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Abstract[1]

This paper adapts the Crepon, Duguet, and Mairesse (1998) approach to estimate the relationship between innovation and productivity and the realities of innovative activities in developing countries. Panel data for Argentina during the period 1998-2004 to estimate a structural model in which different types of firms' innovative behavior—including in-house activities and the incorporation of external technologies—feeds into the probability of achieving successful results in product and process innovation, which in turn explains labor productivity. The endogeneity of this three-stage process is controlled for. The results suggest that all types of innovative activities are relevant to explain success in product and process innovation, and both are important factors to explain labor productivity. Moreover, investing systematically in R&D implies an extra payoff in labor productivity. These results suggest that investing in different types of innovative activities—and not only in R&D—and doing in-house activities systematically contribute to firms' innovative and economic performance.

JEL Codes: O33, O14, O12
Keywords: Innovation, Productivity, Argentina

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1. Introduction

There is one element of the Argentine national innovation system which has remained constant over time: the volatility of the macroeconomic environment, which complicates attempts to calculate the return on investment in innovation. In the 1990s, relying on a currency-board regime, Argentine GDP per capita grew at an annual rate of 3 percent. However, growth was uneven. The economy was affected by the Tequila crisis in 1995 and entered a recession period after the Russian and Brazilian crises of 1998-99, culminating in one of the major crises of Argentine history at the end of 2001. Since 2003 and until 2009, the economy has experienced rapid growth (of around 8 percent), led predominantly by commodity prices and the price-competitiveness of national production enhanced by the exchange rate policy. However, inflation became progressively an issue of concern, and internal political struggles, together with the international crisis of 2008-09, increased the level of uncertainty in the country.

The last two decades clearly illustrate what the literature has claimed about volatility and abrupt changes in Argentine policy regimes. This historically unstable setting might have created a general lack of confidence in the sustainability of any existing policy regime, which could, in turn, explain firms' defensive or short-term practices.[2] In this context, it is worth researching whether there is a payoff for firms that pursue longer-term strategies such as improving their capacity for innovation.

In a recent paper, Lugones, Suárez, and Moldovan (2008) claim that most Argentine firms not only survive but also manage to become innovators without necessarily following long-term innovation strategies (i.e., without committing significant resources to innovation or doing so only sporadically). However, as the authors acknowledge, this cannot be generalized; there are also some other firms (a minority group of 8 percent of their sample) that do commit to innovation and achieve better results in terms of productivity.

There are success stories of firms committed to long-term strategies. For example, the Inter-American Development Bank (IDB) funded research on export discoveries highlighted some successful cases of firms that that relied on their internal capabilities and their connections in global value chains to actively discover new export opportunities. Successful cases were

[2] See for example Arza (2005b), Fanelli and Frenkel (1996), Kosacoff (1996, Kosacoff and López, 2002, Kosacoff, 2000, Porta, 1996

reported by Artopoulos et al. (2010) in the areas of wood furniture, ships, and TV programming and by Sánchez et al. (2008) in blueberries, chocolate, and biotechnology for human health.

These examples from the literature underscore the prevalence of heterogeneity in Argentine firms' behavior.[3] Our research attempts to identify the main determinants of firms' innovative behavior and to assess the effect of different innovation activities on productivity. We propose a structural model using panel data techniques. The aim is to analyze the relationship between different innovation activities, innovation in products and processes, and labor productivity.

We believe that one of the shortcomings of the existing literature is that only R&D is generally considered as the relevant knowledge input, while other efforts in innovation are neglected. To overcome this drawback, we considered different inputs of innovation in our structural models, including *in-house activities* (R&D and industrial engineering and design) and the incorporation of technologies produced by *external sources.* The latter are threefold: i) technologies embodied in machinery, ii) intangible technologies, and iii) information and communication technologies (ICT). In order to assess whether firms committed to long-term innovative activities received an extra payoff in terms of economic performance, we evaluated whether systematic efforts in R&D have an independent effect on labor productivity

We found that increasing the intensity of all four types of innovative activities increases the probability of producing innovative outputs. In particular, in-house activities are relatively more relevant for product innovation, while investment in embodied technologies is relatively more relevant for process innovation. We found that both innovative outputs are conducive to increasing labor productivity, with the effect of process innovation being a bit stronger. Finally, we found that systematic efforts in long-term, in-house R&D were economically rewarding.

The paper is organized into seven sections. Section 2 presents the conceptual framework. Section 3 contextualizes our study by presenting some indicators of the evolution of the Argentine economy during the period under analysis, aiming at showing the intensity of macroeconomic and structural shocks to which firms were exposed. Section 4 presents the models and the data. Section 5 illustrates our main variables with descriptive statistics from innovation surveys. Section 6 discusses the econometric results, and Section 7 concludes.

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[3] Some assessments on firms' heterogeneous innovative behavior in Argentina can be found in: Arza (2005a), Chudnovsky et al. (2006), Lugones et al. (2008), and Marin (2006).

2. Conceptual Framework: Adapting the CDM to Developing Countries

To empirically estimate the structural system, we will adapt the framework created by Crepon, Duguet and Mairessec (1998), henceforth referred to as CDM.

The CDM framework proposes an interdependent relationship between investment in R&D, innovative outputs, and firms' performance. This framework has been adopted by many scholars analyzing the direct and indirect impacts of innovative activities.[4]

In developing countries, and particularly in Latin America, evidence of the effect of innovation on performance is more scattered and usually rather descriptive or based on simple regression analysis. In the Argentine case, the issues more often tackled in the literature regarding innovation and economic performance are related to: insufficient commitment to long-term innovative activities,[5] unsatisfactory structural change which went against knowledge-intensive activities,[6] the role of multinational corporations (MNCs) in enhancing innovation, productivity and competitiveness,[7] and classifying innovative activities and assessing their effectiveness.[8]

The CDM framework has been used very rarely used in developing countries. Some exceptions attempting to account for simultaneity in the relation between innovation and performance are worth mentioning:

1. Jefferson et al. (2006) used Chinese panel data to estimate the impact of R&D in terms of productivity and profitability. The paper establishes a lag structure to offset simultaneity biases and corrects for endogeneity. The authors found that R&D has a positive effect on both profitability and productivity.
2. Antoncic et al. (2007) used a structural equation framework on cross-sectional data for Slovenia and Romania to test hypotheses about the positive impact of organizational support and alliances on innovativeness and, in turn, a positive

[4] See for example Benavente, 2006, Duguet, 2006, Galia and Legros, 2004, Griffith et al., 2006, Jefferson et al., 2006, Lööf and Heshamti, 2006, Lööf and Heshmati, 2002, Lööf et al., 2001, Parisi et al., 2006, van Leeuwen, 2002, etc.
[5] Arza, 2005b, Lugones et al., 2008.
[6] Katz, 2001, Katz and Stumpo, 2001.
[7] Arza and López, 2008, Chudnovsky and López, 2001, Marin, 2006, Marin and Bell, 2005.
[8] Lugones et al., 2006, Lugones, Suárez and Le Clech, 2007.

impact of innovativeness on firms' performance (measured by growth, profitability, and wealth). They found empirical support for their hypotheses.

