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ARTICLE

Firm size, foreign capital and modes of innovation: an analysis of manufacturing firms in Argentina

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ABSTRACT

This article analyzes the differences of firms in terms of innovation activities, external linkages and innovation modes according to their size and the presence of foreign capital. Using the National Survey of Employment and Innovation, we show that firms with foreign capital participation present a differentiated innovative behavior once they are stratified by firm size. Foreign-owned firms vis-à-vis domestic firms tend to make greater innovation efforts and are characterized by implementing more complex innovation modes, combining DUI and STI modes. However, larger foreign firms make in average relatively less innovation efforts and implement less complex innovation modes. These results revalue the analyses that consider the heterogeneity of foreign firms and show that those of larger relative size are not the ones with the best innovative performance, contrary to what happens with domestic capital firms.

KEYWORDS: Innovation modes; firm size; foreign capital

1. Introduction

There are two stylized facts corroborated by the literature on the innovative behavior of firms: i) firms with foreign capital based in developing countries are more innovative than those with domestic capital and ii) larger firms are more innovative than those of relatively smaller size. These two empirical trends have led to treat size and the presence of foreign capital as controls for any estimation of the determinants of innovation, assuming that foreign-owned firms are a homogeneous actor.

The International Business literature has incorporated firm size of multinational corporation (MNC) subsidiaries as a variable of interest, insofar as it captures the subsidiary's availability of resources and autonomy for decision making process, including those affecting innovation (JOHNSTON; MENGUC, 2007). Some studies have shown that large-sized firms have greater autonomy *-vis-à-vis* small ones- to develop internal capabilities and competitive advantages, which allow for innovation, product diversification and better economic performance (CHIAO et al., 2008; JOHNSTON; MENGUC, 2007).

On the other hand, MNCs have deepened their differentiation by size due to the emergence of small and medium-sized companies that rapidly internationalize, specializing in knowledge-intensive, high value-added activities and in stablishing stronger linkages with the host national innovation system (NIS) (DIMITRATOS et al., 2003).

In this paper we start from the idea that foreign-owned firms' innovative activity, external linkages, and innovation modes could be more complex and heterogeneous than the perspectives offered by the innovation economics literature, which simply recognizes that larger-sized firms are more innovative than smaller ones and that foreign-owned firms are more innovative than domestic ones. Based on the literature cited above, foreign firms located in developing countries can be expected to have innovation and learning strategies guided by the exploitation of ownership advantages. On the other hand, small-sized firms may have the flexibility to explore innovation opportunities derived from the local context. The literature focused

on developing countries was oriented to measure the effect of foreign capital on innovation (ARZA; LÓPEZ, 2010; DE NEGRI, 2010; ZUCOLOTO; CASSIOLATO, 2013), but without differentiating by firm size. Recognizing the heterogeneity of firms owned by foreign capital located in developing countries is key to guide public policy.

In this paper, we empirically assess the innovative behavior of the firm through the relationship between firm size and presence of foreign capital, linking the NIS approach with the International Business literature. Using data from the first National Survey of Employment and Innovation (ENDEI-I), we investigate the interaction between firm size and the presence of foreign capital on its innovative behavior, considering the types of internal innovation efforts, linkage with the NIS and predominant modes of innovation (JENSEN et al., 2007). Applying a broad view of the innovation process (LUNDVALL, 2009) allows us to account for the heterogeneity of innovation behaviors that goes beyond formal R&D, which is especially important in developing countries where adaptive innovation process predominate.

The structure of the paper is organized as follows. The second section analyzes three sets of literature on the relationship between foreign capital, firm size and innovation behavior. The third section discusses the background of the literature for the Argentinean case. The fourth section presents the empirical strategy, including the description of the data used, the selection of variables, and the specification of the econometric models. The fifth section presents the results and discussion. Finally, the sixth section offers the main conclusions.

2. Conceptual relationships between size, foreign capital and innovation modes

The conceptual framework of the article combines three sets of literature: (i) on learning and modes of innovation, (ii) on foreign-owned firms in developing countries and, (iii) on the heterogeneity of these firms according to their size.

2.1 Interaction, learning and modes of innovation

The starting point is to consider innovation as a systemic and complex phenomenon (LUNDVALL, 2009), which depends significantly on the interactions between firms and other organizations, both professionalized in internal Research and Development (R&D) departments as the non-professionalized (ANDERSEN, 1992). Those activities allow firms to obtain, develop and exchange knowledge, information and resources with its environment. In this sense, the technological and innovative behavior of companies is associated with the socio-institutional space in which they are located (LUNDVALL, 2009), made up of national networks of companies and institutions, as well as international networks in which they may operate through commercial relationship and capital ownership (parent companies and subsidiaries).

Under the NIS approach, the innovation and learning processes of firms are influenced by the territorial specificities where they are located and by the relationships they establish with global partners, parent companies and other companies in the global value chain. Therefore, a multidimensional conceptualization of the innovation process is required to capture the heterogeneity of innovative behaviors and interactions that firms deploy at the local and global levels.

The literature on innovation modes (JENSEN et al., 2007) contributes to this multidimensional approach of innovation by identifying two ideal modes of innovation. The first mode, called Science, Technology and Innovation (STI), is centered on the relationship between formal Science and Technology (S&T) institutions and the productive sector (NELSON & ROSENBERG, 1993). It focuses on codified knowledge, generated from R&D activities, human capital (scientific personnel) and R&D partnerships (APANASOVICH, 2016). In this case, explicit and global scientific knowledge has a relevant and complementary role to locally embedded tacit knowledge (JENSEN et al., 2007).

The second mode, called Doing, Using and Interacting (DUI), is based on learning by experience and interaction within the productive

and commercial process. It is associated with a broad perspective of innovation that, in addition to formal mechanisms of knowledge diffusion and generation, includes informal learning processes through interaction and experience (LUNDVALL, 2009). DUI-based innovation mode emphasizes the role of linkages involving exchange and circulation of technical, tacit and localized knowledge, derived from collaboration with customers and suppliers (FITJAR; RODRIGUEZ-POSE, 2013).

At the firm level, complementation rather than substitution between STI and DUI modes is observed. Empirical evidence indicates that firms that combine both modes are more innovative than those that rely mainly on one or neither of them (JENSEN et al., 2007; GUO; CHEN; JIN, 2010; ISAKSEN; KARLSEN, 2012; NUNES; LOPES, 2015).

2.2 Interaction between foreign capital and the NIS in developing countries

The linkages and degree of integration of foreign-owned firms with NIS actors depends on multiple factors, such as the mandate assigned by the headquarters (in the case of MNCs) or by the foreign shareholders of a domestic firm, the technological advantages available in the host country and the capabilities accumulated by the firm (ALMEIDA; PHENE, 2004; LE BAS; SIERRA, 2002; PATEL; PAVITT, 2000).

