Environmental management and innovation activities in developing countries: A case study of Argentine manufacturing firms

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Abstract

Based on micro data for 716 manufacturing firms from the Second Innovation and Technological Behavior Survey for 1998-2001, in our econometric analysis we find that firm size and technology acquisition expenditures increase both the probability of undertaking environmental management activities (EMA) and the quality of environmental management. In addition, we find a positive impact of environmental regulatory pressures on innovative behavior. Despite the fact that foreign ownership is associated to a decrease in the quality of environmental management, foreign firms are more prone to undertake EMA and generate positive environmental spillovers, by inducing simple clean production management in domestic firms with high absorption capabilities.

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I. Introduction

The possibility of fostering a sustainable development process depends, to a significant extent, on the environmental management activities (EMA) undertaken by firms. While in industrialized countries these activities are mostly carried out in response to environmental regulations and to market incentives by firms with innovative capabilities, this is not often the case in developing countries.

The enforcement of environmental regulations in most developing countries is rather weak and firms have limited innovative capabilities. Nonetheless, in the context of greater competition in the domestic market due to trade and foreign investment liberalization, it is likely that firms may have to devote more resources to innovation activities to be able to survive and develop. Furthermore, they may have to pay more attention to EMA in view of the requirements of buyers in the export markets or even in the domestic market and/or to the diffusion of EMA among foreign firms.

In the Argentine case, while the impact of the Convertibility program and structural reforms on economic and social development issues during the 1990s has been largely analyzed, only few studies, based on limited datasets, have paid attention to environmental activities by private firms

The data collected in the Second Survey of Innovation and Technological Behavior, which was recently undertaken by the National Statistical Institute (INDEC-SECYT-CEPAL, 2003), can be used to fill the gap and to shed light on the importance and determinants of EMA performed by Argentine manufacturing firms during 1998-2001.

Since there is considerable heterogeneity in the performance of manufacturing firms and, in addition, a significant share of them has not performed EMA, it is essential to begin the analysis by enquiring on the determinants of these activities in Argentine firms. In particular, it is important to assess whether manufacturing firms' innovation activities contributed to the diffusion and quality of EMA. Therefore, our analysis begins by attempting to shed light on whether innovation efforts undertaken by firms led to improved quality of EMA.

Specifically, from a policy perspective, it is relevant to distinguish whether the effect of greater innovation efforts is attributable to in-house R&D activities or to external (embodied and disembodied) technology acquisition.

A second important issue is to evaluate the role of environmental regulation, which has been the instrument usually employed by national governments to reduce the environmental burden of firms' economic activities.

The introduction of environmental regulations has traditionally been seen as a cost-increasing factor at the firm level, since enterprises are obliged to comply with them by incurring in additional investments and operative costs. However, Michael Porter (1991) suggested that properly instrumented environmental regulations (i.e. market-based) might not only promote better environmental quality and a decline in health risks

associated with pollution, but also increase firms´ competitiveness by triggering innovations that may offset compliance costs. This hypothesis has been well received in business circles though most economists have rejected it arguing that regulations cannot provide incentives for innovation and quality improvement beyond the stimuli of market competition.

Since the available data does not allow us to evaluate the effects of different environmental regulation schemes, we do not attempt to test the Porter hypothesis in this paper. Nevertheless, we can examine what may be considered a `byproduct´ of the Porter hypothesis –namely, evaluate whether environmental regulatory pressure has stimulated innovations (i.e. new products or processes launched to the market) undertaken at the firm level.

As a third issue in our analysis, given the foreign direct investment (FDI) boom that took place in Argentina in the 1990s, it is relevant to evaluate the extent to which the host country has benefited from the intangible proprietary assets possessed by transnational corporations (TNCs) to foster social and economic sustainable development goals. In particular, it is important to analyze the possibility of environmental technology diffusion to domestic firms through spillovers. Environmental spillovers are said to take place when domestic firms are stimulated to undertake EMA (or upgrade their quality) as a consequence that TNCs may not be able to fully prevent environmental technology diffusion from their affiliates to domestic firms, through mobility of human capital, imitation and other externalities.

In addition, recent research has suggested that for spillovers to arise, local firms need to have significant absorption capabilities that allow them to reap benefits from the knowledge possessed by TNCs affiliates. Therefore, we assess whether the existence of spillovers effects is conditional on the absorption capabilities of domestic firms.

