centers.

This paper analyzes cooperative behaviour of innovative firms in the manufacturing sector. We explore the determinants of cooperation for innovation at the general level, and then we include a study on cooperation by type of partner differentiating by: a) cooperation with (S&T) Scientific and Technological infrastructure, such as universities and other research centers; b) cooperation with other firms, including cooperation with suppliers, clients and other institutions that are not part of the group, and c) cooperation with firms of the group.

In Latin America, on average, the percentage of firms engaged in cooperative activities for innovation is residual, ranging from 5.7% of total firms in Chile to 13.9% in Argentina. Those figures are not, however, so distant from the European average. For example, according to the fourth edition of the CIS (Community Innovation Survey), in 2004 10% European firms declared to be engaged in cooperative arrangements for innovation. Clearly, differences with most advanced countries emerge when looking at more dense innovation systems; for example, in Europe the countries in which firms cooperate the most are Denmark (22.2% of cooperative firms); Sweden (21.4%) and Finland (19.2%). In Latin America, just as in frontier economies, innovative firms have a higher propensity to cooperate than non innovative firms. The share of innovative firms that cooperate is 25.5% in Argentina, 23.1% in Mexico, 17.7 in Uruguay, 15.2% in Brazil and 10.5% in Chile: However, in the case of most advanced European countries those shares are sensibly higher (42.7% in Denmark, 42.8% in Sweden and 44.4% in Finland).

In Chile, Brazil and Mexico innovative firms tend to cooperate more with other firms (client and/or suppliers) rather than with science and technology institutes or other firms of the group. In Argentina and in Uruguay the preferred partners of innovative firms are, on the contrary, the S&T research centers and institutions.

In terms of capital ownership, foreign firms cooperate more than domestic ones. As for size, bigger firms show a higher propensity to cooperation with respect to small ones, in all the countries (see table A.1 in the annex). However, when disaggregating by ownership of capital, we see that in Argentina and Uruguay the share of domestic firms collaborating with universities and S&T institutes is higher than the foreign one; while in general foreign firms tend to cooperate more with other firms of the group (see table A.2 in the annex).

As for the sectoral dimension, the distribution of firms is heterogeneous across sectors, and on average the high technological sectors, like chemicals and electronics, show the higher shares of collaborative firms with respect to the number of innovative firms in the sector (see table A.1 in the

annex); this result is similar to the evidence available for frontier countries (Miotti and Sachwald, 2003; Dachs et al., 2004; Abramovsky et al. 2005). Table 4 and 5 in the annex show, respectively, the patterns of collaboration by size and type of partners, and by sector and type of patterns.

Before presenting the model, and as a complement to this preliminary descriptive evidence, a first caveat on data interpretation is required. From basic descriptive figures it is clear that the Oslo and the Bogotá manual capture collaborative efforts differently. In fact, even though in this exercise we have calibrated the definition of collaboration for innovation in order to approximate the definition of the different surveys, there is a certain margin of uncertainty in data interpretation. The magnitude of differences in the shares of collaborative firms between Latin American countries is higher than what we would have expected, and the scale is, sometime, different. For example, when measuring participation in cooperation of innovative firms we do not know if figures are sensitively higher for Argentina and Uruguay because of the specific characteristics of the collaborative process in those countries, or because the questionnaire is capturing different phenomena with respect to the Oslo Manual. Our approach is that we should look at the comparative study in terms of comparisons between national trends; i.e. figures and estimates presented in this study are consistent within the countries; however there is a margin of uncertainty in reading the figures "across" countries. So, while it is correct to affirm that innovative firms tend to cooperate more than non innovative ones in Latin America, we would be skeptical in affirming that innovative firms collaborate more in Argentina than in Brazil, as table 3 seems to suggest. Having this clarification in mind, will help in assessing both the extent to which it is possible to draw comparative analysis from the surveys, as they are nowadays, and to actually identify differences and similarities in cooperative behaviour among the countries of the region.

TABLE 3
COOPERATIVE PATTERNS BY TYPE OF PARTNER (%), LATIN AMERICA, 5 COUNTRIES

	Argentina	Chile	Brazil	Mexico	Uruguay
	(1998-2001)	(2003-2005)	(2003-2005)	(1999-2000)	(2001-2003)
Total Firms (Obs)	1337	1281	12009	1609	814
Cooperating Firms (% of total firms)	13,9	5,7	7,5	7,8	7,7
Innovative Firms (% of total firms)	41,9	47,8	49,6	33,7	31,1
Cooperating Firms (% of innovative firms)	25,5	10,5	15,2	23,1	17,7
Cooperating firms (% of innovative firms) by type of partner					
Cooperating with other firms	11,1	10,1	12,14	19,6	3,7
Cooperating with science and technology institutes	11,2	7,8	8,22	4,6	11,5
Cooperating with firms of the group	10,6	7,3	4,75	n.a.	5,9

Source: Own elaboration on the basis of Innovation Surveys, indicated in table 1.