The literature on MNC spillovers and on global knowledge networks (MARIN; BELL, 2010) focuses on MNCs as vectors of technological change in host countries. According to this literature, foreign capital facilitates diffusion of technological knowledge and enhance competences of national capital companies through technology transfer, the development of suppliers, raising quality standards, and stablishing cooperation ties between local and global companies.

On the contrary, according to Amsden (2009), foreign capital companies in developing countries (generally subsidiaries of MNCs) tend to replace creative capacity with bureaucratic management rules and concentrate their higher value-added functions, such as R&D, in the headquarters. This is associated with a tendency to implement

traditional localization strategies, based on the exploitation of their own or home country assets, and a greater risk aversion than domestic capital companies, with the corresponding impact on innovation activities. In this sense, Amsden, Tschang and Goto (2001) show that in countries where dominant business firms tend to be domestically controlled (Republic of China, India, Republic of Korea) aggregate R&D investments tend to be high (otherwise they could not survive), while countries with a high incidence of foreign capital, such as Argentina, Brazil and Mexico, tend to coexist with low levels of aggregate R&D investments. In addition, Amsden (2009) argues that domestic firms tend to develop most of the "new" industries in the developing world. On the other hand, those controlled by foreign capital benefit from the precise management of the bureaucratic machinery in traditional or already consolidated sectors.

There is a growing literature that points out that under certain conditions foreign-owned firms based in developing countries engage in innovation activities (KUEMMERLE, 1999; ITO; WAKASUGI, 2007; UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT, 2005) and establish different types of technological and productive linkages with local firms and other NIS institutions (LIU; CHEN, 2012; CANTWELL; MUDAMBI, 2005). In particular, the quality of NIS, as well as regulatory aspects referred to intellectual property systems, are determinants for the establishment of R&D departments in host countries (ITO; WAKASUGI, 2007).

Likewise, the literature on MNCs has contributed to the study of innovation activities by studying their strategies (LE BAS; SIERRA, 2002; CANTWELL; SANTANGELO, 1999; DUNNING; NARULA, 1995). These strategies can be separated into two main groups: i) strategies aimed at exploiting an initial technological asset or advantage developed in the country of origin, and ii) strategies aimed at capturing technological advantages in the host country or coordinating efforts for joint developments. In the second group, interactions with the NIS will be stronger than in the first.

When we focus on the determinants of innovation activities by foreign-owned firms within the same country, we must explore other possible hypotheses such as the type of sector in which they operate, their competencies and degree of autonomy in investment and strategic decision making, which we will analyze in the following subsection.

2.3 Size of foreign-owned companies and innovation

The size variable as a differentiating factor in the innovative behavior of foreign-owned firms has not been sufficiently explored by the economics of innovation, but it can be a determining factor to investigate the heterogeneity of foreign-owned firm´s behavior within the same host country.

It is recognized that the expansion of R&D activities has historically been in the hands of large MNCs, because it demands capital resources, time, and managerial knowledge that smaller firms often lack (NARULA; ZANFEI, 2005).

The literature focused on the management of subsidiary firms presents similar arguments: larger size, ceteris paribus other factors, correlates with increased tangible and intangible resources that enhance firms' innovative behaviors (GROVER; DAVENPORT, 2001; PENROSE, 1995). Several studies have identified a positive association between firm size and autonomy for decision making and external linkages (JOHNSTON, 2005; JOHNSTON; MENGUC, 2007). Beugelsdijk and Jindra (2018) find that higher levels of autonomy increase the likelihood of obtaining product innovations and accessing local external networks. Meanwhile, Birkinshaw and Morrison (1995) find that higher levels of subsidiary autonomy are positively correlated with the incorporation of more advanced functions within the subsidiary and with larger firm size.

In contrast, Amsden (2009) observes that subsidiaries of large MNCs in developing countries tend to have complex bureaucratic structures that leave little room for local decision making, with little creative and innovative capacity. In contrast, small MNCs may find

a relative advantage in their simpler and less bureaucratic decision-making structures, resulting in a more receptive climate for new and riskier projects, with greater capacity for adaptation and improvement (DEAN; BROWN; BAMFORD, 1998).

In conclusion, the literature does not establish a univocal relationship between autonomy and size. In part, these contradictions could be corrected by incorporating other dimensions such as the opportunities offered by the NIS of the country in which the foreign capital operates, or the sectors in which it operates.

On the other hand, the International Business literature identifies a new segment of internationalized companies, the micro-multinationals. This literature offers some clues about the differential behavior of smaller foreign-owned companies in terms of innovation behavior. These are characterized by a specialization in sectors with high technological and innovation opportunities, and a high propensity to participate in networks, including alliances with competing firms (DIMITRATOS et al., 2003, 2014; SOOREEA et al., 2018). We can assume that in this case autonomy is associated with absence of bureaucratized interaction networks with the headquarters (*a la* Amsden) that facilitate the search for local opportunities for solving idiosyncratic problems and for the exploration of new knowledge. To do so, the foreign-owned company will not only have to engage in R&D activities, but also deploy more complex modes of external linkages with other local institutions and organizations. However, this will be subject to the quality of the NIS, as pointed out in section 2.2, and to the technological dynamism of the sector in which the foreign capital operates, as suggested by the literature on micro multinationals.

Taking into consideration this background and recognizing its contradictions, we can hypothesized that the relationship between size and the innovation activities of foreign-owned firms located in developing countries, far from being direct, is mediated by a set of structural characteristics that contributes to the autonomy of the firm: (i) the type of home organization and its strategy, (ii) the sectoral

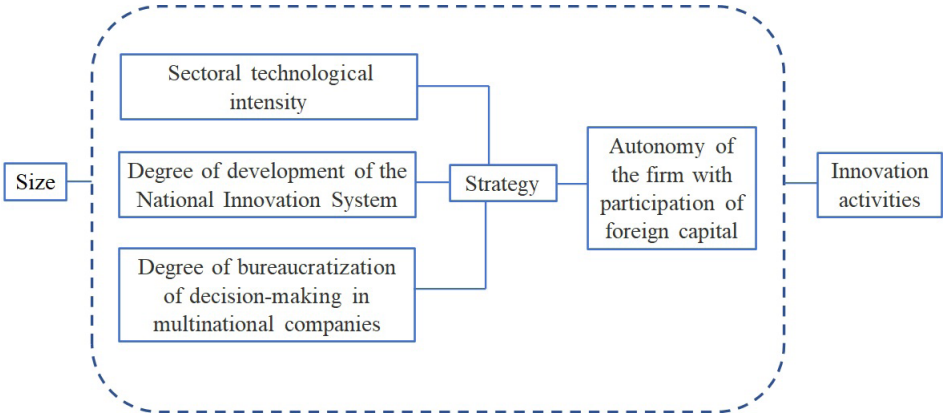

Figure 1
Mediations in the relationship between size and innovation activities of firms with foreign capital. Source: Own elaboration.

determinants of innovation and technological change, and (iii) the modes of linkage with the host NIS (Figure 1).

