Innovation inputs and outputs in Argentine manufacturing firms in bad times (1998-2001)

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Abstract

This paper aims to learn about the determinants and impacts of innovative activities on manufacturing firms' productivity performance during 1998-2001 in Argentina, a period characterized by a long stagnation that finally led to the worst crisis in the country's history. The results show that even in a very hostile scenario, a large number of Argentine manufacturing firms maintained their in house R&D activities (at the same time that they drastically cut their expenditures in embodied and disembodied technologies). More notably, this effort seemingly has had a payoff in terms of innovative outputs, which, in turn, have positively impacted on firms' productivity levels. In other words, firms carried out and preserved their R&D activities mainly for good microeconomic reasons. Our results also suggest that in a country like Argentina R&D activities are needed to innovate, while technology acquisition defines the magnitude of the innovative output. On the other hand, while R&D needs to be a permanent activity to have positive impacts, firms may temporarily discontinue their technology acquisition expenditures in bad times without necessarily hurting their innovative possibilities. In other words, while learning is a continuous process, technology modernization may be a discrete process.

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1. Introduction

After the adoption of the Convertibility Plan and of a far-reaching program of structural reforms in the early 90s, Argentina' economy entered a period of relatively high growth between 1991 and 1998 (only interrupted by the Tequila crisis in 1995). However, in late 1998 the economy entered into a stagnation period that lasted until the end of 2001, when the Convertibility program finally collapsed. As a result, in 2002 the country suffered the worst crisis of its history.

The reforms –specially trade liberalization- were supposed to induce significant productivity and efficiency gains through access to modern technologies, increased competition in the domestic market and a more outward-oriented manufacturing sector.

The first national survey on innovation activities in manufacturing firms carried out in 1997 (INDEC, 1998) revealed that the private sector had reacted to the reforms, among other ways, by increasing their innovation expenditures. Among surveyed firms, the latter had increased from 3 to 3.7% of total sales between 1992 and 1996, including in those figures not only R&D activities but also the acquisition of embodied and disembodied technologies (as well as expenditures in training, engineering, design and consultancies).

However, the response to the change in the rules of the game was far from homogenous. While many domestic firms went bust (this was specially the case among small and medium enterprises –SMEs-) or were sold to foreign investors, others totally or partially abandoned production activities to become importers of foreign goods. In turn, large firms, and especially transnational corporations (TNCs) affiliates, were those that better performed in the new market conditions.

Even if among firms that reacted to the reforms augmenting their innovation expenditures, relying only on technology imports was the exception rather than the rule, the bias in favor of technology imports over domestic innovation expenditures that had traditionally characterized the conduct of Argentine manufacturing firms was if anything reinforced. Hence, during the high-growth period, inputs from abroad (mainly in the form of capital goods imports and foreign direct investment –FDI- inflows) were the main source of technological modernization for the Argentina's economy. In contrast, the intensity of the domestic innovation efforts was overall quite small for a country rich in skills and with a GDP per capita, at that time, of U$S 8000.

The survey, jointly with the evidence from several studies (see, for instance, Kosacoff, 1998 and 2000; Chudnovsky *et al*, 1996; Chudnovsky and López, 1996; Bisang and Malet, 1998) on the subject, showed other flaws of the restructuring process of the Argentina's manufacturing sector. Particularly important, from the point of view of the National Innovation System (NSI) approach, was the weakness of the linkages between manufacturing firms and other agents and

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institutions of the NSI, a fact that was seen as a major impediment for a good innovative performance.

In this scenario, in contrast with the "laissez faire" approach, which had been in force since the early 90s on, some policies to foster endogenous innovation activities were put in place by the Argentine government in 1997, including, among other things, a fiscal credit system for R&D and innovation activities. At the same time, the government acknowledged the coordination failures that constrained the interactions between private firms and local technology institutions and universities within the NSI and some initiatives were taken in that connection (Chudnovsky 1999, López 2002).

Unfortunately, these measures started to be put into practice in a very difficult macroeconomic situation. In these adverse conditions, one would expect that innovation expenditures would have been severely reduced and the "learning to innovate" process at the firm level would have been truncated.

The second survey on innovation in the Argentine manufacturing sector (covering the period 1998-2001) sheds light on these issues (INDEC, 2003). In a context in which the sales fell during the period under analysis, expectedly, innovation expenditures had a drastic reduction. However, and unexpectedly, the same did not happen with in house activities.

The aim of this paper is to learn about the determinants and impacts of innovative activities on manufacturing firms' productivity performance during 1998-2001. Following the available studies made on the basis of information from the Community Innovation Surveys (CIS), we analyze those issues considering innovation as a process which is carried out with some specific inputs (R&D activities, acquisition of embodied and disembodied technologies) and by interacting with other firms and institutions. The innovative process should lead to certain outputs such as sales of new (for the firms or for the market, but not necessarily for the world) and/or significantly improved products[2]. In turn, as innovation is not an end in itself, innovators (i.e. those firms which have launched new or improved products) should have a better performance than non-innovators.

In this regard, it is very important to have in mind that the methodology followed in this paper (which is based on the standard methodology employed in the received literature on the subject) is appropriate to analyze in a rigorous way the influence of key microeconomic variables on the innovation process and outputs (and of the latter on firms' performance), but the data to which we have had access so far have not allowed us to examine the influence of the changing Argentina's macroeconomic environment. The analysis of this latter issue is part of our ongoing research agenda in this area.

The paper is organized as follows. The main conceptual and methodological issues arising from the received literature on the subject are discussed in section 2. In section 3, after describing the main features of the innovative conduct of Argentine manufacturing firms in 1998-2001, econometric exercises are made with data at firm level with the aim of:

[2]. Note must be taken of the fact that the methodology followed in those surveys does not measure process or organizational innovations as outputs from the innovative process (mainly due to the fact that it is not easy to have a quantitative indicator for those outputs similar to the one that can be obtained when product innovations are analyzed –i.e., sales of new or improved products on total sales-).

a) Testing the determinants of both the decision to undertake innovation activities and the intensity of such activities according to firms' size, export orientation, ownership and sector, among other factors.

b) Examining the impact of the different interactions firms have with suppliers, clients, technological institutions, universities, parent companies, licensors, etc. to undertake their innovation activities.

c) Analyzing to what extent the innovative output is related to the variables mentioned in a) and b) and studying whether endogenous and exogenous innovative inputs are substitutes or complements within the innovation process.

d) Testing the impact of innovative output on firms' productivity performance.

On the basis of the results of the econometric exercises, in the final section some conclusions are reached and a research agenda is suggested.

2. Innovation activities and firm performance: some conceptual and methodological issues

The availability of Innovation Surveys in the European Community and in other countries such as Canada in the 90s, has provided valuable information on several dimensions of the innovation process at the firm level that had been previously emphasized in the chain linked model proposed by Kline and Rosenberg (1986) as well as in the NSI literature.

The rich information available from innovation surveys has also fostered new ways of doing research on key issues of the received literature, such as the determinants and consequences of innovation activities, through advanced econometric techniques. Innovation surveys supply data, among other things, on subjects such as:

a) Innovation inputs other than R&D expenditures, such as industrial designs, training, licensing and innovation-related fixed asset investments.

b) The interactions in which firms engage during the innovation process.

c) The innovative output, estimated by the weight of new or significantly improved products and their resulting turnover at firm level.