4.3 The model

We estimate the probability that an innovative firm engages in collaborative innovation activities country by country. The specification of the model follows an evolutionary approach.

First, we recognize the tacit dimension of knowledge and the fact that technological capabilities are embodied, at least to some extent, in individuals, firms and institutions (Polanyi, 1967; Freeman, 1982; Pavitt, 1984); this leads to stress the relevance of R&D capabilities of firms in the analysis of cooperative behaviour; i.e. the standard approach of efficient division of labor in

innovation does not apply. Cooperation in R&D cannot make up for individual capacities of firms. There are non-substitutable innovation efforts that firms must carry on in order to profit from cooperative R&D agreements. In other words, firms' absorptive capacity shapes cooperative behaviour in R&D (Cohen and Levinthal, 1990), and in-house R&D efforts and external sourcing appear as complementary. To profit from cooperation with external agents firms need a certain degree of capabilities to identify potential benefits from R&D cooperation; at the same time enterprises need to dispose of technical capacities to profit from the interchange with other units.

Second, we assume that interactions between firms, institutions, organizations and legal systems - i.e. the national innovation system dynamics- affect knowledge generation and diffusion paths. The codified or non-codified networks determine more or less favorable environments for knowledge generation, diffusion and accumulation, according to the density and specificity of linkages. At the same time, environment shapes the openness of firms to external sources (Cohen and Levinthal, 1990). And, reasonably, the level of technological opportunities available in the environment molds the kind of cooperation and interaction that firms choose to be engaged in (Klevorick et al. 1995). Firms that belong to an environment offering high opportunities may be more likely to search for cooperation and be more open to external sources to gain access to key information and technologies (Laursen and Salter, 2005). At the same time, more innovative firms reshape the environment and can induce a process of increasing returns inducing universities and research centers, and other firms, to be willing to cooperate with them.

Third, we assume that the dynamics of R&D cooperation reflect a sector specific innovative behaviour. There are sectors where innovation commonly derives from cooperative R&D projects, think for example about the role of consumers as innovators in new ICT-based activities or the well-know clustering effect like the Silicon Valley one; and there are sectors that are more science-based than others, like the chemical and the pharmaceutical sectors or the biotechnological industry, in which science-industry links are almost ordinary (Pavitt, 1984; Dosi, 1988).

To estimate the determinants of collaboration we use a simple Probit model, which follows the subsequent specification:

$$P_a(coop_i = 1) = f_a(X_i^{FIR}\beta + X_i^{InSTR}\delta + X_i^{CTRL}\gamma + \varepsilon_i)$$

(1)

Or:

$$P_a(coop_i = 0) = 1 - f_a(X_i^{FIR}\beta + X_i^{InSTR}\delta + X_i^{CTRL}\gamma + \varepsilon_i)$$

Where: ($coop_i$) is the dependent variable, measuring collaboration for innovation. P_a denotes the probability that a firm engages in cooperative innovative projects, f_a is the probit probability distribution function, X_i^{FIR}, X_i^{InSTR} and X_i^{CTRL} are vectors of independent variables and β, δ and γ the respective vectors of parameters to be estimated, and ε_i the standard errors.

X_i^{FIR} represents a vector of firm specific variables, like size, foreign ownership of capital, skills, etc., X_i^{InSTR} is a vector of independent variables indicating the innovative strategy such as (R&D intensity, patenting, public support, obstacles to innovation etc; X_i^{CTRL} is a vector of specific control variables, industry level cooperation, technological opportunities, etc.

We include as independent variables a set of factors that affect the probability of a firm to engage in collaborative innovation with other firms, other firms of the group and S&T institutes. The literature identifies some standard variables that are assumed to influence the decision of a firm to cooperate: SIZE, i.e. the natural logarithm of number of employees per firm, SIZESQUARE, which is included to account for non-linear effects, and FOREIGN CAPITAL, which classifies capital ownership of firms and differentiates by national or foreign. In addition to these standard variables, we also consider GROUP, to see if belonging to a group shapes science-industry links and SKILLS to take into account the role of skilled workers in determining the level of openness of the firm.

The model also includes: R&D intensity for measuring the impact of in-house effort on openness and collaboration with foreign parties, the degree of novelty of the innovation introduced and the patenting strategy. We also control for the impact of receiving public support as a determinant of cooperative behaviour. All surveys include several questions regarding obstacles that firms face to innovate. Among them, we include: lack of access to finance, relevant information, and qualified personnel. Two control variables are included: the technological opportunities of the market and industry level cooperation for accounting for sectoral differences. (See tables in Annex for detailed comparative descriptive analysis)

We estimate the probability of engaging in collaboration; then we recalibrate the model for each of the possible strategies by type of partner: market collaboration, when the firm collaborates with other firms, such as clients/suppliers and competitors. In the estimation of the model we proceed, country by country, as follows: first we run a probit regression of equation (1), and then we run separate equations differentiating collaboration by type of partner (S&T institutes, other firms, such as client and suppliers, –industry- and other firms of the group) to identify if determinates differ, or influence in a different way, the various types of collaboration.