3. Backgrounds of the Argentine case and formulation of hypothesis

The hypotheses of this article emerge from some discrepancies in the background literature on foreign-owned firms (mostly MNCs) and innovation in Argentina. Those discrepancies could be associated with an unexplored source of heterogeneity within foreign-owned firms.

First, the work of Arza and Lopez (2010) find evidence indicating that foreign ownership has a negative effect on the intensity of internal innovation activities of manufacturing firms, which is explained by the indivisibilities of these activities that lead them to be carried out exclusively in the parent companies. In the opposite direction, the empirical work of Crespi and Zuniga (2012) shows that foreign-owned firms in Argentina have a higher propensity to invest in innovation activities than domestic-owned firms, and to make greater relative innovation efforts (measured as the ratio of innovation expenditure

per employee). Finally, Dinenzon, Robert and Yoguel (2011) show that subsidiary firms in Argentina usually resort to the R&D efforts made by headquarters and/or other subsidiaries, though firms that have formal R&D teams show a greater capacity to make use of these external resources.

Although these results are not comparable in a strict sense, we can see that there is no clear evidence on the effect of the presence of foreign capital in firms on its innovative behavior. In turn, the international literature already cited presents different arguments on the innovative behavior of subsidiaries, while the new International Business literature identifies a new role of smaller firms in the internationalization of capital. In this sense, in relation to innovation activities, a hypothesis aimed at exploring the heterogeneity of foreign-owned firms is proposed in order to corroborate their differential innovative behavior.

> H1: The innovation activity of foreign-owned firms is heterogeneous regarding firm size.

Second, in terms of the local embeddedness strategies of foreign-owned firms and their relationship with innovation, Arza and Lopez (2010) show that subsidiary firms in Argentina tend to exploit technology developed in other parts of the world. In this sense, the expansion of MNCs did not translate into supplier-user interactions in the national space but it was mainly limited to technology acquisition strategies (LAVARELLO, 2004).

In relation to the size of the subsidiaries, ERBES et al. (2011) highlight that size is relevant to explain the quality level of the relationship between subsidiary and headquarters, and between subsidiary and NIS institutions, i.e., local clients and suppliers, consultants, universities, and technology centers. According to these authors, the characteristics of the NIS in a developing country such as Argentina probably limit the complexity of the external ties of internationalized small and medium-sized companies.

MNCs that entered Argentina since the 1990s, aimed at exploiting competitive advantages associated with natural resources or positioning themselves within the domestic market, focused their R&D activities on adapting products and processes to the characteristics of local markets

(PORTA; RAMOS, 2002; CHUDNOSKY; LOPEZ, 2007; ANLLÓ; RAMOS, 2008; DINENZON; ROBERT; YOGUEL, 2011), without a contribution to the process of capital accumulation, generation of productive linkages and/or accumulation of technological capabilities (PORTA; RAMOS, 2002)1.

Thus, large foreign-owned subsidiaries are probably more oriented towards exploiting the technological capacity generated by the parent company. However, links with local companies and institutions will be oriented towards accessing complementary resources or capabilities, establishing more complex or sophisticated links. On the other hand, small and medium-sized companies with foreign capital participation could show greater external openness, but based on low level of sophistication ties (informal cooperation, consultancies or HR training). Based on the above, the following research hypothesis is proposed:

> H2: firms with foreign capital participation differ in their links with NIS institutions according to their size, which, as the literature points out, is linked to the strategy of foreign capital in the region.

Third, regarding learning and innovation modes, although scarce, the available empirical evidence for the case of Argentina -specifically for firms belonging to multinational networks- corroborates the findings of the seminal work of JENSEN et al. (2007): combining DUI and STI modes increases the probability of success in innovation and better economic performance. For example, Morero (2010) shows that in the automotive sector (with a high presence of foreign firms) the innovative performance of Argentine auto parts firms is directly related to a complementarity between internal sources of interactive learning (DUI and STI mode) and external sources of knowledge (mainly national linkages). Erbes et al. (2011) analyze the development of learning and innovation processes in MNCs subsidiaries located in Argentina (with more than 100 employees) corroborating the existence of a positive relationship between absorptive capacities, good practices of human resource management, work organization and the innovative behavior.

[1] Narula and Marín (2003) show that subsidiary companies have higher labor productivity and higher wages than local companies, but in terms of knowledge creation there is little difference with local firms.

Among MNC affiliates in Argentina there is evidence that the forms of labor-management relations that promote organizational and individual learning processes that move away from the Taylorist-Fordist model are more frequent than in domestic firms (ROITTER et al., 2009). The subsidiaries of larger MNCs develop a decentralized human resource management strategy, associated with high levels of autonomy, especially in relation to staff involvement and communication from the company to employees (DELFINI; ERBES, 2011). Small MNCs subsidiaries (less than 100 employees) are characterized by greater communication from the company to employees and employee participation in work teams.

Thus, in Argentina there is evidence that the subsidiaries of relatively larger MNCs are characterized by having formal R&D teams (oriented to product and process adaptation), with greater critical mass, and advanced forms of work organization (DUI mode). These companies are associated with the case of more successful companies that manage to combine elements of the DUI mode with elements of the STI mode to obtain a better innovative performance. Subsidiaries or foreign-owned small or medium-sized firms, on the other hand, are likely to be more restricted in allocating resources to formal R&D laboratories and more oriented to informal learning from experience, user-producer interaction, and open to the search for complementary assets with external actors. Therefore, the following hypothesis is proposed:

> H3: The learning modes of companies with foreign capital vary according to their size, with large ones being more likely to implement the complex mode (combining DUI and STI modes), relative to the rest of the companies.

4. Methodology

4.1 Database and variables

The empirical analysis was based on data from the first National Survey of Employment and Innovation Dynamics (ENDEI-I), on a sample of 3,691 Argentine manufacturing firms, with 10 or more

employees, for the period 2010-2012. The sample is representative by industry and firm size, and it reproduces the manufacturing structure in terms of the origin of capital.

The variables of interest are the presence of foreign capital, firm size, and the interaction between the two, which allows capturing the differential effect of foreign capital by size. The presence of foreign capital was operationalized as a binary variable indicating the presence (or not) of this attribute in firms (whereas firms are MNC subsidiaries or domestic firms with foreign participation). The firm size variable follows the ENDEI-I categorization, which groups them into small-sized, medium-sized or large-sized, according to the number of employees[2]. Companies with foreign capital represent 9.2% of the sample and are concentrated among the largest companies (60.2% of the companies with foreign capital are large) (Table 1).

The dependent variables are divided into three groups, according to each research hypotheses. The first group consists of eight binary variables indicating the presence of different types of innovation activities and a continuous variable indicating the financial means devoted to innovation activities, measured by the share of total innovation expenditure over current revenues.

The second group consists of five variables indicating the nature and characteristics of the linkages maintained by the firm. The first three seek to capture the type of linkage in terms of innovation modes (FITJAR; RODRÍGUEZ-POSE, 2013). The fourth variable represents the degree of openness, based on the number of linkages that the company maintains (CHEN; CHEN; VANHAVERBEKE, 2011). The last variable refers to the complexity of the linkages considering the nature (type of actors and objectives) of the linkage that the company sustains (FIGUEIREDO, 2011) (see Tables A.5 and A.6 in the Appendix).