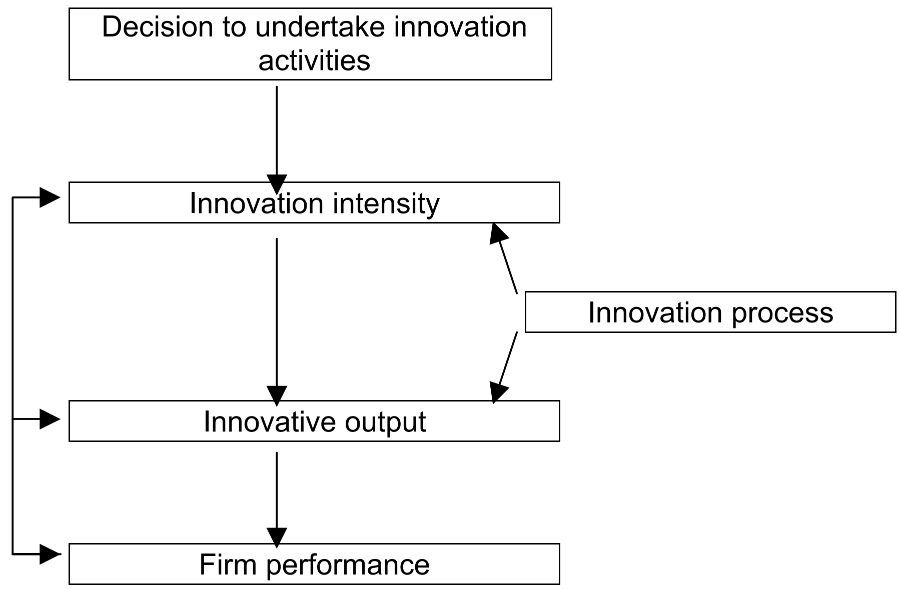
To analyze the information from these surveys with an approach based on the notion of the firm as a learning entity with bounded rationality, most recent papers have followed in one way or another the conceptual framework set by Crepon, Duguet and Mairesse (1998) (or CDM model from now on).

As shown in figure 1, first, there is a decision to allocate financial and human resources to innovate or not. Second, the amount of financial and human resources assigned to innovation activities provides a measure of the intensity of innovation. Third, there is (or there should be) an innovative output that should be related to the innovation intensity[3] and/or to some other

[3]. Undertaking innovative activities is not the same as being an innovator, and for being an innovator is not always needed to have innovative expenditures. For instance, Crepon *et al* (1996) report that only 20 % of the near 10,000 manufacturing firms in their sample that did some research in 1989 innovated between 1986 and 1990, while only 74

features of the innovation process (such as interactions with different agents and institutions of the NSI). Finally, the firm's performance should be related to the innovative output[4].

Figure 1



Source: Kemp *et al* (2003).

The received literature on this subject usually introduces a number of variables that are used as determinants of the probability of engaging in innovative activities and of the intensity of those activities. These variables are simultaneously employed to control for other aspects that could influence the innovative output as well as the firms' performance beyond those relations that are of central interest for the CDM model as above described. Among those variables are firm's size, ownership, export activity, labor skills, sector, profitability, market power, etc. (see table A.1 in the appendix for a list of the available studies and some details about their methodology).

In turn, firms' performance is captured through a variety of indicators, including labor and total factor productivity, profits, rates of growth of sales, total assets, exports, etc. The election of the indicators generally depends not only on research objectives but also on data availability (see Kemp *et al*, 2003 and Kleinknecht and Mohnen, 2002) for surveys of the results of most of the papers produced on this subject).

Available studies also take explicitly into account some aspects of the innovation process that may impact on the efficiency with which firms transform innovative inputs into innovative outputs. As innovation is an interactive process, the cooperation with other firms or universities, linkages with suppliers, knowledge about customers, etc. are key issues in this regard.

Before presenting the results of our own estimations for the Argentine case, it is useful to highlight some aspects of the innovation surveys and of the studies based on them in order to

% of all innovators performed some R&D. Of course, at least a part of these differences may arise from innovative activities that are not captured in the R&D indicator (see below).

4. To deal with the feedback loops from firm performance to innovation inputs and outputs, as well as with the correlation of error terms of each equation which may be reflecting non-observed variables or firm specific effects, several studies based on the CDM model solve all the stages simultaneously.

know the specific advantages and limitations of the adopted methodology. It is also important to make some adaptations to fit the CDM model to the reality of innovation activities in a developing country such as Argentina.

Regarding inputs, in most available studies the innovation intensity is measured through R&D expenditures or employees and/or by innovation expenditures as compiled in the Innovation Surveys. In this regard, it is important to have in mind two things:

i) Firms (specially SMEs) often make expenditures in informal innovation activities which are usually hard to estimate (since, for instance, they are a byproduct of learning by doing processes and/or firms are not able to know how many monetary or labor resources are assigned to them since no dedicated department or team exists) but that can be very relevant, specially in developing countries. Unfortunately, a large part of these activities is not captured in the available innovation surveys (hence, we will not be able to take into account the impact of these informal inputs).

ii) While it may be understandable that studies for developed countries do not take into account technology acquisition when measuring innovative inputs, this cannot be the case when analyzing firms' innovative behavior in developing countries, where external sources of technology are in general more relevant than in house innovative activities. As Argentina's innovation survey includes questions on the acquisition of embodied and disembodied technology, we will be able to include the respective flows when measuring innovative inputs. Examining if external and in house innovative expenditures are complementary or substitutes is also a key issue for this kind of studies in developing countries[5].

Regarding outputs, in available innovation surveys, as stated before, the firms' innovative output is measured by the weight of new or significantly improved products on firms' turnover (this methodology was also followed in the Argentine survey). The main advantage of this indicator is the direct link between the innovation effort and commercial success. This procedure has also advantages over previous studies that employed patents, an indicator which has well know limitations and of little use in the Argentine case where manufacturing firms have relatively few patents[6].

On the other hand, in innovation surveys the innovative output may consist not only of "true" innovations but also of products that can be new for the firm but not the industry (imitations). This is very important since in the case of developing countries most new products or processes are in fact imitations even when introduced via licensing agreements or foreign direct investment.

In contrast, measuring innovative output in terms of sales of new products has three main disadvantages: i) sectors have diverse product life cycles, which should be adequately controlled for a proper estimation of the innovative output; ii) the variable is based on the respondent's own judgment (what is considered to be an innovation for a small firm might not qualify as such for a large firm); iii) it does not measure process and organizational innovations as innovative outputs (when it is obvious that the former do not necessarily lead to new or improved products).

[5]. The study by Hu *et al* (2003a) on China takes explicitly into account these specific features of the innovative process in a developing country.

[6] According to INDEC (2003) 98 firms have registered 317 patents in 1998-2001. About 10% of the innovators have obtained patents.

In this paper we will be able to control for sectoral characteristics as seen below. However, we have some doubts on the accuracy of the answers of firms about their innovative output that we cannot control, and we know that process and organizational innovations are not reflected in the indicator of sales of new products or improved products. Hence, when interpreting the obtained results it is important to have in mind these limitations of the data on which our analysis is based.