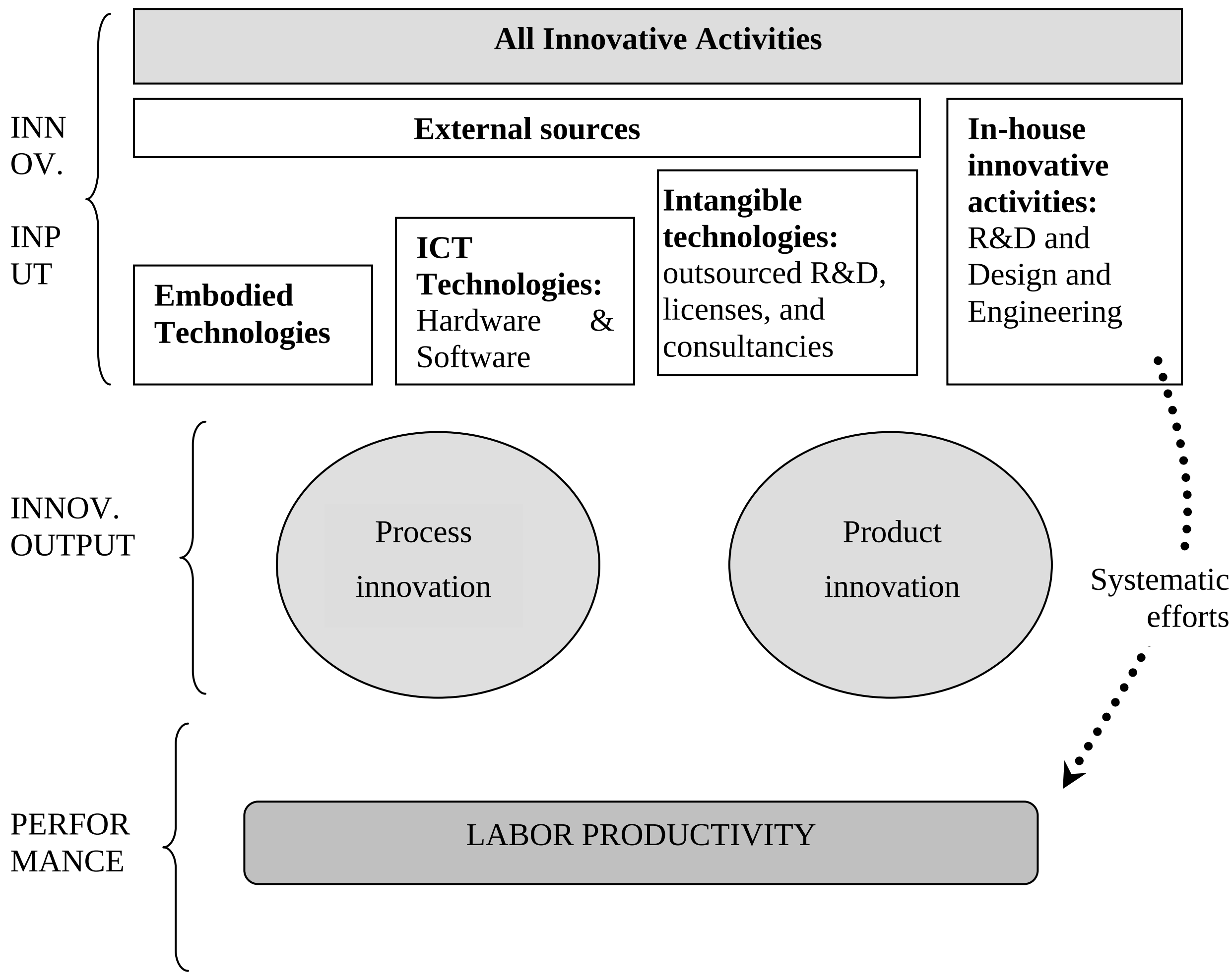
3. Benavente (2006) applied an adapted version of the CDM framework using Chilean cross-sectional data and found that neither R&D nor innovative results (share of innovative sales) have an effect on productivity (measured as value added per worker).

For the Argentine case, Chudnovsky, López, and Pupato (2006) applied a modified version for the CDM framework using data from two consecutive innovation surveys covering the period 1992-2001. They showed that R&D performers had better chances of becoming innovators who, in turn, perform better in terms of labor productivity than non-innovators. The paper estimated each equation of the CDM system separately. Their results, therefore, might be affected by simultaneity biases.

We believe that one of the shortcomings of the existing literature is that it is narrowly focused on in-house R&D activities, while most efforts to innovate in developing countries are not in-house or R&D related. In our sample, only 25 percent of firms performed R&D in at least one year during the period 1998-2004 and only 9 percent pursued R&D on a continuous basis. Therefore, we propose an adapted version of the CDM framework to account for different types of innovative activities, which is represented in Figure 1.

Rather than just considering R&D activities, we also include other innovative activities as explanatory variables for product and process innovation. We identified two main groups of innovative activities: those produced by external sources and those carried out internally in firms. Three types of external sources were identified: technologies embodied in equipment, intangible technologies, and ICT technologies.

Figure 1. Conceptual Framework, Adapted from CDM



Source: Authors' compilation based on Crepon, Duguet, and Mairesse (1998).

While it may be understandable that studies for developed countries do not emphasize technology acquired from external sources 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 we indicated in the introduction, besides analyzing heterogeneity in innovative behavior, we are also interested in assessing whether there is an extra payoff, in terms of labor productivity, for firms that are systematically involved in long-term in-house activities. It is believed that in-house activities increases firms' absorptive capacity (Cohen and Levinthal, 1990), which improves their capacity to make the most of every technological opportunity that arises.

In sum, our hypotheses are the following:

H1: All types of innovative activities matter for achieving product and process innovation, which in turn increases labor productivity.

H2: There is an extra payoff, in terms of labor productivity, for firms that are systematically involved in in-house innovative activities.

The next section illustrates with macro and sectoral data the level of fluctuations in the Argentine context during the period analyzed in this study.

3. The Argentine Context

3.1. The Convertibility Period (1991-2001)

The structural reform policies carried out in the 1990s in Argentina were part of a stabilization program. Motivated by episodes of hyperinflation in the late 1980s, the stabilization relied heavily on the exchange rate as nominal anchor. The structural reforms, in tune with the Washington Consensus, included trade liberalization, privatization of public enterprises, and deregulation of many activities. They pursued allocative efficiency and relief to the financial needs of the public sector.

The combination of these measures set up an incentive structure against the production of tradable goods, shifting the country's productive specialization towards the exploitation of natural competitive advantages, linked to agriculture (also food-related products), oil and mining, and services. Industrial policy remained generally horizontal (with the important exception of the automotive sector), sympathetic to the idea of not distorting market mechanisms.

In order to rebuild the eroded profitability of the industry without changing the exchange rate regime, public policy primarily used “fiscal devaluation” while the private sector re-organized production. Productivity grew in the vast majority of firms due to the reduction of jobs and the intensification of the labor process. However, there were still some that upgraded their production system by incorporating imported capital equipment. The differential behavior across firms deepened heterogeneity in the productive structure; however technical change and productivity growth were usually explained by external sources. Although there were niches of production close to international state of the art, the abovementioned dynamics led to a significant weakening of the industrial sector as a whole, with small and medium firms being the most affected.

These dynamics of modernization and replacement of local suppliers by imports as a result of the opening of the production function led to a sharp weakening of the local productive system. The impact on the labor market was undeniable: the unemployment rate grew steadily, reaching record levels after a brief crisis of 1995.

3.2. After Convertibility (2002-2009)

Argentina's economy could not cope with the international scene that followed the East Asian crisis in 1997 and the Russian crisis a year later. The abrupt interruption in capital flows to emerging nations as a result of the Russian default put a halt to GDP growth, leading to an economic recession that lasted until the end of the decade. Capital flows definitely stopped in the second half of 2001, when a bank run triggered capital flight. Social unrest together with unpopular measures to contain capital flight (*corralito*) prompted a social and massive mobilization that ended the mandate of President de la Rúa in December 2001. The devaluation of early 2002 took place in a context of economic, social, and political crisis without precedent in Argentine history. The decrease in the level of activity had a strong impact on the unemployment rate, which climbed to 22 percent, while the price increase that followed the devaluation produced a sharp decline in the real income of a large part of the population.

The recovery process began in a situation of largely idle production capacity due to the deep slump in economic activity produced by the crisis. Moreover, the recession partly contained expectations of inflation, and the effect of devaluation on prices was modest.

The elastic response of physical production is explained by the exceptionally high profit margins—wages recover late and very slowly—and the stabilization of the exchange rate after the devaluation.

The change in relative prices redefined the production structures towards labor-intensive tradable goods. The manufacturing industry grew at higher rates than the overall economy throughout the expansion phase 2002-2008: in constant terms, while the manufacturing sector grew at average annual rate of 11.3 percent (Table 1, col. III). the whole economy grew at an average annual rate of 8.5 percent. In contrast, the average annual growth rate of the manufacturing sector during the Convertibility Period (1991-2001) had been 1.3 percent (Table 1, col. I).