The third group is composed of a single nominal categorical variable, which captures the preponderant innovation mode in the firm, resulting from a Latent Class Analysis (LCA) applied on a

[2] Small companies have between 10 and 25 employees, medium-sized companies from 26 to 99, and large companies have 100 or more employees.

TABLE 1
Distribution of companies by origin of capital and size, in percentage

Size	With Foreign Capital participation	Without participation of Foreign Capital
Small	13.6	45.3
Medium-	26.1	37.8
Large	60.2	16.9
Total	9.2	90.8

Source: Own elaboration based on ENDEI I.

set of observable variables representative of the innovation modes (JENSEN et al., 2007)[3]. This exercise allows to extend the previous results referred to formal innovation efforts, considering also non-formal efforts, characteristic of the DUI mode, such as the type of workforce management and the organization's external links. The LCA allows to identify four underlying classes[4] in the sample: i) Low innovative activity, ii) DUI mode, learning mode focused on experimentation with little orientation to R&D activities, iii) STI mode, given the high probability of performing R&D internally[5], and iv) DUI+STI mode, the most complex mode according to Isaksen and Karlsen (2012). These results allowed the construction of the innovation modes variable, which captures the preponderant modes in each company (VERMUNT, 2010).

A detailed explanation of the three groups of dependent variables can be found in Table A.5 of the Appendix. In addition, all models use the standard control variables from the literature, more fully described in Table A.6 of the Appendix[6].

[3] For a detailed description of the observable variables used, the LCA results and the predicted categories distribution see Tables A.1, A.3 and A.4, in the Appendix.

[4] Based on the Akaike and Bayesian information criteria, the structural model with four classes was selected (table A.2 of the Appendix). It was not possible to estimate a model with more than four classes, due to the non-convergence of the models.

[5] A "pure" STI mode does not emerge from the LCA because companies with strong formal innovation efforts also show a high share of non-formal efforts.

[6] The dependent variable Innovation Efforts was used as a control variable in the models of external linkages and modes of innovation.

4.2 Descriptive statistics of the main variables of interest

A simple descriptive analysis comparing the average of the dependent variables according to the origin of capital and the size of the companies suggests, as first evidence, that the smaller foreign-owned companies show an important dynamism in their innovation behavior, in some cases even surpassing those of a relatively larger size. This can be seen in Table 2, which compares the average performance of foreign capital companies differentiated by size in innovation activities, such as: making or not making innovation efforts, in particular (different types of efforts), innovation expenditures and the type of external linkage with the NIS.

Special mention should be made of the sectoral dimension, which is introduced as a control variable in the proposed regressions due to its relevance in explaining the innovative behavior of the companies[7] (MALERBA; ORSENIGO, 1997; PAVITT, 1984). The descriptive analysis of the distribution of foreign-owned companies by size and sector identifies a high concentration of foreign companies in the "Others" category[8], followed by the sectors of Publishing, Chemical and pharmaceutical products, Rubber and plastic products, Other non-metallic minerals, Machinery and miscellaneous equipment, and Bodywork, trailers, semi-trailers and auto parts (Table 3). Excluding the case of Publishing, all these sectors have a high level of spending on innovation activities.

This shows that spending on innovation activities by foreign capital companies is concentrated in sectors different from those in which spending by domestic capital companies is concentrated. In particular, Furniture, Other non-metallic minerals, Rubber and plastic products,

[7] This paper does not go further into the analysis of the heterogeneity of behavior of companies of foreign origin at the sectoral level due to not having enough observations for the different activities.

[8] The Others category contains, among others, companies in the automotive sector, where there is a high presence of companies with foreign capital.

TABLE 2
Innovation profile of foreign-owned companies, differentiated by size

Companies with Foreign Capital	Innovation Efforts (Innovation Expenditures/ Current Income)	Type of innovation activities, in percentage of companies								Interaction with the NIS, in percentage of companies and average values of Openness and Complexity				
		1	2	3	4	5	6	7	8	External	STI	DUI	Openness	Complexity
Small	4.07	82.1	50.0	82.14	46.4	25.0	71.4	67.9	71.4	75.0	35.7	71.4	1.54	1.929
Medium-sized	2.54	57.1	30.0	87.1	54.3	28.6	58.6	58.6	57.1	68.6	34.3	62.9	1.40	1.614
Large	1.98	67.4	38.6	88.0	81.5	43.5	81.5	71.2	71.2	85.3	64.1	81.5	2.22	2.168
Total	2.33	66.3	37.6	87.2	71.3	37.9	74.8	67.7	67.7	80.1	53.9	75.89	1.95	2.007

Source: Own elaboration based on ENDEI I. The values correspond to the subsample of 282 companies with foreign capital that have carried out innovation activities. Note: 1. Internal R&D, 2. External R&D, 3. Acquisition of Machines and Equipment, 4. Acquisition of Hardware and Software, 5. Technology Transfer, 6. Training, 7. Consulting and 8. Industrial Design & In-house Engineering (ID&E)

TABLE 3
Distribution of foreign-owned companies and expenditure on innovation activities, by industry

Industries	Participation of Companies with Foreign Capital over Total Companies	Expenditure on Innovation Activities / Current Income, 2010-2012 average, in percentage	Expenditure on Innovation Activities / Current Income, 2010-2012 average, in percentage			
			Total	Small	Medium-sized	Large
Foodstuffs	8.1	1.7	2.3	3.5	2.5	1.6
Textile products	5.1	1.4	2.4	s/d	3.7	1.8
Garment	0.0	0.5	0.0	s/d	s/d	s/d

Source: Own elaboration based on ENDEI-I.

TABLE 3
Continued...

Industries	Participation of Companies with Foreign Capital over Total Companies	Expenditure on Innovation Activities / Current Income, 2010-2012 average, in percentage	Expenditure on Innovation Activities / Current Income, 2010-2012 average, in percentage			
			Total	Small	Medium-sized	Large
Leather	5.3	1.3	1.5	s/d	s/d	1.5
Wood	0.0	1.4	0.0	s/d	s/d	s/d
Pulp and paper	8.2	1.4	1.3	s/d	1.8	1.1
Publishing	11.8	1.6	1.9	1.4	1.4	3.0
Chemical and pharmaceutical products	20.3	2.1	2.3	4.9	1.9	2.2
Rubber and plastic products	10.9	2.3	2.6	3.2	1.3	2.9
Other non-metallic minerals	11.5	2.0	3.2	s/d	3.2	3.2
Common Metals	8.8	1.5	1.6	s/d	s/d	1.6
Other metal products	6.6	1.9	1.8	s/d	0.1	2.4
Machinery and miscellaneous equipment	10.5	1.9	1.3	1.0	1.6	1.1
Medical Devices	7.6	2.8	1.1	1.3	s/d	0.9
Other transport equipment	0.0	1.8	0.0	s/d	s/d	s/d
Furniture	2.3	1.9	3.3	s/d	3.3	s/d
Electrical equipment, radio and television	7.5	2.1	0.8	s/d	0.5	0.9
Bodywork, trailers, semi-trailers and auto parts	14.7	1.8	1.3	2.3	1.5	1.1
Others	26.2	1.9	1.6	s/d	3.2	1.2
Total	9.2	1.8	1.9	2.5	2.0	1.8

Source: Own elaboration based on ENDEI-I.