3. Innovation inputs and outputs in Argentine manufacturing firms

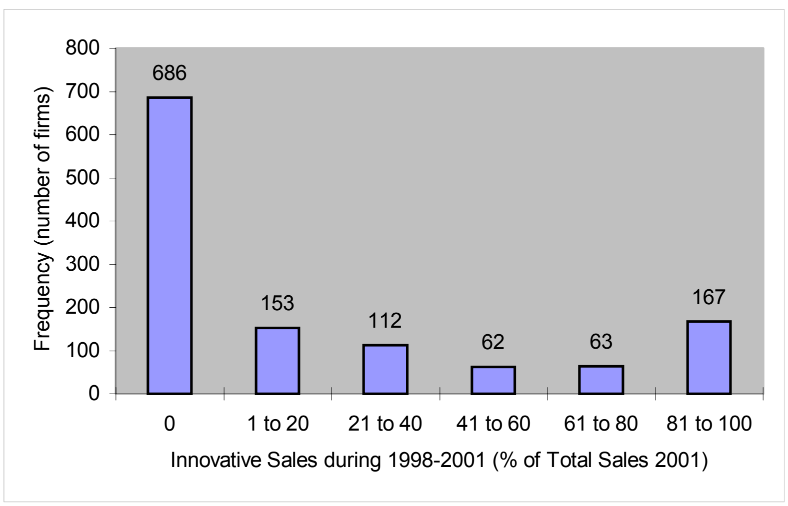
a. Descriptive statistics

As mentioned in the introduction, at the end of 2002 a second national survey on innovation activities and technological conduct of Argentine manufacturing firms between 1998 and 2001, following the Oslo and Bogotá Manuals methodologies, was undertaken by the National Statistical Institute with the support of other institutions and elaborated by a team of experienced researchers (INDEC, 2003).

The initial dataset available to us contained information for 1365 firms. After removing 122 data errors and outlying observations, a clean dataset for 1243 firms was obtained for descriptive and econometric purposes[7].

In this section, our interest lies in presenting descriptive statistics in order to inquire for differences in the technological behavior and performance among innovators and non-innovators. To begin with, a firm is considered to be an innovator if it declared positive innovation output (innovative sales) during 1998-2001. Figure 2 presents a diagram of the distribution of the surveyed firms according to their intensity of innovative sales.

Figure 2 – Distribution of innovative sales



Out of 1243 firms, 557 have achieved a positive level of innovation output and are thus considered as innovators. This group of firms has an average of 52.2% of innovative sales in total turnover in 2001, but the dispersion of firms around this value is large. For example, there is a group of 167 highly innovative firms (which amounts to 30% of total innovators), with a

[7]. Firms deleted were those that reported: less than ten employees, capital goods investment higher than total sales in 1998 or 2001, innovative sales higher than total sales, skilled labor intensity higher than one and/or zero employees or sales in 2001.

percentage of innovative output during 1998-2001 that amounts to more than 80% of the total turnover in 2001. On the other hand, 153 innovators (27% of this group) have low output intensities, which range from 1% to 20% of total sales. Finally, 686 firms (55.2% of the firms surveyed) declare a null share of innovative sales during the period under analysis (hence, they are non innovators).

Table 1 shows that although large firms are a minority among surveyed firms (5.7%), their relative weight increases among innovators. In turn, while 81.3% of the total surveyed firms are domestic, their share decreases to 75.8% when the group of innovators is considered. Hence, the group of innovators has a larger presence of large and foreign firms than the whole sample.

Table 1 - Distribution of firms according to size and nationality (in percentages)

	Large	Medium	Small	Total
All surveyed firms (1243)				
Domestic	2.3	10.2	68.7	**81.3**
Foreign	3.4	6.2	9.2	**18.7**
Total firms	**5.7**	**16.4**	**77.9**	**100**
Innovators (557 firms)				
Domestic	3.8	10.8	61.2	**75.8**
Foreign	5.9	7.9	10.4	**24.2**
Total Innovators	**9.7**	**18.7**	**71.6**	**100**
Non innovators (686 firms)				
Domestic	1.2	9.8	74.8	**85.7**
Foreign	1.3	4.8	8.2	**14.3**
Total non innovators	**2.5**	**14.6**	**82.9**	**100**

Note: Firms are classified as small, medium or large if their total sales average in 1998-2001 is less than 25 millions of pesos, between 25 and 100 millions or more than 100 millions, respectively. A firm is considered to be foreign if its share of foreign capital is al least 10% of total capital.

The descriptive statistics for firm performance and innovation activities are summarized below, with particular focus on eventual differences between innovators and non-innovators.

Firms' performance

From table 2, it is clear that total sales per employee in manufacturing firms decreased substantially during the period 1998-2001 (15%). This fall is notably larger for non-innovators than for innovators (24.2% and 6.4%, respectively). Furthermore, the former seem to have higher productivity levels than the latter. Hence, it may be suggested that innovative sales improve firm performance.

The percentage of skilled labor on total employees was roughly constant during the period of analysis. Expectedly, innovators employ more skilled labor than non-innovators (39% against 30%) throughout the period of analysis.

Table 2 also shows that around 50% of the firms have exported in 1998 and 2001, while this figure reaches 60% for imports. It is interesting to note that the percentage of innovators involved in exporting or importing is substantially higher than for non-innovators (for example, 67% of innovators and only 42% of non innovators exported in 2001). Somewhat unexpectedly, non-innovators have a higher average export propensity than innovators in both years (and the gap in fact increased between 1998 and 2001).

Investments in capital goods have decreased considerably; while 69% of the surveyed firms reported positive investments in 1998 only 62% did so in 2001. Nevertheless, the average investment intensity has been on average roughly constant at 8% of total sales among firms that invested in those years (notably, the investment intensity of innovators is not only lower than average but also has decreased slightly, while the opposite occurs among non innovators).

Table 2 – Firms' performance - Descriptive statistics

	1998		2001		98-01
	Average*	%**	Average*	%**	Average
All surveyed firms (1243)					
In terms of total employees					
Sales*** (pesos)	128599	100	109367	100	118983
Skilled labor (%)	33.7	100	35.3	100	34.5
In terms of total sales (%)					
Exports	21.9	50.0	23.0	53.4	22.5
Imports	17.3	60.3	15.5	60.3	16.4
Investment in capital goods	8.8	69.2	7.7	61.9	8.3
Innovators (557 firms)					
In terms of total employees					
Sales*** (pesos)	148828	100	139373	100	144100
Skilled labor (%)	38.4	100	40.5	100	39.5
In terms of total sales (%)					
Exports	20.1	62.8	20.6	67.1	20.4
Imports	17.1	74.9	16.3	74.3	16.7
Investment in capital goods	7.6	81.5	5.0	74.9	6.3
Non innovators (686 firms)					
In terms of total employees					
Sales*** (pesos)	112174	100	85004	100	98589
Skilled labor (%)	29.9	100	31.0	100	30.4
In terms of total sales (%)					
Exports	24.3	39.5	26.1	42.3	25.2
Imports	17.6	48.5	14.4	48.8	16.0
Investment in capital goods	10.2	59.2	11.0	51.3	10.6

* Calculated for firms that report a positive value of the respective variable.
** Percentage of firms that report a positive value of the respective variable.
***: Excluding sales of goods produced by third parties.

Innovation and Research and Development activities

The intensity of R&D expenditures for R&D performing firms slightly increased during the period of analysis (table 3). Furthermore, this trend holds for innovators and non-innovators as well. However, R&D expenditures still have a minor share of total innovation activities in 2001 when compared to the other technology inputs considered.

The percentage of R&D performing firms has increased slightly, from 24.7 up to 26.6% of the firms sampled. This percentage is substantially lower among non-innovators. In other words, most of the R&D performing firms have achieved positive innovative output levels in 2001 (out of 331 firms that invested in R&D in 2001, 264 are innovators).