4.4 The results

Results of our estimations are line with similar analysis already available in the literature. For example, Abramovsky et al. (2005) estimated a probit model for a set of 4 European countries to identify the determinants of the probability of a firm to be involved in an R&D cooperation agreement. Their results showed that the main factors affecting R&D cooperation were the use of strategic mechanisms to protect innovation, the R&D intensity, the public support and the incoming knowledge spillovers.

Table 4 reports the results of the marginal effects of the probit estimation. Results show that countries display different patterns; however it is possible to identify three main issues which shape collaborative innovation in general terms:

(i)   Firms with higher levels of skills for innovation tend to cooperate more with external agents; i.e. the scale and quality of internal human resources for innovation influences the willingness and capacity of firms to collaborate with external agents. Collaboration is, hence, a complementary strategy for internal capabilities and not an alternative. The variable skill is significant and positive for all the countries with the exception of Chile.

(ii)   Being in an environment which is perceived as technologically vibrant and innovative stimulates firms' openness; i.e. firms which recognize that external agents/institutions are repositories of relevant knowledge will be more prone to collaborate. Hence supply of technological information and availability of technological opportunities supports collaborative efforts. The variable technological opportunity is significant in all cases with the exception of Chile.

(iii) Collaborative behaviour shows a sectoral pattern. There are sectors in which firms tend to collaborate more than in other sectors; i.e. there are sectors which firms require more interaction and linkages with external agents to innovation. The variable industry level cooperation is significant in all cases with the exception of Argentina.

Chile is the country which shows the most varied results, considering that the probability that a firm engages in collaborative arrangements for innovation is mainly determined by the patenting strategy and the average propensity to collaborate of other firms in the same industry. This result confirms the theoretical hypothesis that usually firms that decide to engage in cooperative arrangements for innovation are firms with a clear innovation strategy (which can be explained by the patenting propensity) and that cooperative behaviour is influenced by the sectoral specialization.

Firm's size only affects the propensity to collaborate in the case of Brazil, in which it is more likely that bigger firms are involved in collaborative innovation projects than small firms. In Brazil, Mexico and Uruguay firms which belong to a group tend to collaborate more, while this is not the case in Argentina or Chile. Foreign capital ownership positively affects collaboration in Argentina and in Uruguay, while no significant evidence is available in Chile, Brazil and Mexico. Firms obtaining public support for innovation tend to collaborate more than firms not receiving public support in Argentina and in Brazil, while for the other countries there is no significant impact of public policy con collaborative patterns. Firms performing more radical innovations tend to be more open that less innovative firms; this result is significant for Brazil, Mexico and Uruguay. In Argentina, Brazil and Chile patenting is positively associated with collaboration. Collaboration seems to provide a solution in case of lack of access to finance only for Brazilian and Uruguayan firms. Lack of access to information on technologies appears as non significant in all cases, with the exception of Mexico, where it negatively affects collaboration; i.e. Mexican firms tend to compensate the difficult in accessing to technological information by carrying out joint innovation projects.

TABLE 4
MARGINAL EFFECTS OF PROBIT ESTIMATIONS;
PROBABILITY OF HAVING A COOPERATION AGREEMENT

	Argentina	Chile	Brazil	Mexico	Uruguay
Size (Ln e)	0,07	-0,044	0.060***	0,081	-0,010
	[0.072]	(0.053)	[0.010]	0,147	(0.095)
Size squared (Ln e 2)	-0,003	0,005	0,000	-0,003	0,003
	[0.007]	(0.005)	[0.000]	0,011	(0.010)
Group	0,043		0.070**	0.117 ***	0,161***
	[0.044]		[0.030]	0,041	(0.046)
Skills	0.431***	-0,069	0.070*	0.028 ***	1,487**
	[0.158]	(0.08)	[0.030]	0,009	(0.724)
Foreign Capital	0.121**	0,054	0,000	0,028	0,086**
	[0.052]	(0.054)	[0.010]	0,048	(0.044)
R&D intensity	1,182	0,12	1,220	-0,003	-0,526
	[1.189]	(0.176)	[17.21]	0,011	(0.646)
Public support	0.303**	0,045	0.090***	0,143	0,152
	[0.122]	(0.032)	[0.020]	0,112	(0.107)
Novelty of innovation	-0,029	0,028	0.140***	0.079 **	0,100***
	[0.037]	(0.027)	[0.020]	0,033	(0.038)

(continued)

Table 4 (concluded)