Textile products and Foodstuffs stand out. When disaggregating these companies by size, it is verified that small foreign-owned companies spend more than medium and large ones on innovation activities over current revenues in the sectors of Food, Chemical and pharmaceutical products, Rubber and plastic products, Medical devices and Bodywork, trailers, semi-trailers and auto parts. This evidence, although descriptive, justifies the hypotheses put forward in the paper.

4.3 Identification strategy

In this section we present the estimations of three groups of econometric models, each one according to the three hypotheses of the article. In all the models we use as independent variables *presence of foreign capital*, *size*, and the interaction of both variables. The interaction as an explanatory variable will allow us to explore the differential incidence of size in companies with presence of foreign capital on the different dependent variables selected, according to the working hypotheses. Similar methodological approach was implemented by Pasali and Chaudhary (2020). They compare the economic performance (in terms of sales growth, employment, and productivity) of foreign-owned companies and domestic companies differentiated by size. Our research proposes a similar application for the innovative behavior of companies.

The first group analyzes the propensity of firms to carry out different types of innovation activities and the expenditure allocated to these activities. In each regression, the sample is limited to those companies that carry out at least one innovation activity, and a probit model is estimated for each type of innovation activity. The aforementioned causal and control variables of interest are included in all models.[9] In the case of expenditure on innovation activities, the two-stage sample selection model of Heckman (1979) is used, starting

[9] With the exception of the models in which there is a simultaneity problem with the dependent variable.

with a sample selection equation on the *Innovation Profile* variable, and then estimating by ordinary least squares (OLS) the variable *expenditure on innovation activities over current income*.

The second group of models analyzes the cooperation links with external actors. It is assumed that external linkages are the result of two decisions: to invest (or not) in innovation activities and the search for complementarity or external cooperation ties. Starting from the original sample selection equation[10], the Heckman model for binary variables is used to estimate the probability of *External Linkage*, *DUI Linkage* and *STI Linkage*, and the Heckman model for ordered variables to analyze *Openness* and *Complexity* of external ties.

The third econometric exercise consists of estimating a multinomial probit model on the categorical variable *Modes of Innovation*.

5. Econometric results

Regarding the first group of dependent variables, we observe that the presence of foreign capital is statistically significant in explaining the dependent variables in 6 of the 9 models (Table 4). Size also explains the propensity to perform different innovation activities. But when we analyze the interaction between the presence of foreign capital and size, we observe that the strength of the direct relationship is lost as we move from smaller firms to medium and large firms, where significant and negative coefficients prevail. In this context, we verify that foreign-owned firms differ from domestic firms by a greater propensity to engage in innovation activities, but the prevalence of innovation activities decreases as we move from small to medium-sized and large foreign-owned firms. Beyond this general trend, some particularities are observed, for example, large foreign-owned firms that stand out for their propensity to acquire Hardware and Software,

[10] In all the external linkage models, the estimated sample selection equation is used for the Innovation Profile variable.

TABLE 4
Summary of econometric estimates determining types of innovation activities and spending on innovation activities (Hypothesis I).

Explanatory Variables	Innovation Efforts (Heckman model)		Innovation Activities (Probit models)							
	Sample Selection Equation (Innovation Profile)	Expenditure on innovation activities/ Current income	Internal R&D	External R&D	Acquisition of Machines and Equipment	Acquisition of Hardware and Software	Technology Transfer	Training	Consulting	ID&E
Foreign Capital (FC)	**-0.369***	**0.0117****	0.466	**0.649****	0.0904	-0.183	**0.532***	**0.496***	**0.686****	**0.493***
	(0.206)	(0.006)	(0.317)	(0.257)	(0.348)	(0.260)	(0.295)	(0.278)	(0.282)	(0.286)
Medium-sized companies (MC)	**0.145****	**-0.00635*****	-0.0996	-0.0733	0.0965	0.0771	0.134	0.0393	0.101	0.0541
	(0.057)	(0.002)	(0.070)	(0.075)	(0.088)	(0.067)	(0.092)	(0.067)	(0.069)	(0.070)
Large companies (LC)	**0.324*****	**-0.0121*****	-0.000816	0.0823	-0.157	**0.303*****	**0.284*****	**0.206****	**0.338*****	**0.340*****
	(0.088)	(0.002)	(0.092)	(0.093)	(0.116)	(0.089)	(0.109)	(0.090)	(0.089)	(0.093)
FC*MC	0.430	**-0.0131***	**-0.742****	**-0.557***	-0.219	0.0644	-0.0528	**-0.551***	-0.407	-0.51
	(0.266)	(0.007)	(0.359)	(0.309)	(0.407)	(0.307)	(0.343)	(0.323)	(0.328)	(0.333)
FC*LC	0.271	**-0.0137****	**-0.764****	**-0.657****	-0.0572	**0.483***	0.0516	-0.234	**-0.585***	**-0.614****
	(0.253)	(0.006)	(0.340)	(0.282)	(0.381)	(0.290)	(0.317)	(0.306)	(0.305)	(0.311)
Control Variables										
Exports	0.344***	-0.00191	0.231***	0.0452	-0.0185	0.0337	0.0135	0.00362	0.00274	0.110*
	(0.061)	(0.001)	(0.065)	(0.067)	(0.082)	(0.064)	(0.079)	(0.064)	(0.064)	(0.065)
Imports	0.179***	-0.00141	-0.0058	0.123*	-0.00319	0.0762	0.185**	0.144**	0.0317	0.0587
	(0.061)	(0.001)	(0.069)	(0.071)	(0.088)	(0.066)	(0.085)	(0.067)	(0.068)	(0.068)
Technological Complexity	0.236***	0.000735	0.252***	0.111*	0.0555	0.264***	0.152*	0.245***	0.242***	0.187***
	(0.052)	(0.001)	(0.061)	(0.066)	(0.078)	(0.060)	(0.079)	(0.060)	(0.061)	(0.062)

Source: Own elaboration based on ENDEI-I. Note: All models include sectoral controls (19 binary variables indicative of each sector). ***p<0.01, **p<0.05, *p<0.1.

TABLE 4
Continued...