Table 3 - Innovation and R&D activities - Descriptive statistics

			1998		2001		98-01 Average
			Average*	%**	Average*	%**	
All surveyed firms (1243)							
In house R&D			0.84	24.7	0.97	26.6	0.91
Technology acquisition	Imported	Embodied	4.03	21.1	2.15	18.6	3.09
		Disembodied	0.61	10.3	0.82	11.7	0.71
	Domestic	Embodied	2.52	33.8	1.70	34.7	2.11
		Disembodied	0.94	37.0	0.86	42.8	0.90
Total Expenditures in Innovation Activities			4.52	51.3	3.15	54.1	3.84
Innovators (557 firms)							
In house R&D			0.90	46.1	1.02	47.4	0.96
Technology acquisition	Imported	Embodied	3.73	31.8	2.09	27.6	2.91
		Disembodied	0.57	15.4	0.89	17.2	0.73
	Domestic	Embodied	2.19	52.2	1.59	52.8	1.89
		Disembodied	1.13	56.9	0.97	64.1	1.05
Total Expenditures in Innovation Activities			4.55	76.7	3.35	79.7	3.95
Non Innovators (686 firms)							
In house R&D			0.53	7.3	0.75	9.8	0.64
Technology acquisition	Imported	Embodied	4.66	12.4	2.27	11.2	3.46
		Disembodied	0.68	6.1	0.70	7.1	0.69
	Domestic	Embodied	3.26	18.8	1.95	20.0	2.61
		Disembodied	0.53	20.8	0.65	25.5	0.59
Total Expenditures in Innovation Activities			4.47	30.8	2.78	33.4	3.62

* Expenditures as a percentage of total sales. Calculated for firms that report a positive value for the respective variable.

** Percentage of firms that report a positive value for the respective variable.

From table 3, it is also clear that expenditures in technology external to the firm decreased significantly during 1998-2001 among innovators as well as among non-innovators. This trend is particularly visible in the case of (domestic and imported) embodied technology[8]. Nevertheless, the latter is still by far the most important source of technology acquisition for manufacturing firms in Argentina in terms of expenditure intensity.

In this sense, when all surveyed firms are considered, investments in foreign technology are higher than in domestic ones in the case of embodied technology both in 1998 and 2001, while the opposite occurs with regard to disembodied technology. Furthermore, the percentage of firms that declared to have innovative expenditures from domestic sources is larger than that of those that acquired technology from foreign sources (this result holds both for innovators as well as for non innovators in 1998 and 2001). This suggests that, even if firms invest more intensely in the acquisition of foreign technologies than in domestic ones, the latter have a higher level of diffusion.

Although the intensities of the different sources of technology acquisition do not show a uniform pattern when comparing innovators and non-innovators (see table 3), expectedly the

[8]. Embodied technology includes capital goods and hardware investments related to innovation activities. Disembodied technology consists of external R&D, software, technological licenses, training and consulting expenditures related to innovation activities. This information is provided by the survey, together with the percentage that in each of those technological inflows comes from foreign sources. The latter allows disembodied and embodied investments to be further divided into domestic and imported expenditures.

percentages of firms reporting positive expenditures in these sources are systematically larger among innovators.

Cooperation linkages

The Second Survey of Innovation in Argentina also provides information on cooperation linkages related to innovation activities undertaken by manufacturing firms during 1998-2001[9]. Table 4 shows that manufacturing firms have, primarily, engaged in cooperation linkages with domestic sources. This fact is especially clear in the case of research and training institutions. Suppliers emerge as the most important source of cooperation employed by firms, among both domestic and foreign linkages. On the other hand, government institutions are, by far, the least widespread source. In general, innovators are markedly more involved in cooperation linkages than non-innovators. This is valid for every linkage type considered irrespectively of its domestic or foreign condition.

Table 4 - Cooperation linkages related to innovation activities during 1998-2001 (percentage of firms)

Al Surveyed Firms (1243)		
Type	Domestic linkages	Foreign linkages
Research and Training Institutions	41.7	9.8
Suppliers	44.5	24.7
Clients	33.8	14.6
Other Firms	38.1	13.4
Government agencies	6.4	0.8
Firms of the same group	22.4	15.0
Innovators (557 firms)		
Type	Domestic linkages	Foreign linkages
Research and Training Institutions	56.7	15.8
Suppliers	54.9	37.2
Clients	43.3	22.4
Other Firms	51.2	21.0
Government agencies	9.7	1.6
Firms of the same group	29.8	21.0
Non innovators (686 firms)		
Type	Domestic linkages	Foreign linkages
Research and Training Institutions	29.4	5.0
Suppliers	36.0	14.6
Clients	26.1	8.2
Other Firms	27.6	7.3
Government agencies	3.8	0.1
Firms of the same group	16.3	10.1

b. Econometric analysis and results

Within the framework of the CDM model, this section analyzes the innovation activities and performance of Argentine manufacturing firms in 1998-2001. We begin with a brief comment on the estimation procedure and the measurement of the variables of the model. Afterwards, the

[9]. The information available is whether the firms engaged or not in such linkages during 1998-2001, but not on the quality or type of them.

main findings are presented. Tables with econometric results and further details can be found in the appendix.

Estimation strategy

In accordance with the received literature, the first three stages described in section 2 were estimated taking into account possible sample selection biases that may arise as result of the fact that a significant share of the firms surveyed report neither innovation expenditures nor innovative output (37% and 55% respectively). Two standard sample selection models for those variables were estimated by the maximum likelihood procedure (see the appendix for details). The final stage involves the ordinary least squares (OLS) estimation of the impact of the innovative output on the performance of the firm.

The econometric exercises involve five dependent variables. The first stage of the CDM model requires defining a dummy variable to distinguish between firms that have and have not incurred in positive innovation expenditures in 1998-2001. Secondly, the intensity of innovation expenditures is measured by the yearly average of innovation expenditures (relative to total employment in 2001) during the period of analysis. In the estimation of the third stage of the CDM model, a firm is considered to be an innovator if it has reported positive sales accounted by new or significantly improved products introduced during 1998-2001. The magnitude of this variable (measured per employee in 2001) defines the intensity of the innovative output in the fourth stage of the CDM model. Finally, the performance of the firm is measured by the sales per employee in 2001[10,11].

In every stage of the estimations we have included the usual control variables employed in the literature such as size, labor skills, foreign ownership, exports and whether the firm is independent or belongs to a group[12]. The size of the firm is measured by the number of total employees in 2001. Labor skills are measured as the average ratio of technical and professional employees to total employees in 1998 and in 2001. The dummy for foreign ownership is equal to one if non-resident investors own more than 10% of a firm's equity capital[13]. To capture the effects of export activity on the dependent variables, a dummy, which is equal to one if the firm exported in 1998 and in 2001, was included. In the first three stages, we also control for differences in the firms' innovation processes (such as interactions and/or cooperation linkages with foreign or domestic government agencies, clients, suppliers, universities, competitors, etc.) using dummy variables[14]. Finally, the surveyed firms were classified into four sectors (labor, scale, R&D and natural resources intensive) in order to control for different availability of technological opportunities.

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[10]. Excluding sales of goods produced by third parties.

[11]. The three continuous dependent variables (innovation expenditures, innovative output and productivity) are measured in natural logarithms. The dummy variables (probability of having innovative expenditures and being an innovator) are used in the selection equations of the sample selection models applied to the first and the third stage of the CDM model.

[12]. See the appendix for more details on the measurement of the variables.

[13]. The reported results are not significantly altered if this dummy takes the value one when foreign ownership is 51% or 100% of the firm's capital.

[14]. In the estimation of the third stage of the CDM model, the distinction between foreign and domestic linkages was avoided only because it would have consumed too many degrees of freedom in the regression and, hence, the estimations would have lost statistical significance.

The decision to undertake innovation activities and the intensity of innovation

The initial step of the estimation aims at identifying the determinants of the first two stages of the CDM model: the decision to undertake innovation activities and the intensity of these activities at the firm level.