Table 1 Average Growth Rates of Gross Value of Manufacturing Production Measured in Constant (1997) Pesos

	Average annual growth (percent)			
ISIC Rev. 3	**1991-2001 (I)**	**1998-2001 (II)**	**2002-2008 (III)**	**2002-2004 (IV)**
Manufacturing	1.3	-6.4	11.3	11.4
Food products and beverages	2.7	-2.4	9.1	13.0
Tobacco products	0.8	-2.6	4.9	5.6
Textiles	-5.9	-15.9	8.2	14.5
Wearing apparel; dressing and dyeing of fur	-2.2	-10.1	7.9	4.5
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	2.9	-6.6	12.7	20.6
Wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	2.0	-8.0	8.2	20.1
Paper and paper products	3.5	-2.1	7.0	5.6
Publishing, printing and reproduction of recorded media	4.9	-6.6	9.7	10.2
Coke, refined petroleum products and nuclear fuel	0.3	-2.7	11.0	11.7
Chemicals and chemical products	2.6	-2.3	6.3	6.6
Rubber and plastics products	6.7	-1.8	7.7	9.4
Other non-metallic mineral products	-0.7	-11.8	12.6	13.2
Basic metals	0.6	-5.4	11.2	12.6
Fabricated metal products, except machinery and equipment	-2.4	-9.3	9.4	10.5
Machinery and equipment n.e.c.	-2.9	-10.9	14.2	21.1
Office, accounting and computing machinery	-3.7	-0.3	8.6	6.6
Electrical machinery and apparatus n.e.c.	-2.6	-9.0	12.1	18.7
Radio, television and communication equipment and apparatus	7.4	-10.8	25.6	40.3
Medical, precision and optical instruments, watches and clocks	-6.3	-10.6	17.6	23.1
Motor vehicles, trailers and semi-trailers	8.4	-15.2	13.0	15.0
Other transport equipment	-10.5	-14.2	8.0	16.8
Furniture; manufacturing n.e.c.	4.3	-13.0	2.5	0.8

Source: Center of Production Studies (CEP), Ministry of the Economy, Argentina.

Moreover, the devaluation of the exchange rate pushed exports, which grew for most sectors as can be seen in Table 2, col. III. For the manufacturing sector as a whole, the average growth rate between 2002 and 2008 was 16.3 percent. Moreover, while the export coefficient was 27.3 percent in 2007, it had been 14.3 percent in 1997, the peak year of the Convertibility period.

Table 2. Average Growth Rates of Exports Measured in US Dollars

	Average annual growth (percent)			
ISIC Rev. 3	**1992-2001 (I)**	**1998-2001 (II)**	**2002-2008 (III)**	**2002-2004 (IV)**
Manufacturing	8.1	-1.0	16.3	12.0
Food products and beverages	5.2	-4.9	18.8	16.9
Tobacco products	179.7	-13.5	18.8	2.0
Textiles	4.0	-7.0	8.9	7.9
Wearing apparel; dressing and dyeing of fur	5.7	-12.6	8.5	7.2
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	4.9	-5.4	2.9	3.6
Wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	26.5	-9.4	26.3	60.7
Paper and paper products	19.3	0.1	10.8	15.2
Publishing, printing and reproduction of recorded media	17.3	-0.8	3.1	-1.4
Coke, refined petroleum products and nuclear fuel	13.1	20.5	15.5	22.6
Chemicals and chemical products	12.0	8.4	15.7	12.1
Rubber and plastics products	50.3	-5.3	20.5	17.4
Other non-metallic mineral products	3.5	-6.8	13.2	13.3
Basic metals	7.4	5.5	16.2	6.9
Fabricated metal products, except machinery and equipment	8.4	-3.2	18.2	9.5
Machinery and equipment n.e.c.	10.7	4.2	14.5	-2.1
Office, accounting and computing machinery	-9.2	7.8	-1.0	-10.5
Electrical machinery and apparatus n.e.c.	28.5	1.4	10.5	-2.7
Radio, television and communication equipment and apparatus	33.7	-7.4	14.9	2.8
Medical, precision and optical instruments, watches and clocks	39.1	14.1	14.0	11.2
Motor vehicles, trailers and semi-trailers	62.7	-16.1	33.3	39.7
Other transport equipment	89.1	-2.5	64.9	115.9
Furniture; manufacturing n.e.c.	43.2	16.5	-4.1	-6.1

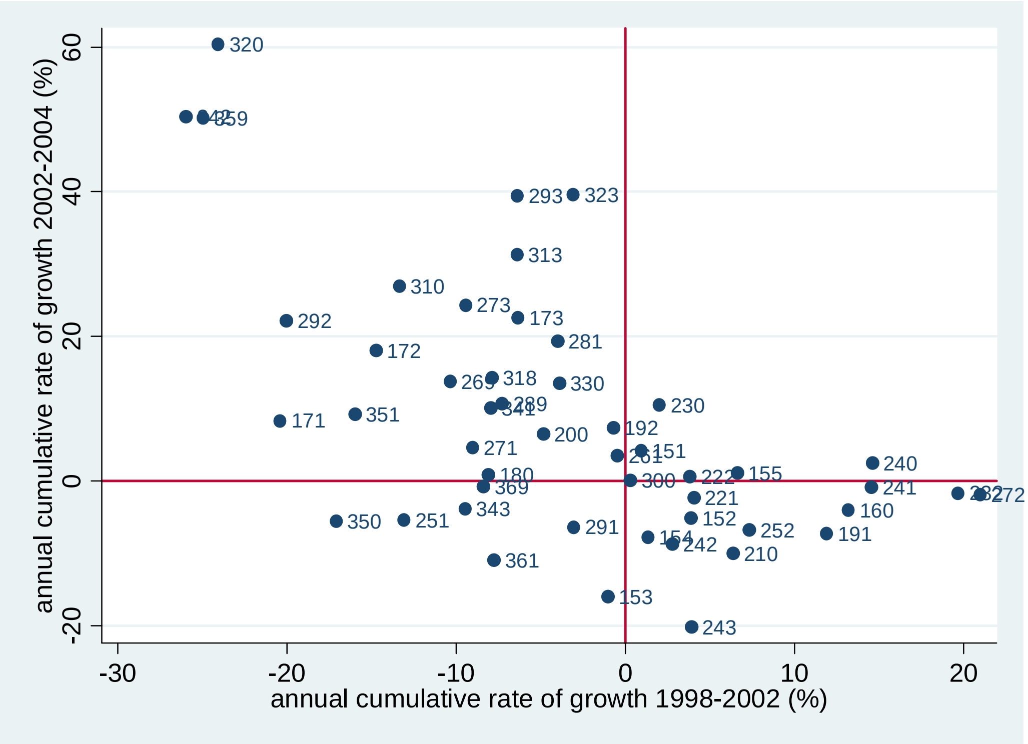
Source: Center of Production Studies (CEP), Ministry of the Economy, Argentina.

The sub-periods within the different macroeconomic regimes studied in this paper (1998-2001 and 2002-2004), comprise, in terms of economic growth, the worst part of Convertibility and the best part of the new regime, although 2002 was still a recession year and economic expansion continued until 2008. For example, the rate of growth for the manufacturing sector as a whole, in constant terms, was -11.6 percent for 2001 and 27 percent for 2003.

As seen in Table 1, most sectors grew as a result of leaving Convertibility behind. However, the dynamics across sectors differed. In general, those sectors that had lost participation in manufacturing activity during the recession and crisis period (1998-2002), gained participation in the first years after devaluation (2002-2004). This is noticeable in Figure 2, which depicts cumulative growth rates in the share of each sector in total manufacturing over the two periods: 2002-2004 (horizontal axis), and 1998-2002 (vertical axis). The negative slope of the clouds of sectors suggests that those that gained share were among those that had lost share during the recession and crisis.