In this paper, firm level data for 1998-2001 is used to provide answers through econometric techniques to the following questions:

1) What are the determinants of the probability of undertaking EMA and of their quality? In particular, is the adoption of EMA and their quality influenced by the innovative activities performed by manufacturing firms?

2) What types of EMA are encouraged by environmental regulatory pressure on manufacturing firms? Are innovation activities stimulated in firms that are under environmental regulatory pressures?

3) Are foreign firms more prone to undertake EMAs than domestic firms?

4) Do foreign firms' EMA spillover to domestic firms? Do spillovers depend on the absorptive capabilities of domestic firms?

The paper is organized as follows. Section II contains a survey of the recent research work on these topics. Section III presents a brief description of the evolution of the Argentine economy and the main features of innovation, foreign direct investment and

environmental management issues during the 1990s. Section IV discusses some issues regarding environmental management in Argentina. In Sections V and VI the empirical analysis and its main results are respectively presented. Section VII discusses the policy implications of our findings and suggests further research issues.

II. Previous research

The research efforts that have been undertaken regarding the three main issues that are analyzed in the rest of this paper are reviewed here. Firstly, we explore the determinants of the decision to adopt EMA and the quality of the environmental management, paying special attention to the relative importance of regulatory pressures *vis a vis* market incentives. Secondly, we analyze the linkages between innovative activity and environmental management, focusing on the `private´ relationship between being innovative (i.e. launching new products or processes to the market) and engaging in environmentally sound activities (especially adopting proactive pollution prevention – PP- practices) and on whether environmental regulatory pressure stimulates innovations at firm-level. Finally, as TNCs are one of the main vehicles for allowing developing economies to close the `technology gap´ with the developed world, we review the literature on environmental technology diffusion to domestic firms as a result of TNCs´ spillovers.

a) Determinants of the decision to adopt EMA and the quality of the environmental management

Several econometric studies have been undertaken both in developed and developing countries (LDCs) on these issues. In the United States, Anton, Deltas & Khanna (2004) analyzed the observed variability in the quality of environmental management systems (EMS) adopted by manufacturing companies using a sample of S&P 500 firms. They found that strong threats of future liabilities, consumer pressures, high capital-output ratios and a large number of facilities overseas (and thus more exposition to global competition) made firms more likely to adopt higher quality EMS. In addition, Khanna and Anton (2002) tested the factors influencing U.S. firms to undertake proactive environmental management also using a sample of S&P 500 firms. They found that the threat of environmental liabilities, high costs of compliance with anticipated regulations and market and public pressures played a statistically significant role in inducing corporate environmentalism. In turn, Khanna and Damon (1999), using a sample of publicly traded firms of the chemical sector, examined the motivations for firms´ participation in the voluntary 33/50 Program[1]. They demonstrated that the benefits due to public recognition and the existence of a regulatory framework that would impose penalties on firms that did not undertake proactive measures for self-regulation provided strong incentives for participation.

In Japan, Nakamura, Takahashi and Vertinsky (2001), using a sample of 193 firms and several sources of published data for the financial, economic and environmental variables, examined econometrically the determinants of Japanese manufacturers to

[1]. A program launched by the U.S. Environmental Protection Agency (EPA) in 1991 to induce firms to voluntarily reduce their emissions of 17 high priority toxic chemicals.

incorporate environmental goals in their decisions. They found that firm size, average age of firms´ employees, export ratios and debt ratios were significant. On the contrary, firms' intangible assets (advertising and R&D) were important in only a few aspects of Japanese firms' processes.

When analyzing developing countries, an important difference emerges with regards to regulatory pressures, since the enforcement of environmental regulations in LDCs is weaker. Nevertheless, the importance that firms may assign to potential regulations should not be underestimated, since the threat of a possible closure -which affects the firm's image- as well as the possibility -even though remote- of having penal sanctions applied are increasingly making companies in LDCs more concerned with environmental behavior.