The size of the firm is a relevant explanatory variable in the first stage[15]. The estimation results suggest that when the size of a representative firm increases by 1%, the probability of engaging in innovation activities increases by 0.07%, *ceteris paribus*[16]. This could be the result, among other determinants, that innovation expenditures are, again *ceteris paribus*, more difficult to undertake and to finance the smaller is the firm. However, the intensity of the innovation expenditures (second stage of the CDM model) is negatively affected by the size of the firm, although the statistical significance is weaker (15%).

Expectedly, labor skills and exports have a positive and significant impact in both of these stages of the CDM model. This is not the case for the dummy representing foreign ownership, which appears to increase the chances of undertaking innovation activities but does not affect the intensity of expenditures for a firm which is already engaged in those activities. The dummy variable for being part of a group was not found to affect any of these stages of the model.

As mentioned above, cooperation linkages are part of the innovation process that might influence the technological behavior of industrial firms. In general, the econometric exercises reveal that domestic relationships of cooperation do not have a significant impact on the magnitude of the innovation effort (the exceptions are linkages with suppliers and with other firms or consultants). On the other hand, cooperation with different foreign sources seems to have a positive impact on that variable (linkages with foreign suppliers seem to be specially important in this regard). A surprising exception is relationships with foreign clients (negative and significant coefficient).

Firms belonging to labor intensive sectors have a smaller probability of having innovative expenditures and the intensity of innovation in those sectors is lower than in R&D, scale or natural resource intensive ones. In turn, firms operating in R&D intensive branches are, *ceteris paribus*, the most prone to undertake innovation activities and to have higher innovation expenditures per employee.

The innovative output

As mentioned above, the innovative output of the firm is measured by the sales per employee in 2001 accounted by new or improved products introduced during the period 1998-2001. Since we are interested in testing whether different innovation inputs have specific impacts on the innovative output of the firm, we have classified them first into embodied or disembodied technological expenditures, and further into developed in-house or acquired domestically or abroad.

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[15]. Throughout this section we characterize a variable as “statistically significant” if the p-value of its associated coefficient is smaller than 10%.

[16]. When discussing the magnitude of the marginal effect of an independent variable in the first stage of a sample selection model, it is necessary to define a representative firm as a benchmark. This is because the econometric setup implies that the marginal effect of each variable depends on the values of the rest of the independent variables. For example, the marginal effect of a change in the size of a firm will depend on whether the firm exports or not. By representative, we mean a domestic firm in the natural resources or labor-intensive sectors, of average size and labor skills, which did not export during 1998-2001. Whether this firm is part of a group is indistinct because this variable was not found to affect the probability of undertaking innovative activities.

The results reveal that in house R&D performers have a greater probability of having a positive innovative output and that this effect becomes larger if the firm is a continuous R&D performer (i.e. if the firm had positive R&D expenditures in every year during 1998-2001). In contrast, other domestic or imported technological inputs do not seem to have a significant impact on this probability.

Turning to the innovative output intensity, it is observed that, for innovators, R&D investment has a positive impact only if it is done in a continuous fashion. Notably, while embodied technology (acquired either domestically or abroad) expenditures have a positive and significant effect on the intensity of innovative sales, disembodied technology seems statistically insignificant.

Beyond their statistical significance, the magnitude of the estimated coefficients provides information on the economic impact of the variables under analysis. In this case, the results suggest that the impact of imported embodied technology is about three times larger than the estimated effect for continuous R&D expenditures (this means that for a continuous R&D performer, each peso per employee invested in embodied technology will, *ceteris paribus*, yield an innovative output three times larger than for each peso per employee invested in R&D). On the other hand, the small coefficient associated to domestic embodied technology indicates a minor economic impact of this variable. Disembodied technology inputs have no impact on the firms' innovative output.

In order to capture substitution or complementarity effects among R&D and the different kinds of extramural technology sources on the innovation output intensity, the usual practice is to include interaction terms between those variables in the econometric regressions (see, for example, Hu *et al* 2003a). Following this methodology, we have found no general evidence supporting the existence of these effects[17].

Nevertheless, the estimation results suggest that while R&D investment is a fundamental determinant of the probability of successfully developing innovations (but a moderate factor in output intensity), extramural (in particular, embodied) technological flows significantly contribute to increase the magnitude of the innovative output, *given that the firm is an innovator*. This result can be interpreted as evidence of a kind of complementary effect between R&D and extramural technological flows that differs from the usually considered link in the received literature. In this way, R&D seemingly contributes to increase the absorption capabilities of manufacturing firms.

In obtaining these results, controls for size, labor skills, exports, group and foreign ownership were included. The size of the firm has a positive effect on the probability of having an innovative output. However, size has a decreasing impact on the intensity of the innovative output (with a weak statistical significance). Labor skills have the expected positive signs in both steps of the estimation but no significance. Export activity during 1998-2001 only impacts the probability of having an innovative output. The results for these three variables are qualitatively similar to those obtained in the first two stages of the CDM model, but in general the statistical significance is considerably smaller in this stage. This is not the case with dummies for foreign ownership and group, which impact neither on the probability nor on the intensity of the innovative output.

The results also show that cooperation linkages have heterogeneous impact on the innovative output of manufacturing firms in Argentina. Interactions with research and training institutions,

[17]. This result generally holds when technological flows are measured either as continuous or dummy variables as well as for continuous or sporadic R&D performers.

suppliers and other firms have a significant impact only on the probability of launching new products, but not on the intensity of that activity. The opposite occurs when cooperation is undertaken within firms belonging to the same group. Linkages with clients or government agencies have no impact on the innovation output.

Regarding sectors, there are no differences in terms of the probability of becoming an innovator for firms operating in the different groups of industries above-mentioned. In turn, firms in natural resources intensive sectors, *ceteris paribus*, seem to have the highest innovation intensity *vis a vis* those operating in other sectors.

Firm performance

Finally, the OLS regression of sales per employee on the intensity of innovative output (both measured in 2001) yields a positive and significant effect of the latter on the former. In other words, being an innovator has a direct benefit for the firm: it contributes to improve its labor productivity in the period under analysis.

In addition to the standard controls usually considered in these regressions (such as proxies for physical and human capital, foreign ownership, group and sector) we have included the performance observed in 1998 as an additional regressor. This provides a simple way to account for (unobserved) historical factors that may cause differences among the firms' performances in 2001, which would be difficult to account for in other ways. For example, it is possible that some unobserved factors at the firm level that affected productivity in 1998 continue to do so in 2001. If some of them happen to be correlated with the intensity of the innovative output, it is unlikely to obtain unbiased estimates of the impact of the latter on productivity without including the lagged dependent variable. In fact, the positive and significant coefficient associated to the lagged productivity variable indicates that these unobserved factors are important determinants of productivity and that better performance in 1998 contributed to better performance in 2001.

Proxies for labor skills and physical capital have the expected positive impact on productivity. Export activity and being part of a group are not significant, but foreign ownership is, indicating that foreign firms are, *ceteris paribus*, more productive than domestic firms.

4. Concluding remarks

The results of the analyzed survey show that even in a very hostile scenario, a large number of Argentine manufacturing firms maintained their in house innovation activities (at the same time that they drastically cut their expenditures in embodied and disembodied technologies). This suggests that these firms consider that R&D activities are part of their routines and that are a valuable asset to be preserved even in bad times.

More notably, our exercise has shown that this effort seemingly has had a payoff. Performing R&D activities has a positive and statistically significant impact on a firm's probability of becoming an innovator (that is, of having sales of new or significantly improved products during the period under analysis). In turn, being an innovator has a positive impact on firms' productivity performance. In other words, firms carried out and preserved their R&D activities mainly for good microeconomic reasons.

In this regard, it is very relevant to take into account that only continuous R&D efforts have an impact on the intensity of the firm's innovative output, while discontinuous expenditures do not.