	Argentina	Chile	Brazil	Mexico	Uruguay
Tech opportunities	0.211***	0,015	0.120***	0.089 **	0,229***
	[0.064]	(0.044)	[0.200]	0,04	(0.072)
Patenting	0.111*	0.090**	0.050**	0,009	-0,045
	[0.062]	(0.042)	[0.020]	0,06	(0.078)
Lack of access to finance	0,045	0,038	0.070**	0,013	-0,088**
	[0.043]	(0.031)	[0.030]	0,045	(0.043)
Lack of access to information (include tech info)				-0.096 *	
	-0,075	-0,035	0,040		0,105**
	[0.072]	(0.028)	[0.060]	0,045	(0.062)
Lack of qualified personnel				0,055	
	0,023	-0,002	-0,010		0,049
	[0.052]	(0.027)	[0.050]	0,045	(0.058)
Industry level cooperation	-0,001	1.121***	0.890***	0.967 ***	0,720***
	[0.001]	(0.26)	[0.270]	0,352	(0.169)
Observations	670	516	1258	542	354
Pseudo R-squared	0,11		0,126	0,121	0,2628

Source: Own elaboration.
Note: Robust standard errors in parentheses.
*** significant at 1%.
** significant at 5%.
* significant at 10%.

Table 5 shows the results of the marginal effects of the probit estimations of the probability to engage in collaboration by type of partner.[81] The determinants of collaboration differ by type of partner and between countries. The main result of the analysis by type of partner is that it reconfirms the relevance of sectors patterns for collaborative behaviour. The variable industry level cooperation is significant in all cases, with the exception of Argentina, with regard to collaboration with other firms and other firms of the group.

Bigger firms tend to collaborate more with all types of partners in Brazil. In Argentina firms belonging to a group tend to collaborate more with other firms of the group, while in Brazil they tend to collaborate more with S&T institutes. In Uruguay they tend to collaborate more with both types of partners. Skills influence collaboration with all partners in Argentina, while in Uruguay skills mainly affect collaboration with S&T institutes. Firms which invest more in R&D tend to collaborate more with S&T institutes in Argentina; in the other countries this is not relevant. Foreign capital only affects the probability to collaborate with other firms of the group of Argentinean and Uruguayan firm. Public support influences collaboration with all partners in Brazil, while in Chile and Uruguay it increases the probability of collaborating with S&T institutes. The degree of novelty of innovation positively influences the probability of engagement in collaboration with all types of partners in Brazil and Uruguay, while in Argentina firms which carry out less radical innovation tend to collaborate more with universities and S&T institutes. Patenting determines collaboration with S&T and with other firms in Brazil, and with all partners in Chile. Lack of access to finance influences the decision of Argentinean firms to collaborate with other firms, while in Brazil it determines the collaboration with S&T institutes and with other client/supplier firms.

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[81] Mexico is not included in the coparative analysis by type of partner, since the Mexican survey does not collect information con collaboration by type of partner.

TABLE 5
PROBIT ESTIMATIONS; PROBABILITY OF HAVING A COOPERATION AGREEMENT BY TYPE OF PARTNER (MARGINAL EFFECTS)