With regards to Latin America, Dasgupta, Hettige and Wheeler (2000) studied econometrically the determinants of environmental management in a large sample of Mexican factories. They found that environmental performance is manly determined by regulatory pressures, implementation of ISO 14000 standards and provision of general environmental education for plant employees. Otero, Peterson Zwane and Panayotou (2002), using survey data from a sample of manufacturing firms, investigated the determinants of environmental investments in Venezuela. They found that, despite relatively weak formal regulation, past penalties and environmental permit status were strongly correlated with environmental investment and that firms that exported to rich countries choose to invest more. However, they found little evidence of community pressure impacting on firms' environmental decisions. Similarly, Ferraz, Peterson Zwane, Seroa da Motta, and Panayotou (2002), using survey data from a sample of manufacturing firms in Brazil, found that a past history of inspections and formal sanctions, market pressures, having received publicity about their environmental performance and being publicly traded in international equity markets were strongly correlated with present environmental investment. On the contrary, they found little evidence of informal regulation affecting firms' decisions through direct community complaints. In addition, Borregaard and Dufey (2002) analyzed, although not econometrically, the environmental management practices undertaken in the mining sector in Chile and Peru based on a literature review, interviews to selected experts in the respective countries and a survey applied to 50 mining companies in Chile. They found that environmental regulations regarding foreign investment (or, more often, production in general), consumers´ requirements, local image, international financial markets, competitors´ pressures, national and international NGOs pressures and environmental guidelines by the headquarters or parent companies located abroad influenced firms´ environmental practices. However, they concluded that pressures for improved environmental performance derived primarily from international factors. Previously, Dasgupta, Laplante and Mamingi (1997) had undertaken a descriptive study about firms traded in local capital markets in Argentina, Chile and Mexico (and the Philippines). They concluded that, if properly informed, capital markets may provide financial and reputational incentives for firms to engage in environment protection activities. Therefore, and given the well-known financial difficulties that governments face in LDCs, they suggested that instead of enforcing compliance, public resources

should be more efficiently devoted to the dissemination of information that would allow stakeholders to make better-informed decisions.

In Asia, Kaiser and Schulze (2003) studied econometrically the decision of Indonesian manufacturing firms to engage in reported environmental abatement expenditures using a data-set of 22000 large and medium scale manufacturing establishments. They found that exporting and foreign-owned firms were significantly more likely to incur in environmental expenses. Therefore, they suggested that the most effective form of pollution abatement may not be through bureaucratic enforcement but through the encouragement of "voluntary" good practices. Furthermore, Bartzokas (2002) undertook a descriptive study of the fertilizer industry in China and Turkey and found that, in spite of enforcement difficulties, environmental regulations were increasingly influencing the adoption of environmental practices and the investment behavior in environment-clean technologies in both countries. In addition, the author highlighted that the increasing public concern about environmental deterioration was also becoming a pressure factor.

Regarding Argentina, there are at least two studies that are relevant. Firstly, Chudnovsky, López and Freylejer (2000) undertook a descriptive analysis of the environmental management practices of Argentine industrial firms focusing especially on the progress made in the adoption of pollution prevention (PP) measures during the nineties. Given the absence of information, they worked on a questionnaire answered by 32 large enterprises and 120 SMEs. Although the sample was small, their findings have been the main source of information for shedding light on these issues until the Second Survey of Innovation was undertaken. Overall, they found that there has been progress in the adoption of more advanced environmental practices within the Argentine industry but that such progress has been concentrated in a small group of firms, especially large, export-oriented or TNC subsidiaries. On the contrary, most domestic firms have made little progress in this field. Their results showed that EMA evolution during the nineties has been mainly affected by factors such as local environmental regulations and pressures from external market demands, TNC strategies and changes in competitive conditions in the local market. A positive relationship between innovatory/quality capabilities and EMA adoption (especially PP) was found. However, they found that environmental regulations did not generate overall competitiveness improvements through innovation offsets but rather that they fostered a reinforcing effect on the initial competitiveness conditions of each firm or industry.

Secondly, Chidiak and Gutman (2004) analyzed econometrically the binary decision of undertaking environmental activities and the determinants of the intensity of the environmental practices adopted by firms using data from the Second Survey on Innovation for the period 1998-2001. Their results revealed that big firms with important shares of foreign capital, with technical, innovative and quality management capacities (specifically, the innovation variable they found to be significant was `innovations launched to the market´) and with regulatory and market pressures tended to undertake better environmental management activities. In contrast, variables such as `innovation expenditures´, `exports´, `capital investment´ and `belonging to a pollutant sector´ turned out to be not significant or the absolute values of their coefficients, even if significant, were very small. With regards to regulations, the study showed that "regulatory

pressure" was a significant variable for the binary decision of undertaking environmental activities or not but that it was irrelevant for the decision concerning the quality of the environmental management practices adopted by firms.