As a result of these changes, the sectoral structure between peak years of the Convertibility regime and the new one (1997 vs. 2007) was not dramatically different (Table 3). Some changes nevertheless deserve further attention. First, there was a very important increase in the weight of basic metals in value added, which is mostly explained by the increase in prices. Second, there was a decrease in the share of the oil sector, mainly due to internal price controls which retarded physical growth in this sector in comparison to total manufacturing. Third, technology-intensive sectors such as machinery and the automobile industry gained share in value added. In exports, the structure was quite similar, led by food products, automobile, oil, and chemicals.

Figure 2. Evolution of Shares in Total Manufacturing of All 3-Digit Sectors



Source: Center of Production Studies (CEP), Ministry of the Economy, Argentina.

Table 3. Sectoral Shares in Manufacturing Current Value Added and Exports, for Peak Years 1997 and 2007

Sectors	Shares (percent)					
	Value added			Exports		
	1997	2007	growth	1997	2007	growth
Manufacturing	100	100		100	100	
Food products and beverages	20.71	25.28	22 percent	41.67	42.03	1 percent
Tobacco products	3.52	2.88	-18 percent	0.12	0.04	-68 percent
Textiles	4.36	2.26	-48 percent	1.55	0.87	-44 percent
Wearing apparel; dressing and dyeing of fur	2.89	0.84	-71 percent	0.85	0.31	-63 percent
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	2.59	2.24	-14 percent	5.30	2.61	-51 percent
Wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	2.83	3.71	31 percent	0.49	0.64	29 percent
Paper and paper products	2.55	2.51	-1 percent	1.46	1.28	-13 percent
Publishing, printing and reproduction of recorded media	4.99	1.97	-61 percent	0.54	0.20	-64 percent
Coke, refined petroleum products and nuclear fuel	11.43	6.37	-44 percent	4.33	9.91	129 percent
Chemicals and chemical products	10.92	11.31	4 percent	7.93	9.82	24 percent
Rubber and plastics products	5.21	2.52	-52 percent	3.09	2.74	-11 percent
Other non-metallic mineral products	2.75	3.24	18 percent	0.67	0.47	-30 percent
Basic metals	3.65	12.50	243 percent	5.68	7.14	26 percent
Fabricated metal products, except machinery and equipment	3.74	4.03	8 percent	0.90	0.82	-10 percent
Machinery and equipment n.e.c.	4.60	6.30	37 percent	2.71	2.76	2 percent
Office, accounting and computing machinery	0.07	0.09	30 percent	0.15	0.07	-51 percent
Electrical machinery and apparatus n.e.c.	1.53	2.09	37 percent	1.17	0.81	-31 percent
Radio, television and communication equipment and apparatus	0.90	0.23	-74 percent	0.41	0.27	-32 percent
Medical, precision and optical instruments, watches and clocks	0.48	0.42	-12 percent	0.36	0.47	29 percent
Motor vehicles, trailers and semi-trailers	5.71	7.45	30 percent	17.64	14.12	-20 percent
Other transport equipment	0.47	0.53	13 percent	2.29	2.30	1 percent
Furniture; manufacturing n.e.c.	4.09	1.22	-70 percent	0.69	0.34	-51 percent

Source: Center of Production Studies (CEP), Ministry of the Economy, Argentina.

4. Research Design and Methodology

4.1. Data

We construct a balanced panel[9] of firms that answered the Second Innovation Survey,[10] with data for 1998-2001—and the Third Innovation Survey,[11] with data for 2002-2004, which will be called "the Survey" in this paper. These data were produced by the National Institute of Statistics of Argentina (INDEC). This left us with 835 firms. However, some firms have missing observations in one or more variables. Moreover, we excluded from the analysis extreme observations[12] for all continuous variables and therefore the number of observations used differs in different estimations. It is worth noting that our sample includes both innovative and non-innovative firms, and the original sample was drawn so as to be representative of the manufacturing sector as a whole.[13]

All nominal information has been deflated to the year 1998 using the sectoral (2-digit ISIC Rev. 3) Argentine producer price index (IPP, Spanish acronym for "Indice de Precios al Productor"). This index measures the price evolution of national and imported products that are offered in the national market (net of taxes). National production directed to national and international markets is used as the weighting vector for those prices.

In the following sub-section we present our econometric model. The details about the definition of variables are presented in the Appendix.

4.2. Structural Model

In this paper we apply a structural model formed from three sets of equations around three key concepts represented in Figure 1: innovative inputs, innovative outputs, and economic performance.

The first equation estimates the intensity of investment in four different types of innovative activities illustrated in Figure 1.

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[9] We prefer to work with a balanced panel because many of the variables used in the analysis were only reported in the Second Innovation Survey.
[10] See INDEC (2003)
[11] See INDEC (2006).
[12] Extreme values are observations lying more than two standard deviations above the mean.
[13] Each sample was randomly drawn by INDEC from National Economic Census. Therefore, to a large extent randomness intervenes in the definition of balanced samples. However, balanced samples always involve certain degree of bias since firms included are those that remained in the market during the whole period of analysis.

Equations 1

$$(1.1)\ Inhouse\_IA_{it} = V_{it}^{'}\beta + \varepsilon_{it}$$

$$(1.2)\ Extint\_IA_{it} = V_{it}^{'}\beta + \varepsilon_{it}$$

$$(1.3)\ Extict\_IA_{it} = V_{it}^{'}\beta + \varepsilon_{it}$$

$$(1.4)\ Extinc\_IA_{it} = V_{it}^{'}\beta + \varepsilon_{it}$$

The dependent variables are the intensity of investment in in-house activities (*Inhouse_IA*), in intangible technologies (*Extint_IA*), in ICTs (*Extict_IA*), and in embodied technologies (*Extinc_IA*). All of them are expressed in natural logs.[14] Vector *V* includes all explanatory variables of innovative behavior, such as firms' characteristics, sources of information, sources of financing, and sectoral and period controls.

Equations 2

$$(2.1)\ new\_prod_{it} = \delta_1 p\_Inhouse\_IA_{it} + \delta_2 p\_Extint\_IA_{it} + \delta_3 p\_Extict\_IA_{it} + Z_{it}^{'}\delta + \varepsilon_{it}$$

$$(2.2)\ new\_proc_{it} = \delta_1 p\_Inhouse\_IA_{it} + \delta_2 p\_Extint\_IA_{it} + \delta_3 p\_Extinc\_IA_{it} + Z_{it}^{'}\delta + \varepsilon_{it}$$

$$(2.3)\ innovator_{it} = \delta_1 p\_Inhouse\_IA_{it} + \delta_2 p\_Extint\_IA_{it} + \delta_3 p\_Extinc\_IA_{it} + Z_{it}^{'}\delta + \varepsilon_{it}$$

The dependent variables are dummy variables that account, respectively, for the existence of new or improved products, new or improved processes, or either of them. The main explanatory variables are the predictive values for dependent variables in equations (1). Vector *Z* includes firms' characteristics, sources of information, cooperation with other actors of the NSI, and sectoral and period controls.

Equation 3

$$(3)\ q\_lab_{it} = \gamma_1 p\_innovator_{it} + \gamma_3 cont\_RD + Y_{it}^{'}\gamma + \varepsilon_{it}$$

[14] Our database includes innovative and non-innovative firms. Thus, we replace the 0 value of our dependent variables with 0.00001 so as to keep all firms in the analysis.

The dependent variable is labor productivity measured as sales over employment in natural logs. Given that innovation in products and processes are not independent, we estimate this equation three times, using as explanatory variables the predicted probabilities of, in turn, product innovation, process innovation or either calculated from equations (2). In all cases a dummy variable that accounted for systematic investment in in-house R&D during the period 1998-2004 was included. Vector *Y* includes firms' characteristics, investment intensity over the period 1998-2001 and sectoral and period controls.