	Argentina			Brazil			Chile			Uruguay		
	By type of partner			By type of partner			By type of partner			By type of partner		
	ST infrastructure	industry	Group	ST infrastructure	industry	Group	ST infrastructure	industry	Group	ST infrastructure	industry	Group
Size (Ln e)	0,07	0,022	0,055	0.040***	0.050***	0.010***	-0,012	-0,015	0,05	-0,040	-0,016	-0,004
	[0.047]	[0.043]	[0.043]	[0.010]	[0.010]	[0.000]	(0.04)	(0.053)	(0.041)	(0.062)	(0.021)	(0.030)
Size squared (Ln e 2)	-0,005	-0,002	-0,003	0,000	0,000	0,000	0,002	0,002	-0,004	0,006	0,002	0,000
	[0.005]	[0.004]	[0.004]	[0.000]	[0.000]	[0.000]	(0.004)	(0.005)	(0.004)	(0.006)	(0.002)	(0.003)
Group	-0,002	0,021	0.042*	0.060**	0.040*	0.110***	..	..	..	0.088***	0,009	0.028***
	[0.025]	[0.030]	[0.025]	[0.020]	[0.030]	[0.020]				(0.033)	(0.011)	(0.012)
Skills	0.299***	0.157*	0.167***	0,030	0,030	0.200***	-0,016	-0,072	-0,016	1,031**	0,133	-0,005
	[0.080]	[0.093]	[0.060]	[0.020]	[0.030]	[0.020]	(0.058)	(0.089)	(0.066)	(0.475)	(0.166)	(0.180)
Foreign Capital	-0,037	0,024	0.121***	0,000	0,000	0,000	0,037	0,051	0,037	-0,050	0,002	0.047***
	[0.024]	[0.033]	[0.038]	[0.010]	[0.020]	[0.010]	(0.045)	(0.052)	(0.042)	(0.035)	(0.009)	(0.017)
R&D intensity(a)	1.623**	-0,753	0,312	2,520	3,540	2,500	0,208	0,094	0,116	-0,143	-0,112	0,022
	[0.772]	[1.146]	[0.567]	[12.070]	[15.270]	[5.780]	(0.134)	(0.18)	(0.132)	(0.392)	(0.157)	(0.138)
Public support	0,177	0,144		0.120***	0.080***	0.020**	0.045*	0,03	0,006	0.133**	0,035	
	[0.108]	[0.091]		[0.020]	[0.020]	[0.010]	(0.027)	(0.031)	(0.023)	(0.066)	(0.028)	
Novelty of innovation	-0.045*	-0,008	0,021	0.090***	0.120***	0.040***	0,02	0,028	0,032	0.053*	0.033*	0.019*
	[0.026]	[0.025]	[0.017]	[0.020]	[0.020]	[0.01]	(0.022)	(0.027)	(0.021)	(0.027)	(0.014)	(0.013)
Tech opportunities	0.114***	0.133***	0,038	0,020	0.14***	0.02***	0,058	0,019	0,016	0.145***	0,021	0,036
	[0.040]	[0.042]	[0.032]	[0.020]	[0.02]	[0.01]	(0.036)	(0.043)	(0.034)	(0.052)	(0.022)	(0.022)
Patenting	0,06	0,068	0,022	0.050***	0.04**	0,010	0.068**	0.076*	0.080**	0,005		
	[0.044]	[0.046]	[0.030]	[0.020]	[0.02]	[0.01]	(0.034)	(0.041)	(0.037)	(0.048)		
Lack of access to finance	0,009	0.051*	0,004	0.070**	0.08***	0,010	0,006	0,026	0,02	-0,036	0,002	-0,012
	[0.028]	[0.029]	[0.020]	[0.030]	[0.03]	[0.01]	(0.024)	(0.03)	(0.025)	(0.030)	(0.009)	(0.012)
Lack of access to information (include tech info)	0,021	-0,014	-0,023	0,060	0,020	-0.02*	0,008	-0,034	-0,015	0.082**	0.026*	-0,002
	[0.046]	[0.048]	[0.042]	[0.050]	[0.060]	[0.010]	(0.026)	(0.028)	(0.023)	(0.039)	(0.020)	(0.021)
Lack of qualified personnel	-0,034	0,004	-0,017	0,030	-0,010	0,010	0,001	-0,001	-0,014	0,047		-0,013
	[0.034]	[0.035]	[0.028]	[0.030]	[0.040]	[0.010]	(0.021)	(0.027)	(0.02)	(0.042)		(0.017)
Industry level cooperation												
Industry level cooperation_ST	0.003**			-0,040			1.127***			0,775***		
	[0.001]			[0.320]			(0.26)			(0.167)		
Industry level cooperation-industry		0,003			0.840***			1.125***			0,282***	
		[0.002]			[0.290]			(0.286)			(0.185)	
Industry level cooperation_group			0			0.450**			0.972***			0,312***
			[0.001]			[0.230]			(0.203)			(0.144)
CONSTANT										-0,325**	-0,077	-0,124**
										(0.144)	(0.080)	(0.067)
Observations	670	670	650	1258	1258	1258	516	516	516	354	293	354
Pseudo R-squared	0,1	0,07	0,26	0,162	0,115	0,401				0,2497	0,2919	0,3708
Wald	63,47	27,57	92,96							69,61	24,88	55,2

Source: Own elaboration.
Note: Robust standard errors in parentheses
*** significant at 1%.
** significant at 5%.
* significant at 10%.
(a) in the case of Argentina is LN(R&D/sales).

5. Conclusions and policy implications

Results show that cooperation is reduced in terms of critical mass in Latin America; however, the determinants of cooperative behaviour in innovation in Latin America are similar to those obtained in similar studies for frontier countries. This suggests that cooperative behaviour is strongly affected by sectoral specialization, internal absorptive capacity of firms (which in our study is proxied by skilled workers) and by the innovative propensity of the environment, more than by the systemic conditions for the country in question. (A policy corollary would hence be that Latin American countries need to prioritize the creation of endogenous scientific and technological capabilities, production structure modernization and structural change in first place, and not purely focus on creating incentives for collaboration for innovation).

Policies in the last decade have been calling for cooperation and articulation between different agents of the national innovation system to support innovation, however more research and methodological reflection is needed in order to increase the capacity of measuring the way in which firms establish and develop relationship with external counterparts, the impact of different factors on cooperative behaviour and to evaluate the impact on innovation to fine tune policies.

Few could argue against the fact that links and collaborations positively affect firms, universities, and to broader extent countries' innovativeness; however it is less straightforward derived what the conditions are in order for cooperative R&D to ensue, what are the standards of excellence and the structural determinants for cooperation to increase firms' (agents, universities, and countries) performance and which is the set of incentives which best favors such cooperation. And even less consensus exist on which type of collaborative arrangement better suits innovation, which are the incentives which favour the various forms of cooperation, what policies can do to effectively support innovation through collaboration.