Hence, discontinuing in house R&D activities would have a negative influence on the results of those activities. This fact reminds us of the importance of considering that firms also learn to innovate and that this learning must be a continuous process to be effective.

As expected from the evidence already available on this subject, innovation activities by manufacturing firms in Argentina mainly take the form of technology acquisition (mostly in the form of machinery and equipment). Even if only R&D activities have a statistically significant impact on a firm's probability to become an innovator, at the same time, the acquisition of embodied technologies (specially when they are imported) has a positive and statistically significant influence on the intensity of the innovative output, being this influence much higher than that of performing R&D activities.

How can we construe these findings? On one hand, no evidence of complementarity or substitution between in house innovative activities and technology acquisition was found when following the methodology used in the received literature. However, it may be the case that in a country like Argentina R&D activities are needed to innovate, while technology acquisition defines the magnitude of the innovative output (in other words, this would be a different form of complementarity yet unexplored in the studies on this subject).

On the other hand, while R&D, as stated before, needs to be a permanent activity, firms may temporarily discontinue their technology acquisition expenditures in bad times without necessarily hurting their innovative possibilities. In other words, while learning is a continuous process, technology modernization may be a discrete process.

The rest of our results regarding the determinants of innovative inputs and outputs are mostly in line with those found in the received literature. Large firms are more prone to have innovation expenditures and outputs than small firms, but their innovative efforts are less intense (in terms of expenditures per employee). While belonging to a conglomerate does not seemingly have an impact on the firm's innovative behavior, foreign owned firms have higher probabilities of having expenditures in innovation activities.

The availability of skilled personnel has a positive impact both on the probability as well as on the intensity of the firm's innovative effort. In turn, exporting firms are more innovative than inward oriented ones. Enterprises operating in natural resources, scale or R&D intensive sectors are more prone to have innovation expenditures than those in labor-intensive branches. The intensity of innovation expenditures is also higher in the first three groups. The magnitude of the respective coefficients indicates that firms in R&D intensive sectors have the highest probability of expending in innovation and have the highest innovation expenditures per employee. In contrast, in terms of output the only difference among the four groups is that firms in natural resources intensive branches have the highest output intensity.

Finally, linkages with suppliers seem to be the most relevant among the interactions that firms establish with other agents and institutions for undertaking innovation activities and having innovative outputs. Relations with firms belonging to the same corporation also seem to be relevant for the intensity of both innovation expenditures and outputs.

Regarding the research agenda, to learn more about the determinants and impacts of the innovative behavior of Argentine manufacturing firms the following issues are important:

i) Given the sharp contrast between the scenarios in which the two innovation surveys were made in Argentina, it would be interesting to test the influence of the changing macroeconomic environment on the magnitude and impact of the innovative activities at firm level.

ii) Since the number of firms declaring to be innovators seems to be quite high, more research is needed on the scope and quality of the innovations introduced by Argentine manufacturing firms.

iii) The obstacles for the innovation process should be examined, paying special attention to the role of the access to finance in that regard.

iv) While we have found that some linkages within the NSI are relevant for the firms' innovative process, it would be important to learn more about the precise nature and impact of those linkages, considering specially the different role of domestic and international linkages.

v) More research is needed on the relations between domestic innovative efforts and the acquisition of technology and, within the latter, between embodied and disembodied technology inflows, as well as between foreign and domestic ones.

vi) During the period under analysis a number of policies were introduced in order to foster innovative activities in the private sector. Learning about the impact of those policies would be relevant in order to assess and, eventually, improve them.

Finally, since, as stated before, the methodology of the CIS, followed also in the Argentina's case, focus exclusively in product innovations, it would be useful to introduce in future surveys questions aimed at capturing process or organizational innovations, which can obviously be very relevant for firms' performance. This would allow a more complete picture of the determinants and impact of the innovative processes in Argentina.

Appendix

Table A.1 - Studies based on the CDM model. Source: Mairesse & Mohnen (2003).

Study	Individual Data	Endogenous variables	Estimation method	Other comments
Crepon-Duguet-Mairesse (1998)	France 1986-1990	R&D, patent (or share of innovative sales), labor productivity	ALS	Censored data for R&D
Duguet (2002)	France 1986-1990	Radical innovation, incremental innovation, TFP growth	FIML logit for innov., 2SLS or GMM for TFP growth	Separate estimation for various technological opportunities
Galia and Legros (2003)	France 1994-1996	R&D, innovation output, training, quality, profitability	ALS	Censored data for R&D and training, dichotomous data for quality; allows for feedback effects
Janz, Loof and Peters (2003)	Germany and Sweden, 1998-2000	Innovation expenditures/employee, innov. sales/employee, and sales/employee	FIML for gen. Tobit on innov. expend., other equations by 2SLS with correction for selection bias	Censored data for innovation expenditures; feedback effect from productivity on innov. output
Van Leeuwen-Klomp (2001)	Netherlands 1994-1996	Innovation input (R&D or innov. expend.), innovation output, productivity (in levels or growth rates)	OLS, 3SLS limited system, or 3SLS full system (with or without correction for selectivity)	Productivity measured by revenue per employee or value added per employee; feedback effect from revenues on innov. output
van Leeuwen (2002)	Netherlands Panel data from CIS2 and CIS2.5	R&D, innovation output, growth in revenue/employee	FIML gen. tobit for R&D or innovation output; separate FIML for growth of revenue/employee with correction for selection bias	Dynamic model for 1994-96 or pooled model for 1994-96 and 1996-98; innov. output measured by new sales or by new and improved sales.
Benavente (2002)	Chile	R&D, patent (or share of innovative sales), labor productivity	ALS	Censored data for R&D
Loof and Heshmati (2002a)	Sweden	Innov. expend. per employee, innovative sales per employee, and value added per employee	FIML for generalized Tobit on innov. expend., other equations by 2SLS with correction for selection bias	Also estimated with only radical innovations; productivity estimated in levels and growth rates; feedback effect from productivity on innov. output
Loof and Heshmati (2002b)	Sweden	Innov. expend. per employee, innovative sales per employee, and labor productivity	FIML for gen. Tobit for innov. input, other equations by 3SLS with correction for selection bias	Labor productivity measured as innov. sales/employee or value added/employee; feedback effect from productivity on innov. output
Loof Heshmati, Apslund and Naas (2002)	Finland, Norway and Sweden 1994-1996	Innov. expend./employee, innovative sales/employee, and labor productivity	FIML for gen. Tobit for innov. input, other equations by 2SLS and 3SLS with correction for selection bias	Estimation for all innovations and for radical innovations; feedback effect from productivity on innov. output
Jefferson, Huamao, Xioajing and Xiaoyun (2002)	China Panel data 1995-1999	R&D, share of innovative sales, productivity (or profitability)	Separate estimation of each equation by OLS and IV	Square term on innovative sales
Parisi, Schiantarelli and Sembenelli (2002)	Italy, Panel data 1992-1994 and 1997-1995	Labor productivity growth, product innovation, process innovation Product and process innovations estimated by logit or conditional logit, product. growth estimated by IV		
Hu and Jefferson (2003b)	China (Beijing area) 1991-1997	R&D, output and profit Individual and SURE estimation of 2 or 3 equations with correction for selection bias		

The Econometric model

Two standard sample selection models for innovation expenditures and innovative output were estimated by the maximum likelihood procedure. The model and the assumptions needed for the estimation are:

regression equation: $y_i = X_i\beta + u_{1i}$

selection equation: $s_i = 1[Z_i\gamma + u_2 \geq 0]$

X_i and Z_i are vectors of control variables and $1[*] = 1$ if $*$ is true and 0 otherwise.
Furthermore, $u_1 \sim N(0, sigma)$, $u_2 \sim N(0,1)$ and $corr(u_1, u_2) = rho$

Each sample selection model consists of two equations. The selection equation estimates the probability of observing a strictly positive value of the dependent variables under analysis. The regression equation estimates the intensity of the latter, using the observations for which those variables are strictly positive. Therefore, the selection equation of a first sample selection model estimates the first stage of the CDM model (i.e., the probability of having positive innovation expenditures) while its regression equation estimates the intensity of those innovation expenditures (second stage of the CDM), given that the firm has positive expenditures. In turn, the second sample selection model estimates the probability of innovating (through its selection equation) and the intensity of the innovative output (through the regression equation -third stage of the CDM model-), given that the firm is an innovator.