We chose this structural model because it is empirically tractable with the information available in our database and represents our conceptual framework. In other words, the model captures the logic of Figure 1 in which the decision to invest in innovative activities feeds into the probability of being successful in product and process innovation, which in turn impacts labor productivity. Moreover, an independent effect for being systematic in long-term innovative in-house behavior is also expected to impact labor productivity. We could not have estimated simultaneous equations because we only have two observations for innovative outcome (i.e., dependent variable of equations (2)) and we would have misused the information available for equations 1 and 3.[15] All models are estimated with robust standard errors.

5. Descriptive Results from Innovation Surveys

In this section we discuss descriptive statistics for the full sample of firms included in each survey (*total* sample) and also from those with information in both surveys (*balanced* sample), which was the sample used in the econometric analysis.

Table 4 presents descriptive statistics for the firms' decisions to invest in innovation. As we have said above, on average firms use a higher proportion of their sales to undertake innovative activities whose source is external to them, primarily through embodied technologies. In fact, only 9 percent of firms in our balanced sample pursued systematic in-house R&D activities during the whole period under analysis (1998-2004). The share of firms that pursued in-house innovative activities (R&D or Design and Engineering) was 24 percent during 1998-2001 and 27 percent during the period 2002-2004. In general, investment in innovative activities decreased in the second period, and this decrease was more pronounced for embodied

[15] Moreover, we could not find a routine built for STATA to estimate simultaneous equations with a panel data structure.

technology. This might be related to the change in relative prices after the devaluation of 2002, since most machinery is imported.

Regarding the comparison between balanced and total sample, differences in the indicators presented are minor. There seem to be more firms in the balanced sample that perform in-house innovative activities, and they invest a bit more intensively in total innovative activities.

Table 4. Inputs: Investment in Different Types of Innovative Activities

	Average 9801		Average 0204	
	total	balanced	total	balanced
Number of firms (mean for the period)	1,835	835	1,626	835
Total expenditures on innovation [as a percent of total sales] (mean of firms' ratios)	1.5 percent	1.8 percent	0.9 percent	1.0 percent
Expenditure on innovation by type [as a percent of total expenditure on innovation]				
Research & Development	9.9 percent	8.6 percent	16.7 percent	12.8 percent
External Research & Development	1.8 percent	2.6 percent	1.8 percent	2.6 percent
Capital Goods	64.8 percent	67.6 percent	53.7 percent	55.0 percent
Hardware	4.3 percent	3.8 percent	5.5 percent	6.5 percent
Software	4.0 percent	4.2 percent	4.2 percent	4.8 percent
Technology transfer	6.9 percent	5.5 percent	7.2 percent	5.1 percent
Training	2.3 percent	2.8 percent	1.4 percent	1.1 percent
Design and Engineering	4.2 percent	5.6 percent	7.0 percent	10.4 percent
Consultancy	1.9 percent	2.1 percent	2.5 percent	2.8 percent
Share of firms that developed in-house innovative activities (investment in R&D or Design and Engineering)	23.7 percent	29.4 percent	27.2 percent	29.0 percent
Share of firms that performed R&D	19.2 percent	25.3 percent	23.1 percent	25.2 percent
Share of firms that performed R&D on a continuous basis				
for seven years	5.1 percent	9.5 percent	5.7 percent	9.5 percent
for three consecutive years	19.0 percent	20.2 percent	13.8 percent	14.3 percent

Source: The Survey (see 4.1 Data)

Table 5 presents the share of firms that identified different types of obstacles and sources of information for innovation. This information is only available for the first period under analysis (1998-2001) and it is provided for the full sample in Table 5. Most firms identify obstacles associated either with the costs of innovation (payback period too long, high training costs, no suitable financing available, unsuitable market structure or small market size) or with failures in the science and technology (S&T) system (few options for cooperation with other firms or institutions, insufficient information about markets, insufficient information about technology, failures in public policies on S&T or poor development of institutions on S&T).

However, if we focused on highly important obstacles, 20 percent of firms in the sample believe that innovation costs are a highly important obstacle, while only 8 percent consider failures of the S&T of high importance as obstacles for innovation.

Regarding sources of information, the great majority of firms use sources internal to the firm or the corporation. Similarly, many firms use what the literature has called *incoming spillovers*,[16] which are generally open sources such as the Internet, conferences, journals, exhibitions, and consultants. Among private actors, clients—especially—and suppliers are relevant. Interestingly, only 5 percent of firms consider the S&T sector (i.e., universities and national/international-private/public R&D centers) as a highly important source of information for innovation.

Table 5. Obstacles and Sources of Information for Innovation, 1998-2001

	Not irrelevant	**Highly important**
Share of firms that identify obstacles for innovation		
Associated with costs	94.8 percent	20.6 percent
Associated with the S&T system	87.9 percent	8.4 percent
Share of firms that identify the following sources of information		
Internal to the firm or corporation	79.7 percent	57.1 percent
Clients	63.0 percent	14.0 percent
Suppliers	66.4 percent	9.7 percent
Competitors	62.3 percent	8.6 percent
S&T sector	29.0 percent	4.8 percent
Incoming spillovers	79.6 percent	21.1 percent

Source: The Survey (see 4.1 Data)

[16] See for example Cassiman and Veugelers, 2002, Veugelers and Cassiman, 2005.

Table 6 shows that around 47 percent of firms in each period stated that they had introduced products or process innovations. Although we do not have information about the degree of novelty for the whole period, 58 percent of firms that declared having introduced new products during the period 1998-2001 also declared that those products were new to the market and not just for the firm. Moreover, among those firms that introduced new products in that period, these new products represented on average 42 percent of sales to the local market and 24.5 percent of exports. If only higher-level innovation (new to the market) was considered, they represented 18 percent and 10 percent of local sales and exports, respectively. Unfortunately, this information is available only for the period 1998-2001.

As for economic performance, productivity increased on average 7 percent between both periods. However, productivity is measured as sales over employment. This implies that the effect of the devaluation on output (e.g., exports) is fully considered while it is not discounted by the price increase of some inputs (e.g., imported machinery or other materials). This may result in an overestimation of the productivity increase.

Regarding the comparison between balanced and total samples, it is clear in this case that firms in the balanced sample are above the average of innovativeness during the period 1998-2001. It must be remembered that randomness plays an important role in the selection of firms in each sample. Still, those differences may reflect a kind of bias in the innovative performance of firms that survived throughout the crisis: they may have been relatively more innovative. However, the same cannot be said regarding labor productivity. In this case, the balanced sample seems to be of poorer performance than the average. Nevertheless, labor productivity is measured as sales over employment, a measure that is very much sector-specific. As we discuss in Section 3, the balanced sample covers a period of important changes in the sectoral structure, which then interferes in the interpretation of whether firms that survived the crises were more or less productive.

Table 6. Innovative Outputs and Economic Performance: Share of Firms that Have Been Successful in Introducing Innovations and Labor Productivity

	Average 9801		Average 0204	
	total	**balanced**	**total**	**balanced**
Innovative Outputs				
Share of firms that introduced a product innovation	39.6 percent	47.3 percent	38.2 percent	37.1 percent
Share of firms that introduced a process innovation	40.6 percent	47.4 percent	36.3 percent	36.2 percent
Share of firms that introduced either a product or a process innovation ("innovative firms")	46.7 percent	56.8 percent	47.0 percent	45.3 percent
Economic Performance				
Labor productivity (mean of firms' productivity) *AR $ of 1998*	113,580	90,866	121,575	120,343

Source: The Survey (see 4.1 Data)

Table 7 presents the share of cooperation with other actors in the NSI for the whole sample. Only cooperation for knowledge exchange was considered. This information was only available for the period 1998-2001.

As can be seen in the table, 45 percent of firms claimed to have established connections to at least one partner and 27 percent claimed to have established cooperation with science and technology institutions. (i.e., universities, training institutes, technology centers, R&D firms, liaison offices, and public research institutes). However, the percentage that claimed to have received some support from science and technology institutions is much lower and does not even reach 2 percent.

As will be seen below, cooperation with different partners has different impacts on the likelihood of achieving product and process innovations. The next section presents the econometric results.