Summing up, in developing countries, the main determinants of the decision to adopt EMA and of the quality of the environmental management adopted by firms seem to be local environmental regulations, firms´ image, consumers´ demands, financial markets´ pressures, size and foreign ownership. Among these, and in spite of the enforcement difficulties governments in LDCs face, regulatory pressures continue to emerge as the main motivation for firms´ engaging in environmental practices.

b) Linkages between innovative activity and environmental management

The second issue refers to the relationship between being innovative and being environmentally sound and proactive and between regulatory pressures and innovation. These interactions are framed in the debate that has been boosted since Michael Porter (1991) and Porter and van der Linde (1995) advanced their hypothesis arguing that properly designed environmental standards (i.e. market-based) can trigger innovations that may offset compliance costs, thereby improving firms´ productivity and competitiveness levels.

In the United States, Jaffe & Palmer (1997) examined econometrically the stylized facts regarding environmental expenditures and innovation in a panel of American manufacturing industries over the period 1973-1991. They found that, on the one hand, lagged environmental compliance expenditures had a significant positive effect on R&D expenditures (although the magnitude of the effect was small) but, on the other hand, that industries´ inventive output (as measured by successful patent applications) was not significantly related to compliance costs.

There are a number of descriptive studies on these issues. Hesselberg and Knutsen (2002), in a research of the tanning industry comprising a number of case studies in Germany, Italy, Portugal, Poland, the Czech Republic, Brazil, Mexico and India, found, on the one hand, that stricter environmental requirements have not so far been an engine of process-innovation and product-innovation offsets à la Porter in developing countries. On the other hand, they found that the `profit squeeze´ is leading Northern European firms to an externalization of the most polluting processes to Southern Europe, Eastern Europe and other LDCs. This outsourcing is not enhancing innovative environmental behavior in the recipient economies because the technology that is being transferred is such that it is possible to obtain the required good product quality without process changes that radically improve environmental practices. In turn, Barton (2002) studied the environmental management in the iron and steel sector in Spain, UK, Belgium, South Korea, Brazil, Czech Republic and Poland. He found that management standards in developed countries –such as ISO 14000 series and the adoption of more proactive EMA- do not always ensure the use of clean technologies are maximized and that the estimated performances of applied technologies are obtained. However, for developing nations, demands of environmental compliance and innovation seem to go together. In Brazil, for example, where the post-privatization transition period has brought

environmental protection into line with firms in the EU, production technology advances have had positive environmental benefits in the sense that there has been a shift towards PP and not solely end-of-pipe systems. Also in Brazil, Borger and Kruglianskas (2004) undertook case studies of three Brazilian enterprises (Daimler-Chrysler, De Nadai and Natura) to analyze the impact of the adoption of an integrated Corporate Social Responsibility strategy on the technological innovation capacity and the environmental management of the firms. They found evidence of a strong relationship between such a strategy and an effective environmental and innovative performance. In a previous study, Lustosa (2001) examined the environmental and innovative behavior of Brazilian industrial firms using data from a large-scale innovation survey from the State of Sao Paulo. She found that companies with highest efforts in R&D were the most likely to adopt environmental innovations. Moreover, she found that the consideration of environmental conservation as incentive for innovation was more clearly present in companies that attributed more importance to their internal R&D departments.

To sum up, empirical research regarding the linkages between innovation and environmental management in developing countries is mostly descriptive. Although results are not conclusive, the available data seem to show that, in LDCs, there may exists a positive correlation between being innovative and being environmentally sound.

c) TNCs´ environmental behavior and environmental spillovers

The environmental behavior of TNCs in developing countries and the environmental `spillovers´ they may generate over domestic companies have generally been approached in a polarized way. While environmental NGOs accuse TNCs of using dirty and obsolete technologies in their affiliates in LDCs, some business-related organizations diffuse successful cases where TNCs employ clean technologies and practices worldwide. With regards to the empirical evidence, only few researchers have actually conducted detailed case studies of the environmental management policies and procedures of TNC-affiliated units in developing countries.