Explanatory Variables	Innovation Efforts (Heckman model)		Innovation Activities (Probit models)							
	Sample Selection Equation (Innovation Profile)	Expenditure on innovation activities/ Current income	Internal R&D	External R&D	Acquisition of Machines and Equipment	Acquisition of Hardware and Software	Technology Transfer	Training	Consulting	ID&E
Legal protection mechanisms		0.00320**	0.578***	0.371***	0.181**	0.301***	0.508***	0.274***	0.260***	0.447***
		(0.001)	(0.061)	(0.060)	(0.077)	(0.059)	(0.069)	(0.059)	(0.059)	(0.061)
Inverse of the Herfindahl-Hirschman Index (HHI)	0.0486	-0.00095	-0.317**	-0.472***	0.435**	0.0996	-0.285*	0.0913	-0.277*	-0.453***
	(0.144)	(0.003)	(0.153)	(0.150)	(0.176)	(0.150)	(0.168)	(0.152)	(0.155)	(0.154)
External Linkage	0.787***		0.213***	0.481***	0.0337	0.242***	0.243***	0.444***	0.793***	0.414***
	(0.050)		(0.063)	(0.072)	(0.080)	(0.062)	(0.086)	(0.062)	(0.065)	(0.064)
Education level	0.00275	0.0001	0.00883***	0.00228	-0.00463*	0.00374	0.00442*	0.00165	0.00361	0.00546**
	(0.002)	(0.000)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
Expenditure on Machinery and Equipment	0.0335***		0.00679	0.0135***	0.0589***	0.0219***	0.0121**	0.0223***	0.0204***	0.0266***
	(0.003)		(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)
Number of Observations	3,575	3,575	2,366	2,366	2,366	2,366	2,366	2,366	2,366	2,366

Source: Own elaboration based on ENDEI-I. Note: All models include sectoral controls (19 binary variables indicative of each sector). ***p<0.01, **p<0.05, *p<0.1.

tend to reduce the probability of investing in R&D, consulting and industrial design and in-house engineering.

In terms of external linkage patterns (second hypothesis), Table 5 shows that the coefficients accompanying the foreign capital variable are not significant. This implies that the behavior of companies with foreign capital does not differ from that of companies with domestic capital. Size variable, however, marks a strong contrast between the behavior of medium-sized and large-sized companies, with or without the presence of foreign capital. The latter show a greater propensity to link up with external actors, greater external openness and greater complexity in their ties, compared to the rest of the companies. When the analysis is restricted to medium and large firms with foreign capital, this tendency loses strength or is reversed in cases where the coefficients are negative and significant, reducing the positive and significant coefficients of the category large firms (without interacting).

Regarding the third hypothesis, on the probability of implementing the different modes of learning and innovation, three models are presented in which each dependent variable corresponds to one of the categories that make up the *Modes of Innovation* variable: DUI, STI or a combination of both, being Low innovative activity as the base category (Table 6).

Here we see that large firms generally stand out for having DUI, STI or a combination of both innovation modes. On the other hand, foreign-owned firms stand out among the group of firms with a complex learning mode (DUI + STI).

When restricted to the group of firms with foreign capital, medium-sized and large firms reveal in most cases a negative relationship with the learning modes (with the exception of the DUI mode), however, the coefficients do not reach significance.

In this context, although there is also heterogeneity of behavior among foreign-owned firms in relation to size, it is not possible to affirm that the most sophisticated learning modalities are typical of foreign-owned firms of relatively smaller size.

TABLE 5
Econometric estimates of linkage with the NIS (Hypothesis II)

Explanatory variables	External Linkage	STI Linkage	DUI Linkage	Openness	Complexity
Foreign Capital (FC)	0.237	0.0492	0.438	0.294	0.376
	(0.285)	(0.255)	(0.285)	(0.210)	(0.237)
Medium-sized companies (MC)	0.00502	0.0886	0.0653	0.0675	0.0328
	-0.0707	-0.0714	-0.07	-0.0569	-0.0601
Large companies (LC)	0.151	**0.322*****	**0.221****	**0.335*****	**0.240*****
	(0.100)	(0.098)	(0.098)	(0.080)	(0.084)
FC*MC	-0.474	-0.376	**-0.660****	**-0.486***	**-0.625****
	(0.329)	(0.301)	(0.328)	(0.248)	(0.275)
FC*LC	-0.212	-0.0217	-0.381	-0.237	**-0.456***
	(0.316)	(0.278)	(0.313)	(0.229)	(0.257)
Control variables					
Exports	0.124*	0.158**	0.0993	0.0955*	0.0856
	(0.071)	(0.070)	(0.070)	(0.058)	(0.060)
Imports	0.0308	0.0364	0.0891	0.0735	0.0201
	(0.070)	(0.067)	(0.069)	(0.055)	(0.058)
Expenditure on innovation activities/ Current income	0.806	1.441	0.773	1.483**	2.118***
	(0.992)	(0.892)	(0.955)	(0.713)	(0.806)
Technological Complexity	0.191***	0.0867	0.130**	0.0916*	0.188***
	(0.068)	(0.066)	(0.066)	(0.056)	(0.057)
Legal protection mechanisms	0.393***	0.401***	0.301***	0.344***	0.373***
	(0.061)	(0.055)	(0.058)	(0.047)	(0.050)
Inverse of HHI	-0.175	-0.333**	-0.216	-0.329**	-0.396***
	(0.160)	(0.143)	(0.156)	(0.131)	(0.141)
Education Level	0.00423	0.00575**	0.00516*	0.00623***	0.00440**
	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
Number of Observations	3,575	3,575	3,575	3,575	3,575

Source: Own elaboration based on ENDEI-I. Note: All models include sectoral controls (19 binary variables indicative of each sector). ***p<0.01, **p<0.05, *p<0.1.

TABLE 6
Estimation of multinomial probit model on predicted variable *Modes of Innovation* (Hypothesis III)

Explanatory variables	Class 2 (DUI mode)	Class 3 (STI mode)	Class 4 (DUI+STI mode)
Foreign Capital (FC)	0.0927	0.208	**0.603***
	(0.382)	(0.323)	(0.340)
Medium-sized companies (MC)	0.0658	**0.347*****	**0.262*****
	(0.096)	(0.082)	(0.097)
Large companies (LC)	**0.271***	**0.799*****	**1.000*****
	-0.148	-0.118	-0.129
FC*MC	-0.027	-0.532	-0.501
	(0.465)	(0.393)	(0.413)
FC*LC	**0.863***	-0.365	0.0126
	(0.446)	(0.384)	(0.397)
Control variables			
Exports	0.168*	0.459*	0.495***
	(0.102)	(0.083)	(0.094)
Imports	-0.0124	0.122	0.105
	(0.104)	(0.086)	(0.098)
Expenditure on innovation activities/ Current income	11.69***	19.90***	18.29***
	(1.799)	(1.501)	(1.604)
Technological Complexity	0.0551	0.379***	0.566***
	(0.088)	(0.075)	(0.086)
Legal protection mechanisms	0.874***	1.195***	1.668***
	(0.112)	(0.094)	(0.099)
Inverse of HHI	-0.104	-0.324	-0.524***
	(0.247)	(0.204)	(0.218)
Number of Observations	3,649	3,649	3,649

Source: Own elaboration based on ENDEI-I. Note: All models include sectoral controls (19 binary variables indicative of each sector). ***p<0.01, **p<0.05, *p<0.1.