Thus, the key element for being a "successful" innovator is then not just being more open, or having more active research collaboration, but it is to be able to choose the appropriate structure and design of collaborative agreements according to the main objectives of the organization (Pisano and Verganti, 2008). The "collaborative architecture" matters and there is no superior form of collaboration. In terms of policies, this means a generalized call for more interaction, networking and partnership between agents is too generic for being effective. Alternately, selecting ex ante the type of collaboration which firms should pursue presumes a deep understating of the innovative strategy of the firm, and it could hamper the policy impact. To better fine tune policies to the desired outcome and to the type of beneficiaries a set of schemes supporting different types of collaboration might be required.

The increasing relevance of innovation in the portfolio of government actions (at the national and regional level) requires better metrics and improved understanding of innovation dynamics. National innovation surveys in Latin America are useful instruments for increasing awareness regarding innovative conduct of firms. However, more work is needed to harmonize data collection and data processing in Latin America to improve the surveys and their comparability within the region and with foreign countries. This is a mid-long term process which requires a dialogue and direct contact between experts, policy makers and national statistical offices within the region and abroad. There is a need to support the exploitation of existing data to improve the quality and to increase our understanding of their meaning. Simplifying access to data and fostering cross-country studies on innovation surveys and reinforcing institutional mechanisms to support closer interaction between data collection, data analysis and policy formulation in Latin America should be a priority.

Currently, national innovation surveys still have difficulties in precisely describing innovative behaviour of firms, and their use for orienting policy making should be cautions and done "cum grano salis". Econometric analysis are useful, but it is important to match the technique with a sound theoretical approach and a deep understanding of the industrial dynamic in the country in order not to

reduce the analysis to a study of "the representative firm"; we could not think that "a fructibus cognoscitur arbor". The advantage of innovation surveys is to show differences in the behaviour of a heterogeneous set of agents in order to help policy makers understand the type of reality in which policies are going to be implemented. How to explore the variety in the behaviour of firms though innovation surveys and how to really make innovation surveys a tool for policy design and follow up is an open and urgent question. Improving the comparability of data across countries, developing surveys which allow tracking the dynamic changes in the behaviour of firms, and matching firm-level analysis with case studies are first major issues to be faced.

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Annex

TABLE A.1

Variable name	Description
Size	ln (Number of employees).
Size2	ln (Number of employees)2.
Group	(0,1) if the firm belongs to a group or not
Skills	Proportion of R&D employment on total number of employees
Foreign Capital	Dummy variable that takes the value 1 if the firm has more than 10% of foreign capital, and 0 otherwise.
R&D Intensity	Proportion of R&D expenditure over turnover (total sales).
Public Support	Dummy variable that takes the value 1 if the firm has received public financial support for innovation activities and 0 otherwise.
Novelty of innovation	Dummy variable that takes the value 1 if the firm has obtained innovative results novel for the market (local, regional or international). It takes the value 0 if the firm obtained results novel only for the firm.
Technological Opportunities	Dummy variable that takes the value 1 if the firm assigns high importance the external information (professional conferences, scientific data bases, Internet, etc) and 0 otherwise.
Patenting	Dummy variable that takes the value 1 if the firm asks and/or obtains patents in Brazil or in the rest of the world.
Lack of access to finance	Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of availability of financial resources, and 0 otherwise.
Lack of access to information on markets	Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of availability of information about markets and 0 otherwise.
Lack of access to information on technology	Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of availability of information about technologies, and 0 otherwise.
Lack of qualified personnel	Dummy variable that takes the value 1 if the firm assigns high importance as an obstacle to the innovation process to the lack of qualified personnel and 0 otherwise.
Industry level cooperation	Mean of cooperative firms at sectoral level. (Food, beverages and tobacco; Textiles and garments; Shoes and leather products; Wood and paper; Edition and impression; Oil and derivatives; Chemistry; Pharmaceutical products; Non metallic minerals and basic metals; Metallic products; Machinery and equipment; Electrical machinery and equipment; Transport material; other manufactures (non specified)).
Industry level cooperation with STI	Mean of cooperative firms with STIs at sectoral level. (Food, beverages and tobacco; Textiles and garments; Shoes and leather products; Wood and paper; Edition and impression; Oil and derivatives; Chemistry; Pharmaceutical products; Non metallic minerals and basic metals; Metallic products; Machinery and equipment; Electrical machinery and equipment; Transport material; Other manufactures (non specified)).
Industry level cooperation with other firms	: Mean of cooperative firms with other firms at sectoral level. (Food, beverages and tobacco; Textiles and garments; Shoes and leather products; Wood and paper; Edition and impression; Oil and derivatives; Chemistry; Pharmaceutical products; Non metallic minerals and basic metals; Metallic products; Machinery and equipment; Electrical machinery and equipment; Transport material; Other manufactures (non specified)).
Industry level cooperation with other firms in the group	Mean of cooperative firms with other firms of the group at sectoral level. (Food, beverages and tobacco; Textiles and garments; Shoes and leather products; Wood and paper; Edition and impression; Oil and derivatives; Chemistry; Pharmaceutical products; Non metallic minerals and basic metals; Metallic products; Machinery and equipment; Electrical machinery and equipment; Transport material; Other manufactures (non specified)).