Table 7. Policy-Relevant Characteristics and Cooperation with Other Actors, 1998-2001

	Share of total sample
Share of firms that co-operated with headquarters on innovation	8.3 percent
Share of firms that co-operated on innovation activities with any partner	44.8 percent
Share of firms that co-operated with universities/higher education or government research institutes	27.4 percent
Share of firms that received public financial or non-for profit support for innovation	1.9 percent
Share of firms that obtained one or more patents (to protect innovations)	6.1 percent

Source: The Survey (see 4.1 Data)

6. Econometric Results

This section presents the results of the structural model inspired by the conceptual framework illustrated by Figure 1. We estimate a system of equations (1) to (3) using balanced panel-data models. We control for the endogeneity of the main explanatory variables by means of estimating each of the equations subsequently from (1) to (3), taking into consideration the results of previous stages.

6.1. Investment in Innovative Activities

Table 8 presents the results of different types of innovative activities. Random and fixed-effects models were estimated, and the latter should be chosen—except for the equation on investment in intangible technologies—as indicated by the Hausmann tests (not presented here). Accordingly, we used fixed-effects models (except for intangible technologies) to estimate the predicted values of dependent variables.

Since the analysis is not restricted to firms that invest in innovation, we included a dummy variable accounting for positive investment in innovative activities. This was done to enable the existence of different constant terms for firms with and without innovative activities. In this way the absence of investment in different types of innovation remains informative when calculating the predicted values used later to explain success in innovation outcomes. This dummy variable is positive and significant as expected in all cases.

Many of the variables included in the model are either fixed over time (i.e., patents and sources of information) or do not present important variability (i.e., size categories, foreign) and therefore results cannot be read from the fixed effects estimations. Reading from the random effect column, we find that size, in general, has a negative effect on the intensity of investment in innovative activities: firms in the smallest group (fewer than 50 employees) invest the highest proportion of their sales in all innovative activities. This finding has previously been reported for Argentina (Arza, 2005a; Chudnovsky et al., 2006).

Having been granted a patent does not affect the intensity of investment. However, there are very few firms with patents in Argentina.

Foreign ownership has a negative effect on the intensity of in-house activities, which is not surprising because the economies of scale of these activities very often require them to be performed in single locations of the global network of multinational corporations (MNCs).

The importance of different sources of information during the period 1998-2001 does not show a clear effect. In fact, the sources of information are only jointly significant at 5 percent for the estimation of in-house innovative activities and at 10 percent for the estimation of intangible technologies. If we focus only on those two dependent variables (Columns I to IV), we find that the higher the perceived importance of sources of information from clients and *incoming spillovers (S_inf_oport),* the higher the probability that the firm will invest in in-house and intangible technologies, respectively. On the contrary, firms that favor sources of information from suppliers are less likely to innovate. These firms may belong to the more traditional manufacturing sector, known as dominated by suppliers in the Pavitt (1984) taxonomy, which usually relies on sources of innovation external to the firm.

Table 8. Investment Intensity in Different Innovative Activities, 1998-2004

Equations 1 estimated with random and fixed effects OLS models

	Inhouse_IA RE (I)	*Inhouse_IA* FE (II)	*Extint_IA* RE (III)	*Extint_IA* FE (IV)	*Extict_IA* RE (V)	*Extict_IA* FE (VI)	*Extinc_IA* RE (VII)	*Extinc_IA* FE (VIII)
D_Inhouse_IA	5.964706***	5.966517***						
	[160.22]	[79.59]						
D_Extint_IA			5.209824***	5.207805***				
			[113.34]	[64.15]				
D_Extict_IA					5.091677***	5.113894***		
					[149.84]	[95.57]		
D_Extinc_IA							6.797244***	6.854557***
							[143.41]	[93.57]
size2: 50-99	-0.065900**	-0.079102	-0.033279	-0.027626	-0.088931***	-0.023960	-0.101924***	-0.093399
	[2.22]	[1.61]	[1.46]	[0.72]	[2.99]	[0.50]	[2.74]	[1.38]
size3: 100-249	-0.215551***	-0.186414**	-0.097434***	-0.070958	-0.115873***	-0.015515	-0.217749***	-0.176517*
	[5.70]	[2.45]	[3.25]	[1.23]	[3.22]	[0.21]	[5.13]	[1.93]
size4: 250-999	-0.335677***	-0.239530*	-0.072921	0.026936	-0.036014	0.160763	-0.052872	0.084718
	[5.45]	[1.70]	[1.46]	[0.28]	[0.65]	[1.40]	[0.81]	[0.56]
size5:>1000	0.052083	0.693148	-0.310349*	-0.105440	-0.228977	0.216002	-0.159746	0.297509
	[0.31]	[1.61]	[1.92]	[0.30]	[1.39]	[0.75]	[0.95]	[0.86]
foreign	-0.138872***	-0.103076	-0.003035	0.025330	-0.031521	-0.206783**	-0.038293	-0.095255
	[2.70]	[0.77]	[0.06]	[0.18]	[0.64]	[1.98]	[0.63]	[0.60]
patent	0.114326		0.057724		0.028188		-0.001898	
	[1.34]		[0.68]		[0.36]		[0.02]	
S_fin_intrafirm	-0.000024	0.000065	-0.000433**	-0.000508	-0.000466**	-0.000401	-0.001263***	-0.001262**
	[0.13]	[0.15]	[2.57]	[1.45]	[2.37]	[1.08]	[4.89]	[2.55]
S_fin_priv	0.002410***	0.003158**	-0.000362	-0.000164	-0.000144	-0.000551	0.006858***	0.006908***
	[2.75]	[2.10]	[0.37]	[0.08]	[0.14]	[0.27]	[5.38]	[3.31]
S_fin_pub_ngo	0.002373	0.001700	0.003504**	0.003593	-0.004482**	-0.005834	0.003464	0.003018
	[1.06]	[0.45]	[2.16]	[1.30]	[2.19]	[1.62]	[1.31]	[0.79]
S_fin_bank	0.000874	0.000887	0.000336	0.000351	-0.000411	0.000120	0.005488***	0.007260***
	[1.24]	[0.61]	[0.69]	[0.38]	[0.57]	[0.10]	[5.38]	[3.79]
S_inf_intrafirm	-0.040981		-0.063407		0.087245		-0.006922	
	[0.72]		[1.44]		[1.62]		[0.11]	
S_inf_science	-0.015822		-0.024145		-0.052548		-0.022996	
	[0.21]		[0.40]		[0.74]		[0.30]	
S_inf_supplier	-0.130890**		-0.045071		-0.006161		-0.018741	
	[2.09]		[0.85]		[0.11]		[0.27]	
S_inf_comp	0.056223		0.070260		-0.093513		0.028651	
	[0.79]		[1.23]		[1.39]		[0.36]	
S_inf_client	0.124638**		0.018563		0.029143		-0.083971	
	[2.05]		[0.35]		[0.49]		[1.26]	
S_inf_oport	0.070212		0.130858**		0.038950		0.114322	
	[0.86]		[2.24]		[0.53]		[1.31]	
Observations	5640	5640	5682	5682	5661	5661	5651	5651
Number of firms	822	822	828	828	825	825	824	824
R-squared	0.93	0.913	0.9099	0.894	0.9073	0.892	0.8937	0.8940
Avergage years	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Máx. years	7	7	7	7	7	7	7	7

Absolute value of z statistics in brackets
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Sectoral and period controls are not presented due to space limitations.
Source: The Survey (see 4.1 Data).

Finally, regarding the sources of financing, many firms (around 30 percent) that did not claim to have made expenditures on innovative activities still allocate percentages to different sources. This is partly explained by differences in the reference period between questions: while the whole period is the reference for the question about finance, the individual year is the point of reference for innovative expenditures. In these estimations we include sources of financing as originally reported by firms. We exclude some of the original categories from the analysis (i.e. international financial institutions and other sources) because very few firms have chosen these options. Given these caveats, the results must be interpreted with caution. It can be concluded that the higher the share of private sources of financing (i.e., suppliers, clients, other firms) the more intensively the firms invest in in-house activities and machinery. Funding from banks also increases the intensity of investment in embodied technologies, while they do not affect the intensity of investment in other activities, possibly due to the fact that machinery may be accepted as valid collateral when borrowing from banks while in-house innovative activities do not. On the contrary, firms that use primarily their own sources invest less in all external technologies, which suggests that financial constraints matter for acquiring external technologies.