6. Concluding remarks

The econometric exercises presented in this article allow the following conclusions to be drawn.

First, foreign capital firms show, on average, a more innovative profile than local firms, issue already highlighted by the literature (CRESPI; ZUNIGA, 2012). However, the results show a negative effect of the interaction between the firm size and presence of foreign capital on innovation efforts, measured as expenditures on innovation activities over sales or as the probability of performing R&D activities (internal and external). Arza and López (2010) had pointed out that firms with the presence of foreign capital tend to make lower R&D expenditures; however, while these authors attribute this to the economies of scale of these activities that mandate to be carried out in unique locations of the global network of MNCs, here we see that this is valid for medium and large-sized firms with foreign capital, but not for those of smaller relative size, which contrast by making greater efforts. On the other hand, Dinenzon, Robert and Yoguel (2011) indicate that MNC subsidiaries tend to make use of the R&D teams of the headquarters and/or from other subsidiaries, which justifies lower expenditures. Again, we see that this result is consistent only with relatively larger MNCs. Descriptive statistics provide information in favor of this argument, as the dynamic behavior of small foreign-owned firms (relative to medium and large ones) is verified. This result is reaffirmed when the sectoral dimension is introduced, since these companies predominate in branches identified as high technology, an issue already pointed out by the literature on micro-multinationals.

Secondly, the set of foreign capital firms does not differ from local firms in terms of external linkage patterns. However, as their size increases, they tend to reduce the likelihood of linkages with NIS actors and their complexity. This is consistent with the finding discussed on the heterogeneity of behavior according to firm size. Within the sample used, restricted to the case of manufacturing companies, the presence of micro-MNCs could be verified, which are inclined to carry out innovation activities and establish links with partners with complementary capabilities that increase their competencies.

Thirdly, in relation to the innovation modes of the companies, the group of foreign capital companies tends to have a complex mode

of innovation. This issue is also identified by Roitter et al. (2009) when they point out that among MNC subsidiaries in Argentina, labor-management relations that promote organizational learning processes that move away from the Taylorist-Fordist model are more frequent. As the size of the companies with foreign capital increases, there is a greater propensity to implement the DUI mode. This is consistent with other studies that highlight the implementation of decentralized human resource management strategies, with high levels of autonomy, staff involvement and internal communication in large subsidiaries (Delfini; Erbes, 2011). Among large firms, no STI or complex mode of innovation stands out, which is consistent with the potential indivisibilities of R&D spending and the tendency to centralize it in parent companies.

In sum, the results found are consistent with the proposition that size and origin of capital are determinants in explaining the innovative behavior of firms. Larger firms with foreign capital do not show a better performance in innovation and linkage with the NIS than small firms.

The results allow us to make the following observations. First, it is possible that larger-sized firms with foreign capital intensify intra-group ties, against autonomy in the search for external complementarities and internal innovation efforts. This reinforces the idea that classic internationalization strategies prevail among large foreign-owned firms, based on access to raw materials or rent or market capture, supported by laboratories that carry out product adaptations and improvements without new product/process development or R&D.

Secondly, in regulatory terms, the identification of differential innovation behavior of companies with foreign capital according to their size is key to the design of public policies that seek to improve the innovative performance of this group of companies.

Finally, considering the heterogeneity of innovation and linkage behaviors in companies with the presence of foreign capital allows us to reinterpret some of the positions faced in the literature on the actions of this group of companies in terms of innovation, and at the same time, to think about public policies aimed at improving the innovative

performance of a productive system in which foreign capital has a strong influence.

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APPENDIX

TABLE A.1
Description of observed indicator variables used to establish smaller number of unobserved groups (latent categories)

Indicator variables	Number of observations	Mean	Standard Deviation (S.D.)	Min.	Max.
DUI mode					
Employees evaluate their performance	3,686	0.1628	0.3692	0	1
Employees collectively organize activities	3,686	0.1384	0.3453	0	1
Employees are encouraged to generate knowledge	3,595	0.5583	0.4967	0	1
Autonomy of employees to solve problems	3,691	0.2642	0.4409	0	1
Employees participating in multiple teams	3,647	0.3858	0.4868	0	1
Suppliers or customers as an external source of information	3,691	0.4172	0.4932	0	1
STI mode					
They carry out In-house R&D	3,691	0.4031	0.4906	0	1
They are linked with Universities or Scientific and technological institutions	3,691	0.2883	0.4530	0	1
Team or area carries out innovation activities	3,691	0.2959	0.4565	0	1

Source: Own elaboration based on ENDEI-I.Table

TABLE A.2
Goodness-of-fit measures for different models estimated by LCA

Estimated model	N ° observations	ll(model)	df	Akaike Information Criterion (AIC)	Bayesian information criterion (BIC)	Chi2	P>Chi2
Two classes	3,567	-17,436.57	19	34,911.13	35,028.54	1,573.73	0.0000
Three classes	3,567	-17,182.85	29	34,423.71	34,602.91	1,066.30	0.0000
Four classes	3,567	-17,019.03	39	34,116.07	34,357.07	738.66	0.0000

Source: Own elaboration based on ENDEI-I.

TABLE A.3
Probability that a firm is characterized by an indicator variable according to its class, based on LCA over 3.567 companies

Observed indicator variables	Class 1	Class 2	Class 3	Class 4
Employees evaluate their performance	0.0181	**0.5801**	0.0255	**0.4764**
Employees collectively organize activities	0.0062	**0.4934**	0.0097	**0.4588**
Employees are encouraged to generate knowledge	**0.3388**	**0.7345**	**0.5739**	**0.9521**
Autonomy of employees to solve problems	0.2464	**0.3909**	0.1957	**0.3526**
Employees participating in multiple teams	0.1900	**0.4488**	**0.3933**	**0.8201**
Suppliers or customers as an external source of information	0.1074	0.3066	**0.6863**	**0.7922**
They carry out In-house R&D	0.0514	0.2517	**0.6716**	**0.9081**
They are linked with Universities or Scientific and technological institutions	0.0858	0.2159	**0.3702**	**0.7163**
Team or area carries out innovation activities	0.0070	0.1236	**0.4850**	**0.8154**
Unconditional probability for each class	0.4102	0.1244	0.3025	0.1628

Source: Own elaboration based on ENDEI-I.

TABLE A.4
Sample distribution of latent classes that make up the predicted variable *Innovation Modes*

Classes	Absolute frecuency	Percentage share	Cumulative percentage share
1	1,586	42.97	42.97
2	357	9.67	52.64
3	1,054	28.56	81.2
4	694	18.8	100
Total	3,691	100	

Source: Own elaboration based on ENDEI-I.