Finally, as mentioned in section 3, the final stage of the CDM model involves the ordinary least squares (OLS) estimation of the impact of the innovative output on the performance of the firm. The regression is based on the standard linear model and its usual assumptions, except that robust standard errors are calculated to avoid heteroskedasticity in the disturbance term.

Definition of variables

The definitions of the variables used in the econometric regressions are found in the following table (parenthesis refer to the names of the variables as they appear in the tables of econometric results, see below).

Table A.2 – Definition of variables

VARIABLE	DEFINITION
Innovation expenditures (lginn)	Yearly average of total expenditure in innovation activities during 1998-2001, per employee in 2001 (log)
Innovative sales (vinntotL and lvinn when measured in log)	Sales in 2001 accounted by new or improved products developed during 1998-2001, in terms of total employees in 2001 (measured in logarithm when regressed in the innovative output intensity equation)
Sginn	Dependent dummy variable in the selection equation for innovation expenditures. Equal to one if the firm reported positive innovation expenditures throughout 1998-2001
Sinn	Dependent dummy variable in the selection equation for innovative sales. Equal to one if the firm reported positive innovative sales in 2001

Productivity in 2001 (lprod01)	Sales of own products per employee in 2001 (log)
Productivity in 1998 (lprod98)	Sales of own products per employee in 1998 (log)
Size (lsize01)	Number of total employees in 2001 (log)
Foreign (IED10)	Dummy equal to one if foreign capital share is equal or greater than 10%
Qualified labor (Lcalprom)	Average share of technical and professional labor between 1998 and 2001
Investment in capital goods (Ikprom)	Average investment in capital goods between 1998 and 2001, in terms of total employee in 2001.
Group	Dummy equal to one if the firm is part of a group
Exports (expo)	Dummy equal to one if the firm exported in 1998 and in 2001
Research and development (RD)	Yearly average during 1998-2001 per employee in 2001
Rddummy	Dummy equal to one if the firm reported positive R&D expenditures during 1998-2001
Rdcont	Dummy equal to one if the firm reported positive R&D expenditures in every year during 1998-2001
RDRDdummy	Interaction term between R&D and RDdummy
RDRDcont	Interaction term between R&D and RDcont
Domestic embodied technology (TDinc)	Yearly average during 1998-2001 per employee in 2001
Domestic disembodied technology (TDdesin)	Yearly average during 1998-2001 per employee in 2001
Imported embodied technology (TMinc)	Yearly average during 1998-2001 per employee in 2001
Imported disembodied technology (TMdesin)	Yearly average during 1998-2001 per employee in 2001
RDTMinc	Interaction term between R&D and Imported embodied technology
RDTMdesi	Interaction term between R&D and Imported disembodied technology
RDTDinc	Interaction term between R&D and Domestic embodied technology
RDTDdesi	Interaction term between R&D and Domestic disembodied technology
Clients (cli)	Dummy equal to one when firm reports cooperation linkages with clients during 1998-2001
Suppliers (pro)	Dummy equal to one when firm reports cooperation linkages with suppliers during 1998-2001
Research and training institutions (cif)	Dummy equal to one when firm reports cooperation linkages with such institutions during 1998-2001
Government agencies (gov)	Dummy equal to one when firm reports cooperation linkages with government agencies during 1998-2001
Other firms (other)	Dummy equal to one when firm reports cooperation linkages with consultants and other firms during 1998-2001
Group linkages (vincgrup)	Dummy equal to one when firm reports cooperation linkages with firms of its group during 1998-2001
SectRN	Dummy equal to one if the firm belongs to the natural resources intensive sector*
SectRD	Dummy equal to one if the firm belongs to the R&D intensive sector*
SectESC	Dummy equal to one if the firm belongs to the scale intensive sector*
SectL	Dummy equal to one if the firm belongs to the labor intensive sector*

* This classification was developed by Pavitt (1984) and later adapted by Guerrieri and Milana (1989) and Guerrieri (1992).

Tables of the Econometric results

Table A.3 – Sample selection model for innovation expenditures – Maximum likelihood estimation

						Number of obs=1243
						Uncensored obs=784
						Censored obs=459
						Wald chi2(20)=394.04
Log likelihood =-2278.32						Prob > chi2=0
	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
Regression equation. Dependent variable: lginn						
lsize01	-0.065645	0.0456197	-1.439	0.15	-0.1550578	0.0237679
IED10	0.0789756	0.2013202	0.392	0.695	-0.3156047	0.473556
Lcalprom	0.9731824	0.2219832	4.384	0	0.5381033	1.408262
expo	0.3718793	0.1444149	2.575	0.01	0.0888314	0.6549273
Group	-0.0359815	0.1684154	-0.214	0.831	-0.3660697	0.2941067
SNIcif	0.0783355	0.142535	0.55	0.583	-0.2010279	0.3576989
SNIpro	0.2484863	0.1496912	1.66	0.097	-0.044903	0.5418756
SNIcli	-0.0567052	0.1415221	-0.401	0.689	-0.3340834	0.220673
SNIother	0.2584674	0.152005	1.7	0.089	-0.039457	0.5563918
SNIvincgrup	-0.078548	0.1607025	-0.489	0.625	-0.3935191	0.2364231
SNIgov	0.2957047	0.1980791	1.493	0.135	-0.0925233	0.6839326
Excif	-0.1663691	0.1780513	-0.934	0.35	-0.5153431	0.182605
Expro	0.8743997	0.1362715	6.417	0	0.6073124	1.141487
Excli	-0.4400055	0.16144	-2.726	0.006	-0.7564221	-0.123589
EXvincgrup	0.4721654	0.1985988	2.377	0.017	0.082919	0.8614118
Exother	0.4589708	0.1678093	2.735	0.006	0.1300706	0.7878711
EXgov	0.093887	0.5815633	0.161	0.872	-1.045956	1.23373
sectRN	0.4969156	0.179477	2.769	0.006	0.1451471	0.848684
sectRD	0.6002023	0.2105182	2.851	0.004	0.1875941	1.012811
sectESC	0.5044764	0.1783325	2.829	0.005	0.1549511	0.8540017
_cons	3.625803	.	.	.	.	.
Selection equation. Dependent variable: sginn						
lsize01	0.2277415	0.0385196	5.912	0	0.1522444	0.3032386
IED10	0.2502876	0.1207769	2.072	0.038	0.0135692	0.4870059
Lcalprom	0.4513213	0.1535648	2.939	0.003	0.1503399	0.7523026
expo	0.2251112	0.0839414	2.682	0.007	0.0605891	0.3896332
Group	0.0310368	0.1030838	0.301	0.763	-0.1710037	0.2330772
sectRN	0.1136436	0.1001161	1.135	0.256	-0.0825805	0.3098676
sectRD	0.3376506	0.1320788	2.556	0.011	0.0787809	0.5965203
sectESC	0.1982012	0.1035804	1.914	0.056	-0.0048126	0.4012151
_cons	-1.111463	0.1716418	-6.475	0	-1.447874	-0.775051
/athrho	-0.038375	0.1433048	-0.268	0.789	-0.3192472	0.2424972
/lnsigma	0.5340245	0.0305224	17.496	0	0.4742017	0.5938473
rho	-0.0383562	0.1430939			-0.3088261	0.237853
sigma	1.705783	0.0520646			1.606731	1.810942
lambda	-0.0654273	0.244063			-0.543782	0.4129273
Wald test of independent equations (rho = 0): chi2(1) = 0.07. Prob > chi2 = 0.7889						

Note: SNI and EX refer to domestic and foreign linkages of cooperation, respectively.