6.2. Innovation Output

Table 9 presents the Probit estimation for product and process innovation. Since in general these are not independent events, we also estimated the probability of succeeding in either products or process in a single variable called *innovator*. The main explanatory variables are the predicted dependent variables of equations (1). We assume that all types of innovative activities exert an influence on innovation in process or products.

Table 9. Success in Achieving Product or Process Innovations, 1998-2004

Equations (2) estimated with Probit random effect models

	new_prod	new_proc	innovator
p_Inhouse_IA	0.269753***	0.245010***	0.405044***
	[14.83]	[13.23]	[15.42]
p_Extint_IA	0.099738***	0.101151***	0.133505***
	[4.48]	[4.30]	[4.35]
p_Extinc_IA	0.091636***	0.136980***	0.250579***
	[4.57]	[6.62]	[13.80]
p_Extict_IA	0.114563***	0.184461***	0.159487***
	[8.02]	[12.48]	[6.54]
size2: 50-99	0.407062***	0.447381***	0.679265***
	[2.88]	[3.09]	[4.46]
size3: 100-249	0.282977*	0.352580**	0.535110***
	[1.71]	[2.11]	[3.03]
size4: 250-999	0.589994***	0.722558***	0.834067***
	[2.69]	[3.20]	[3.41]
size5:>1000	1.082082**	4.169736***	3.259578***
	[2.01]	[4.61]	[3.64]
foreign	-0.013334	1.103166***	0.337006
	[0.06]	[4.52]	[1.35]
S_inf_supplier		1.201480***	1.027611***
		[4.03]	[3.36]
S_inf_comp	1.091246***	1.411739***	0.934210***
	[3.44]	[4.74]	[2.79]
S_inf_client	1.046897***		0.772557**
	[3.59]		[2.55]
coop_cientif	1.199490***	1.165044***	1.357649***
	[5.24]	[5.06]	[5.63]
coop_intrafirm	0.067392	-0.000725	0.228116
	[0.21]	[0.00]	[0.64]
coop_vert	0.813791***	0.554699**	0.526753**
	[3.65]	[2.46]	[2.26]
Observations	5528	5528	5528
Number of firms	806	806	806
Wald chi2	717.31	768.70	680.3
Log Likelihood	-1,704	-1,637	-1,502
Avergage years	6.9	6.9	6.9
Máx. years	7	7	7

Absolute value of z statistics in brackets
* significant at 10 percent; ** significant at 5 percent;
*** significant at 1 percent
Sectoral and period controls are not presented due to space limitations
Source: The Survey (see 4.1 Data).

The results confirmed the assumptions in Figure 1. As expected, investment in innovative activities influences the probability of achieving innovations in products and in processes: all types of innovative activities are significant. More in particular, while in-house innovative activities exert the highest influence on the probability of innovating in both products and process, it seems that it is relatively more important for innovation in products, while investment in embodied technology is relatively more important for innovation in processes.

Regarding the control variables, interestingly, there does not seem to be a linear relationship between firm size and the probability of achieving product or process innovation, as occurs in other countries (see Griffith et al., 2006) but the largest groups of firms shows higher probability of obtaining innovations. Moreover, foreign firms seem to be more likely to achieve process innovation than domestic firms (these innovations may come from their headquarters or from the R&D centers of their corporations). Finally, sources of information and cooperation with other actors have a positive effect on the probability of achieving innovations, especially cooperation with scientific institutions. For innovation in products, cooperation with clients and suppliers seem to be fairly important for success.

Finally, we would like to highlight that the evaluation of our dependent variables (i.e., product and process innovation) is subject to important limitations. First of all, it is a subjective measure; firms themselves evaluate whether they have achieved innovations mostly based on their own parameters of what constitutes an innovation. Misconceptions on innovation might not be randomly distributed; it is likely that firms with more formal R&D activities have a stricter conception of what an innovation is. Secondly, this measure cannot really be compared over time, since answers in 1998-2001 refer to a longer period than answers in 2002-2004.

6.3. Labor Productivity

Table 10 presents the results on labor productivity. Random and fixed effects models were estimated. Although, the latter should be chosen according to the Hausman test (not presented here), the results are not dramatically different. We include the predicted probability of being innovator in process, in products and in either, as the main explanatory variables of labor productivity. Since, as said above, innovation in product and process are not independent (only around 20 percent of firms declared to have innovated ONLY in products or ONLY in process) we did not include both predicted probability together in the estimation of labor productivity.

As expected, both product and process innovations increase labor productivity, with process innovation having a relatively stronger effect. This might be related to the more immediate effect of process innovation on the performance of the firms, while product innovations might have a longer phase of maturity. Furthermore, product innovations may be more important for other performance variables, such as exports or market share.

However, the most interesting finding, as shown in Table 10, is the significant coefficient for continuous investment in R&D. Engaging in R&D continuously for seven years increases labor productivity by around 45 percent, and this effect is independent of whether the firm is an innovator.

This suggests that investing systematically in capacity building pays off in terms of labor productivity. Firms that make systematic efforts to innovate may be more ready to take advantage of available opportunities.

As for the control variables, there appears to be a negative linear relationship between firm size and labor productivity, with small firms being relatively more productive than larger ones. Although this is unexpected, the same result was found for Argentina by Chudnovsky et al. (2006), who studied the relationship between innovation and productivity for the period 1992-2001. The negative effect of size on productivity disappears if one does not take the panel structure into consideration or estimate a pool-OLS model. This suggests that firms' unobservable specificities are tightly related to firm size. Once controlled for, the explicit measure of size becomes a detriment to labor productivity. In turn, as was expected, foreign firms were found to be more productive than domestic firms.

Table 10. Performance: Labor Productivity

	q_lab RE	q_lab FE	q_lab RE	q_lab FE	q_lab RE	q_lab FE
inv_emp_9801	0.042582***		0.042341***		0.041404***	
	[7.73]		[7.66]		[7.56]	
cont_RD	0.455349***		0.460491***		0.450065***	
	[5.09]		[5.17]		[5.09]	
p_new_prod	0.181227***	0.120815**				
	[5.13]	[2.23]				
p_new_proc			0.183921***	0.132936***		
			[5.54]	[2.65]		
innovator					0.216522***	0.169652***
					[7.77]	[4.15]
size2: 50-99	-0.107277***	-0.212650***	-0.108891***	-0.215311***	-0.119867***	-0.223519***
	[2.70]	[3.07]	[2.74]	[3.11]	[3.01]	[3.22]
size3: 100-249	-0.104523**	-0.321431***	-0.108579**	-0.325738***	-0.117340**	-0.331178***
	[2.17]	[3.59]	[2.25]	[3.64]	[2.43]	[3.70]
size4: 250-999	-0.471293***	-0.855084***	-0.478136***	-0.861223***	-0.482980***	-0.863661***
	[7.45]	[6.63]	[7.53]	[6.67]	[7.67]	[6.74]
size5:>1000	-1.584880***	-2.201908***	-1.595453***	-2.210699***	-1.587311***	-2.202385***
	[14.10]	[10.99]	[14.16]	[10.98]	[14.19]	[11.00]
foreign	0.286037***	0.018157	0.264092***	0.004622	0.277419***	0.015182
	[5.66]	[0.17]	[5.24]	[0.04]	[5.52]	[0.14]
Observations	5461	5461	5461	5461	5461	5461
Number of firms	797	797	797	797	797	797
R-squared	0.0823	0.0953	0.0833	0.0961	0.1594	0.099
Avergage years	6.9	6.9	6.9	6.9	6.9	6.9
Máx. years	7	7	7	7	7	7

Absolute value of z statistics in brackets
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent
Sectoral and period controls are not presented due to space limitations
Source: The Survey (see 4.1 Data)

7. Conclusions

This paper attempted to verify whether firms interested in long-term strategies such as improving their capacity to innovate show better economic performance. We adapted the Crepon, Duguet, and Mairesse (1998) approach to the specificities of developing countries, assessing the effect of four different types of innovative activities: in-house activities and external sources of innovation, which include embodied technology, intangible technology and *ICT*.