TABLE A.5
Description of the Dependent Variables

Hypothesis	Variable name	Type of variable	Operational Definition	Observations	Mean	S.D.	Min	Max
H1	Innovation Profile	Binary	Indicates whether the company has carried out at least one innovation activity during the 2010-2012 period.	3,691	0.6597	0.4739	0	1
	Innovation Efforts[a]	Continuous	Simple average of the ratio between expenditure on innovation activities (including R&D) and current annual income, 2010-2012.	3,683	0.0176	0.0267	0	0.2447
			Companies that carry out innovation activities (Innovation Profile = 1)					
	Internal R&D	Binary	Each variable indicates whether the company has carried out the innovation activities (or not) during the 2010-2012 period.	2,435	0.6111	0.4876	0	1
	External R&D	Binary		2,435	0.2764	0.4473	0	1
	Acquisition of Machines and Equipment	Binary		2,435	0.8674	0.3393	0	1
	Acquisition of Hardware and Software	Binary		2,435	0.5819	0.4933	0	1
	Technology Transfer	Binary		2,435	0.1593	0.3661	0	1
	Training	Binary		2,435	0.5910	0.4918	0	1
	Consulting	Binary		2,435	0.4940	0.5001	0	1
	ID&E	Binary		2,435	0.5569	0.4969	0	1

a) This variable is similar to the one used in the literature (ARAÚJO, 2005; DE NEGRI, 2010; ZUCOLOTO; CASSIOLATO, 2013). In addition, the average value of the period 2010-2012 was taken in order to give greater stability to the sample variable. However, the results were replicated for each year, and no significant changes are seen between the estimates. b) Links with the parent company or another group company and links with public programs are excluded, given their low sample presence (less than 5% of companies). c) Figueiredo (2011) presents an additional category that refers to less intense and informal links, for which no information is available in the ENDEI-I. d) The mean values and S.D. of the Low Innovative Activity, DUI Mode, STI Mode, and DUI + STI Mode categories, represent the post-estimated probabilities, and not the actual values assigned to the sample. Source: Own elaboration based on ENDEI-I.

TABLE A.5
Continued...

Hypothesis	Variable name	Type of variable	Operational Definition	Observations	Mean	S.D.	Min	Max
H2	External linkage	Binary	Indicates if the company is linked with at least one external local actor.	3,691	0.5771	0.4941	0	1
	STI linkage	Binary	Indicates if the company is linked with actors of the scientific and technological system	3,691	0.3037	0.4599	0	1
	DUI linkage	Binary	Indicates if the company is linked to local companies, consultants or business chambers.	3,691	0.5196	0.4997	0	1
	Openness[b]	Ordinal	Based on Chen et al. (2011) a variable with four categories was constructed: base category (zero), companies that are not linked to external actors; 1, those that are linked to at least one external actor; 2, those that have been linked to at least two actors; 3, with at least three actors; 4, companies that have been linked with all the actors. External actors: Other companies, Universities, Science and Technology Institutions, Chambers and Consultants	3,691	1.1127	1.2161	0	4
	Complexity[c]	Ordinal	Based on the typology of Figueiredo (2011), a variable with four ordinal categories was elaborated: Base category (zero), companies that do not establish external links; 1, are linked for HR training or organizational changes; 2, for testing and trials, development or improvement, quality management or industrial design activities; 3, represents the companies that are linked for R&D or technological exchange.	3,691	1.3655	1.2670	0	3

a) This variable is similar to the one used in the literature (ARAÚJO, 2005; DE NEGRI, 2010; ZUCOLOTO; CASSIOLATO, 2013). In addition, the average value of the period 2010-2012 was taken in order to give greater stability to the sample variable. However, the results were replicated for each year, and no significant changes are seen between the estimates. b) Links with the parent company or another group company and links with public programs are excluded, given their low sample presence (less than 5% of companies). c) Figueiredo (2011) presents an additional category that refers to less intense and informal links, for which no information is available in the ENDEI-I. d) The mean values and S.D. of the Low Innovative Activity, DUI Mode, STI Mode, and DUI + STI Mode categories, represent the post-estimated probabilities, and not the actual values assigned to the sample. Source: Own elaboration based on ENDEI-I.

TABLE A.5
Continued...

Hypothesis	Variable name	Type of variable	Operational Definition	Observations	Mean	S.D.	Min	Max
H3[d]	Modes of Innovation	Nominal, with more than two categories	"Classic" three-step method (VERMUNT, 2010) for Latent Class Analysis. Using the "modal" assignment rule, a variable with nominal categories is created, which for each observation assigns the value of the class with the highest probability of occurrence. The categories are: i) Low innovative activity, ii) DUI mode, iii) STI mode, and iv) DUI + STI mode	3,567	0.4102	0.4251	0	1
				3,567	0.1244	0.2495	0	1
				3,567	0.3025	0.3539	0	1
				3,567	0.1628	0.3044	0	1

a) This variable is similar to the one used in the literature (ARAÚJO, 2005; DE NEGRI, 2010; ZUCOLOTO; CASSIOLATO, 2013). In addition, the average value of the period 2010-2012 was taken in order to give greater stability to the sample variable. However, the results were replicated for each year, and no significant changes are seen between the estimates. b) Links with the parent company or another group company and links with public programs are excluded, given their low sample presence (less than 5% of companies). c) Figueiredo (2011) presents an additional category that refers to less intense and informal links, for which no information is available in the ENDEI-I. d) The mean values and S.D. of the Low Innovative Activity, DUI Mode, STI Mode, and DUI + STI Mode categories, represent the post-estimated probabilities, and not the actual values assigned to the sample. Source: Own elaboration based on ENDEI-I.

TABLE A.6
Description of Control Variables

Variable Name	Type of variable	Operational Definition	Observations	Mean	S.D.	Min	Max
Exports	Binary	Indicates if the company exports	3,691	0.3885	0.4875	0	1
Imports	Binary	Indicates if the company has external suppliers.	3,691	0.4105	0.4920	0	1
Technological Complexity	Binary	Indicates whether companies consider that their core activity is computerized	3,691	0.5196	0.4997	0	1
Inverse of the Herfindahl-Hirschman Index (HHI)	Continuous, positive values positive	Inverse of the Herfindahl-Hirschman (HH) index at a double digit sector level	3,691	0.5871	0.5076	0.1085	1.5381
Education Level	Continuous, percentage	Percentage share of professional employees over total employment for the year 2012	3,635	6.5373	11.9088	0	100
Expenditure on Machinery and Equipment*	Continuous, in logarithm	Non-Current Expenses in Machinery and Equipment, taking the average for the years 2011 and 2012	3,666	11.8377	7.8798	0	23.1968
Legal protection mechanisms	Binary	Indicates whether the company used industrial models / designs, trademarks, copyrights or patents	3,691	0.2482	0.4320	0	1
Industries	19 Binary variables	Disaggregated to two digits, following the International Standard Industrial Classification (ISIC) Rev. 3	-	-	-	-	-

*The observations of the year 2010 were excluded, due to having many inconsistencies, such as negative values. Source: Own elaboration based on ENDEI-I.