Table A.4 – Sample selection model for innovative sales – Maximum likelihood estimation

Number of obs=1243
Uncensored obs=557
Censored obs=686
Wald chi2(24)=132.11
Log likelihood = -1584.686 Prob > chi2=0

	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
Regression equation. Dependent variable: lvinn						
lsize01	-0.0939784	0.0590798	-1.591	0.112	-0.2097727	0.0218158
IED10	0.2456698	0.170712	1.439	0.15	-0.0889195	0.5802591
group	0.0898485	0.1530003	0.587	0.557	-0.2100265	0.3897235
Lcalprom	0.353688	0.2245606	1.575	0.115	-0.0864428	0.7938187
Expo	0.0790765	0.126677	0.624	0.532	-0.1692059	0.3273588
RDRDdu	-0.0000282	0.0002435	-0.116	0.908	-0.0005054	0.000449
RDRDcont	0.0000522	0.0000193	2.7	0.007	0.0000143	0.0000901
Tdinc	0.0000836	0.0000244	3.424	0.001	0.0000358	0.0001315
TMinc	0.0001702	0.0000516	3.3	0.001	0.0000691	0.0002713
TDdesinc	0.0000235	0.0000327	0.717	0.473	-0.0000407	0.0000876
TMdesinc	-0.0001893	0.0003069	-0.617	0.537	-0.0007908	0.0004122
RDTMinc	-4.45E-08	3.41E-08	-1.305	0.192	-1.11E-07	2.23E-08
RDTMdesi	1.55E-07	4.37E-07	0.355	0.723	-7.01E-07	1.01E-06
RDTDinc	2.07E-08	2.24E-08	0.923	0.356	-2.32E-08	6.46E-08
RDTDdesi	1.47E-08	1.95E-08	0.751	0.452	-2.36E-08	5.29E-08
Cif	-0.0025251	0.1395121	-0.018	0.986	-0.2759638	0.2709137
Pro	0.0111035	0.1443566	0.077	0.939	-0.2718303	0.2940372
Cli	-0.0031703	0.132556	-0.024	0.981	-0.2629753	0.2566347
vincgrup	0.3457916	0.155254	2.227	0.026	0.0414993	0.6500839
Other	-0.1260586	0.1334435	-0.945	0.345	-0.3876031	0.1354859
Gov	-0.1618861	0.1916792	-0.845	0.398	-0.5375704	0.2137983
sectRN	0.3236378	0.1731108	1.87	0.062	-0.015653	0.6629287
sectRD	0.1089543	0.1800476	0.605	0.545	-0.2439325	0.461841
sectESC	0.2305564	0.1557675	1.48	0.139	-0.0747422	0.535855
_cons	9.953453	0.3862412	25.77	0	9.196435	10.71047
Selection equation. Dependent variable: sinn						
lsize01	0.0579381	0.041248	1.405	0.16	-0.0229064	0.1387827
IED10	0.0321925	0.1264186	0.255	0.799	-0.2155834	0.2799683
Group	0.0553628	0.1117319	0.495	0.62	-0.1636278	0.2743534
Lcalprom	0.1490036	0.1615041	0.923	0.356	-0.1675386	0.4655458
Expo	0.2597566	0.0917628	2.831	0.005	0.0799048	0.4396084
RDdummy	0.8106719	0.124663	6.503	0	0.5663368	1.055007
RDcont	1.1929	0.1223264	9.752	0	0.9531445	1.432655
Tdinc	2.52E-06	0.0000277	0.091	0.928	-0.0000518	0.0000569
Tminc	-1.59E-06	0.0000485	-0.033	0.974	-0.0000966	0.0000935
TDdesin	0.0000528	0.0000418	1.262	0.207	-0.0000292	0.0001347
TMdesin	0.0008109	0.0005229	1.551	0.121	-0.0002139	0.0018358
RDTMinc	1.21E-07	1.23E-07	0.98	0.327	-1.21E-07	3.62E-07
RDTMdesi	-1.40E-06	7.31E-07	-1.922	0.055	-2.84E-06	2.80E-08
RDTDinc	1.12E-07	1.30E-07	0.859	0.39	-1.43E-07	3.66E-07
RDTDdesi	7.94E-08	7.47E-08	1.064	0.287	-6.69E-08	2.26E-07
Cif	0.2546278	0.0954357	2.668	0.008	0.0675773	0.4416784
Pro	0.2502382	0.1060508	2.36	0.018	0.0423824	0.458094
Cli	0.0617085	0.1054204	0.585	0.558	-0.1449117	0.2683288
vincgrup	0.0499074	0.1203978	0.415	0.678	-0.1860679	0.2858827
Other	0.169556	0.0974197	1.74	0.082	-0.0213831	0.3604952
Gov	0.1372758	0.1693381	0.811	0.418	-0.1946208	0.4691724

sectRN	-0.1606069	0.1132194	-1.419	0.156	-0.3825128	0.0612991
sectRD	-0.0231686	0.1438184	-0.161	0.872	-0.3050474	0.2587103
sectESC	0.0507517	0.1147647	0.442	0.658	-0.1741829	0.2756863
_cons	-1.292799	0.182247	-7.094	0	-1.649996	-0.9356009
/athrho	0.0678018	0.1229416	0.551	0.581	-0.1731592	0.3087629
/lnsigma	0.259254	0.0418743	6.191	0	0.1771819	0.3413261
rho	0.0676981	0.1223781			-0.1714491	0.2993112
sigma	1.295963	0.0542675			1.193848	1.406812
lambda	0.0877343	0.1591777			-0.2242484	0.3997169
Wald test of independent equations (rho = 0): chi2(1) = 0.30. Prob > chi2 = 0.5813						

Table A5 – OLS regression (with robust standard errors) on productivity

Number of obs=1242
F(11, 1230)=117.45
Prob > F=0
R-squared=06869
Root MSE=0.56212

	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
Dependent variable: lprod01						
vinntotL	1.62E-07	6.44E-08	2.521	0.012	3.60E-08	2.89E-07
expo	0.0059055	0.0336162	0.176	0.861	-0.0600458	0.0718569
Lcalprom	0.2211708	0.0585892	3.775	0	0.1062249	0.3361166
group	0.0803017	0.0517876	1.551	0.121	-0.0213001	0.1819034
lsize01	0.0293335	0.0171541	1.71	0.088	-0.004321	0.062988
IED10	0.0893067	0.0486721	1.835	0.067	-0.0061829	0.1847963
IKprom	1.07E-06	5.76E-07	1.861	0.063	-5.80E-08	2.20E-06
lprod98	0.7888365	0.0403628	19.544	0	0.709649	0.868024
sectRN	0.2839261	0.0478355	5.935	0	0.190078	0.3777743
sectRD	0.1357863	0.0566632	2.396	0.017	0.0246192	0.2469535
sectESC	0.1518241	0.0467544	3.247	0.001	0.0600969	0.2435512
_cons	1.749065	0.4267009	4.099	0	0.9119224	2.586207

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