Regarding the determinants of investment in innovative activities, we found that foreign firms invest less than domestic firms in in-house activities, which may be related to the international division of labor in scale-intensive activities such as investment in R&D. As for the sources of information, it seems that using information from clients increases the intensity of investment in in-house activities, but the opposite finding was reported regarding information from suppliers. We believe that this finding reflects the fact that firms that primarily use these sources belong to traditional sectors which innovate using external sources rather than making in-house efforts. Finally, we found that there were financial constraints to investing in external technologies.

Regarding the knowledge production function, we found that all types of innovative activities were significant to explain success in product and process innovation. In-house activities were the biggest contributors to success in product and process innovation. In relative terms, this type of activity seemed to be especially relevant for explaining product innovation, while embodied technologies were particularly relevant for explaining process innovation.

According to the CDM approach, successful product and process innovation increases labor productivity. Our results validated these assumptions. Innovation in products or in process increases labor productivity. A stronger effect was found in the case of process innovation, which is expected to have a more immediate effect on a firm’s labor productivity. In contrast, product innovation may not have such a contemporaneous effect on labor productivity as much as it might for other performance measures, such as market share or exports. Finally, investing systematically in R&D has a direct payoff in productivity gains.

In sum, our results suggest that investment in all types of innovative activities—and not just in R&D—positively impact firms’ innovative and economic performance. More importantly, when in-house investment is undertaken systematically, an extra reward in terms of labor productivity may be expected.

The main limitations of the present study are related to the lack of information ready available. For example, data on capital stock are not available, and for this reason we opted to include investment in machinery instead. Available information on investment was restricted to only two years. Furthermore, some of the variables with available information for the period 1998-2001 (i.e. notably, sources of information and cooperation) were not surveyed during the period 2002-2004. Finally, some of the variables included in both surveys do not refer to the same length of time.

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Appendix: Variable Definitions

Equations 1.1, 1.2, 1.3 and 1.4 on Innovative Activities

Dependent variables:

Inhouse_IA: Expenditures on in-house R&D and Engineering and Design over sales. When the original values were 0 they were converted into 0.00001. In the regression we use the natural logarithm of this variable.

Extint_IA: Expenditures on intangible technologies. This includes licenses, external R&D and consultancies. When the original values were 0 they were converted into 0.00001. In the regression we use the natural logarithm of this variable.

Extict_IA: Expenditures on ICTs technologies. This includes software and hardware. When the original values were 0 they were converted into 0.00001. In the regression we use the natural logarithm of this variable.

Extinc_IA: Expenditures on embodied technologies (machinery). When the original values were 0 they were converted into 0.00001. In the regression we use the natural logarithm of this variable.

Independent variables:

D_Inhouse_IA, D_Extint_IA, D_Extict_IA, D_Extinc_IA: Dummy variables that adopt the value one when Inhouse_IA, Extint_IA, Extict_IA, Extinc_IA are, respectively, not zero.

Size: following Griffith et al. (2006) we construct a set of size dummy variables according to the firm's number of employees in 1998. Categories are size1: 20–49, size2: 50–99, size3: 100–249, size4: 250–999, and size5 >1,000 employees. These dummies were calculated per year.

Foreign: dummy variable that adopts the value one if foreign participation is 10 percent or above. It is informed jointly for all years within period 1998-2001 and period 2002-2004.

Patent: dummy variable that takes the value one if the firm has been granted at least a patent anywhere during the period 1998-2001.

Sources of financing: Percentage of total innovative activities that were financed by different sources. Information referred jointly to all years between 1998 and 2001 and to 2004. This latter value was repeated for 2002 and 2003. Sources included in the analysis were the following:

- *S_fin_intrafirm*: intra-firm, partners, headquarters or other related firms
- *S_fin_priv*: suppliers, clients and other firms
- *S_fin_pub_ngo:* public research organizations, non-for-profit associations, foundations, and NGOs.

Sources of information: firms' own evaluation of the importance of different sources of information for innovation during the period 1998-2001. Original values, which ranged from 1 to 4, were normalized from 0 to 1. Sources included in the analysis were the following:

- *S_inf_intrafirm:* intra-firm, corporation or related firms
- *S_inf_science:* universities, R&D centers (national, international, private or public)
- *S_inf_supplier:* suppliers
- *S_inf_comp:* competitors
- *S_inf_client:* clients
- *S_inf_oport:* journals, conferences, databases, or Internet.

Sectoral investments in innovative activities: Each regression included the sectoral (2-digit ISIC) investment on innovative activities represented by each dependent variable (before normalizing them over sales). This was done to account for unobserved sectoral specificities that may affect firms' behavior. The coefficients on these variables are not included here but are available upon request.

Period: a dummy variable that adopts the value one for the period 1998-2001. This has the purpose of both controlling for the change in the macroeconomic regime in 2002 and the fact that data come from two different surveys. The coefficient on this variable is not included here but is available upon request.

Equations 2.1, 2.2, and 2.3 on the Probability of Achieving Results through Innovation

Dependent variables:

new_prod: dummy variable that adopts the value one when the firm has created a new or significantly improved product. Novelty is evaluated at the level of the firm. This variable is informed jointly for all years within the period 1998-2001 and within the period 2002-2004.

new_proc: dummy variable that adopts the value one when the firm has created a new or significantly improved process. Novelty is evaluated at the level of the firm. This variable is informed jointly for all years within the period 1998-2001 and within the period 2002-2004.

innovator: dummy variable that adopts the value one when the firm has created a new or significantly improved product or process. Novelty is evaluated at the level of the firm. This variable is informed jointly for all years within the period 1998-2001 and within the period 2002-2004.

Independent variables:

p_Inhouse_IA: predicted values for the variable Inhouse_IA when estimating equation (1.1).

p_Extint_IA: predicted values for the variable Extint_IA when estimating equation (1.2).

p_Extict_IA: predicted values for the variable Extict_IA when estimating equation (1.3).

p_Extinc_IA: predicted values for the variable Extinc_IA when estimating equation (1.4).

Size: see above

Foreign: see above

Sources of information: see above. In this regressions only *S_inf_supplier*, *S_inf_comp,* and *S_inf_client* were included.

Cooperation: dummy variable that adopts the value one when the firm has established a relation with different actors to achieve goals related to essays and tests, technical assistance, design or R&D. This variable was informed only jointly for all the years within the period 1998-2001. The actors included as partners in the analysis are the following:

- *coop_cientif:* universities, technical training institutes, technology centers, R&D firms, liaison offices and public research organizations
- *coop_intrafirm:* headquarters and related firms
- *coop_vert:* clients and suppliers

Sectoral investments in innovative activities: We include sectoral investment in all types of innovative activities. The coefficients on these variables are not included here but are available upon request.

Period: see above.

Equation 3 on Labor Productivity

Dependent variable:

q_lab: labor productivity defined as sales over employment. In the regression we use the natural logarithm of this variable.

Independent variables:

p_new_prod: predicted probability of innovating in new products estimated from equation (2.1).

p_new_proc: predicted probability of innovating in new products estimated from equation (2.2).

p_innovator: predicted probability of innovating in new products estimated from equation (2.3).

inv_emp_9801: investment intensity measured as total investment in capital goods over employment. This information is only available for 1998 and 2001. The average of these observations was used.

cont_RD: dummy variable that takes the value one when the firm has invested systematically on R&D over the whole period 1998-2004.

Size: see above

Foreign: see above

Sectoral investments in innovative activities: In this case we have included the total amount invested in innovative activities per sector. The coefficients on these variables are not included here but are available upon request.

Sectoral dummies: we included sectoral dummies for all sectors at 2-digit ISIC Rev 3. The coefficients on these variables are not included here but are available upon request.

Period: see above.