Source: Own elaboration.

TABLE A.2
DESCRIPTIVE STATISTICS ON FIRMS' COOPERATIVE BEHAVIOR BY OWNERSHIP OF CAPITAL, SIZE AND SECTOR
LATIN AMERICAN COUNTRIES PERCENTAGE OF COOPERATIVE FIRMS
(ON INNOVATIVE FIRMS IN EACH CATEGORY, %)

	Argentina	Brazil	Chile	México	Uruguay
By ownership of capital					
National	18.1	12.3	5.3	23.5	13.8
Foreign	40.1	35.5	9.1	26.7	38.6
By size (n. of employees)					
<10	n.a.	n.a.	n.a.	n.a.	12.5
10-49	13.3	6.3	3.4	n.a.	15.1
50-99	20.8	8.6	7.1	15.8	19
100-249	22.9	11.1	5.6	19.2	18.8
250-499	32.7	13.2	7.1	23.3	23.1
>500	36.4	38.9	13.1	28.8	36.4
By sector					
Food, beverage and tobacco	19.9	13.6	5.8	20.7	16.1
Textiles and apparel	15.2	6.9	3.1	10	16.1
Footwear and products of leather	25.0	12.0	2.4	11.1	33.3
Wood and paper	26.7	0.1	6.4	11.4	0
Edition and impression	27.3	12.0	8	25	9.1
Oil and oil derivatives	50.0	13.6	10	27.3	0
Chemicals	35.1	27.2	9.4	34.7	38.1
Pharmaceutical products	n.d*	28.7	n.d*	38.1	21.7
Non metallic minerals	14.1	17.8	4.5	23.3	14.3
Metallic products	18.2	10.2	5	27.7	0
Machinery and equipment	23.1	17.6	5.4	19.2	10
Electronic and electrical equipment	32.6	22.0	4.8	24.5	7.1
Transport equipment	26.8	23.7	4	35.7	26.7
Other manufacturing industries	14.3	17.6	6.7	13.3	0
Rubber and plastic products	16.3	..	4.1	29.2	18.8
Medical, optical and precision instruments	20.0	..	11.8	22.2	33.3

Source: Own elaboration.
* The pharmaceutical sector is included in n. 7.

TABLE A.3
DESCRIPTIVE STATISTICS ON FIRMS' COOPERATIVE BEHAVIOR BY TYPE OF PARTNER AND OWNERSHIP OF CAPITAL, 6 LATIN AMERICAN COUNTRIES
% of cooperative firms, by type of partner
(on total innovative firms in each category)

	Coop with S&T institutions	Coop with other firms	Coop with other firms of the group
Argentina			
National	10.1	9.1	3.6
Foreign	9.6	13.8	29.9
Brazil			
National	6.6	1	1.6
Foreign	19.8	26.3	27.3
Chile			
National	4.1	5.1	3.7
Foreign	5.8	9.1	6.6
México			
National	4.6	15.6	n. a.
Foreign	4.4	20.4	n. a.
Uruguay			
National	11.7	3.4	1.7
Foreign	10.5	5.3	28.1

Source: Own elaboration.

TABLE A.4
DESCRIPTIVE STATISTICS ON FIRMS' COOPERATIVE BEHAVIOR BY TYPE OF PARTNER AND FIRM SIZE, 6 LATIN AMERICAN COUNTRIES
% of cooperative firms, by type of partner
(on total innovative firms in each category if firm size, measured as n. of employees)

	Coop with S&T institutions	Coop with other firms	Coop with other firms of the group
Argentina			
<10	n. a.	n. a.	n. a.
10-49	4.8	7.2	3.0
50-99	8.8	11.9	3.1
100-249	11.5	8.3	10.6
250-499	12.2	13.3	18.4
>500	15.9	13.6	21.6
Brazil			
<10	n. a.	n. a.	n. a.
10-49	3.5	5.0	0.6
50-99	2.8	7.0	1.4
100-249	5.2	8.7	2.2
250-499	6.4	9.7	3.2
>500	23.9	31.7	17.2

(continued)

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Table A.3 (concluded)

	Coop with S&T institutions	Coop with other firms	Coop with other firms of the group
Chile			
<10	n. a.	n. a.	n. a.
10-49	2.1	3.4	2.3
50-99	6.6	7.1	5.6
100-249	3.3	5.1	5.1
250-499	5.6	7.1	4.8
>500	10.3	13.1	10.3
México			
<10	n. a.	n. a.	n. a.
10-49	5.3	17.5	n.a.
50-99	1.0	17.2	n.a.
100-249	6.0	15.5	n.a.
250-499	5.4	23.5	n.a.
>500			
Uruguay			
<10	12.5	12.5	6.3
10-49	11.3	1.3	3.8
50-99	12.7	3.8	6.3
100-249	9.4	6.3	9.4
250-499	7.7	3.8	11.5
>500	27.3	9.1	0.0

Source: Own elaboration.

TABLE A.5
DESCRIPTIVE STATISTICS ON FIRMS' COOPERATIVE BEHAVIOR BY TYPE OF PARTNER AND SECTOR, 6 LATIN AMERICAN COUNTRIES
% of cooperative firms, by type of partner (on total innovative firms in each sector)

	Coop with S&T institutions	Coop with other firms	Coop with other firms of the group
Argentina			
Food, beverage and tobacco	11.8	10.3	5.1
Textiles and apparel	3.0	6.1	6.1
Footwear and products of leather	15.0	5.0	20.0
Wood and paper	6.7	20.0	6.7
Edition and impression	14.5	5.5	10.9
Oil and oil derivatives	37.5	0.0	12.5
Chemicals	16.0	14.9	19.1
Pharmaceutical products	..	..	..
Non metallic minerals	6.3	6.3	4.7
Metallic products	9.1	12.1	6.1
Machinery and equipment	10.3	11.5	5.1
Electronic and electrical equipment	6.5	15.2	17.4
Transport equipment	9.8	9.8	19.5
Other manufacturing industries	7.1	14.3	0.0
Rubber and plastic products	4.1	6.1	8.2
Medical, optical and precision instruments	0.0	20.0	0.0

(continued)

Table A.5 (continued)

	Coop with S&T institutions	Coop with other firms	Coop with other firms of the group
Brazil			
Food, beverage and tobacco	2.8	5.6	1.3
Textiles and apparel	1.1	2.9	0.2
Footwear and products of leather	4.6	6.4	0.4
Wood and paper	1.0	2.3	0.4
Edition and impression	0.9	2.3	0.6
Oil and oil derivatives	8.3	4.4	5.5
Chemicals	7.3	14.4	3.5
Pharmaceutical products	12.6	12.4	2.1
Non metallic minerals	7.0	7.5	1.6
Metallic products	1.8	4.8	0.4
Machinery and equipment	4.8	8.5	1.3
Electronic and electrical equipment	6.5	5.8	5.2
Transport equipment	4.6	12.7	4.9
Other manufacturing industries	6.2	6.8	1.5
Rubber and plastic products	-	-	-
Chile			
Food. beverage and tobacco	4.4	5.3	3.6
Textiles and apparel	2	3.1	2
Footwear and products of leather	2.4	2.4	0
Wood and paper	3.8	5.7	5.7
Edition and impression	8	8	6
Oil and oil derivatives	10	10	10
Chemicals	8	8.7	6.5
Pharmaceutical products	0	0	0
Non metallic minerals	3.8	4.5	2.5
Metallic products	5	5	5
Machinery and equipment	2.7	5,4	4,1
Electronic and electrical equipment	2.4	4.8	4.8
Transport equipment	2	4	2
Other manufacturing industries	4.4	6.7	6.7
Rubber and plastic products	2.1	4.1	2.1
Medical. optical and precision instruments	5.9	11.8	0
México			
Food. beverage and tobacco	4.6	26.4	n.d
Textiles and apparel	5.0	5.0	n.d
Footwear and products of leather	16.7	16.7	n.d
Wood and paper	0.0	17.1	n.d
Edition and impression	0.0	8.3	n.d
Oil and oil derivatives	0.0	27.3	n.d
Chemicals	6.1	10.2	n.d
Pharmaceutical products	9.5	14.3	n.d
Non metallic minerals	3.3	23.3	n.d
Metallic products	4.3	19.1	n.d
Machinery and equipment	3.8	19.2	n.d
Electronic and electrical equipment	5.7	17.0	n.d
Transport equipment	3.6	39.3	n.d
Other manufacturing industries	6.7	6.7	n.d

(continued)

Table A.5 (concluded)

	Coop with S&T institutions	Coop with other firms	Coop with other firms of the group
Rubber and plastic products	4.2	25.0	n.d
Medical. optical and precision instruments	0.0	5.6	n.d
Uruguay			
Food. beverage and tobacco	10.7	2.7	4.7
Textiles and apparel	16.1	0.0	0.0
Footwear and products of leather	8.3	16.7	8.3
Wood and paper	0.0	0.0	0.0
Edition and impression	4.5	0.0	4.5
Oil and oil derivatives	0	0.0	0.0
Chemicals	23.8	4.8	14.3
Pharmaceutical products	21.7	8.7	8.7
Non metallic minerals	0.0	0.0	14.3
Metallic products	0.0	0.0	0.0
Machinery and equipment	10.0	5.0	5.0
Electronic and electrical equipment	0.0	0.0	7.1
Transport equipment	20.0	6.7	13.3
Other manufacturing industries	0.0	0.0	0.0
Rubber and plastic products	6.3	12.5	0.0
Medical, optical and precision instruments	33.3	0.0	0

Source: Own elaboration.