Meyer (2003) reviewed the existing literature on the subject and concluded that the impact of TNCs on the natural environment of host economies can be either positive or negative: while some authors stress that TNCs transfer modern, environmentally friendly technology and production processes to developing economies, therefore improving the standards prevalent there, others are concerned with the fact that TNCs choose to transfer outdated technology to locations with less stringent environmental regulations, thus fostering a 'pollution haven' effect. In turn, Chudnovsky and López (2002), also surveying the literature on environmental practices of TNCs, suggested that these companies may find it advantageous to comply with home-based standards and regulations that in general tend to be higher and stricter than those in the host country because it is efficient to establish a single set of practices and standards instead of scaling back their environmental investments at overseas facilities. In addition, the greater level of scrutiny that TNCs are exposed to and the prospect of liability for failing to meet the appropriate level of standards tend to drive these firms to adjust their operations to higher requirements than those that might be imposed by local regulations. Nevertheless, they suggest that their actual development impact depends on the volume

and `quality´ of FDI and on the specific characteristics of the host country, especially, its capability to assimilate and take advantage of foreign technology inputs -i.e. their `absorptive capability´. Previously, Zarsky (1999), also in a review of the existing literature, had shown that there is little statistical evidence of either a "pollution haven" or a "pollution halo" for FDI in general. She found that there are cases of egregious local and even national ecological degradation where foreign firms clearly perform like environmental renegades but, on the other hand, there are also cases where foreign firms bring with them higher standards and better management practices -as well as better technologies- and where they are the first to respond to consumer pressures for "greener" products or production processes. In addition, Hansen (1999), based on a review of the existing studies in the field, argued that many transnational corporations adopt cross-border pollution control practices because by standardizing environmental management systems and technologies they gain scale advantages and recoup sunk costs. However, he found that some TNCs continue to opt for local adaptation of their environmental management set up since they find both economic and political advantages for complying with local regulatory systems, market structures and cultures.

There is a vast literature as well reporting specific descriptive analysis of certain developing countries. For example, in India, Bhattacharya (2002) analyzed time series data for industrial production and international trade of identified pollution intensive industries. He found that as a result of the country's policy towards opening up to the global markets over the last decade and the consequent increase in the extent of multinational activities and their share in trade and industrial production, India has become a "pollution haven". Also in India, Ruud (2001) studied local environmental practices of TNC based on an evaluation of 53 affiliated Indian units and detailed case studies and found significant evidence that environmental management at TNC-affiliated units in the country was strongly influenced by their parent's polices and standards. However, he also found that local contextual factors counted with regards to the content and nature of the environmental measures adopted by TNC affiliates and that local performance was not necessarily a replicate of headquarters´ practices. Furthermore, Wheeler (2000) analyzed the evidence referred to the FDI `race-to-the-bottom´ prediction –that polluters in high-income economies relocate their facilities in low-income countries to remain competitive- for China, Mexico and Brazil and concluded that the basic assumptions of that model were invalid. There is no environmental "race to the bottom" due to two main reasons: firstly, communities in developing countries are neither passive agent nor focused exclusively on material gains and, therefore, act to protect their own interests. Secondly, consumers and investors assign significant value to environmental performance and, if they are well-informed, their market decisions provide powerful incentives to reduce pollution. On both counts, the author's forecast was that pollution damage should decline significantly in poor countries as they develop. In addition, Gentry (1998) studied the linkages between private capital flows and the environment in various industries in Mexico, Argentina, Brazil, and Costa Rica and found that private capital flows vary in ways relevant to environmental performance by type, location and sector. In addition he found that, with regards to the environmental effects, capital flows can both increase environmental damage through increased resource use but, at the same time, they can also improve environmental performance through more efficient resource utilization. Finally, he found that improved

environmental performance occurs where it confers commercial advantage, even in the absence of traditional government enforcement.

Regarding econometric studies, Dowell, Hart and Yeung (2000), in a research based on a sample of US S&P 500, found that TNCs´ adopting stringent global environmental standards was positively associated with a higher market value of the company (as measured by Tobin's q). Therefore, they concluded that many TNCs opt to maintain a high level of environmental management and transfer advanced environmentally friendly technology to emerging markets even if this was not required by local standards. Furthermore, Eskeland and Harrison (2002), using data from Ivory Coast, Morocco, Mexico, and Venezuela, tested whether multinationals flocked to developing countries to take advantage of lax environmental standards. Using a number of different measures of pollution, they found some evidence that foreign investors were concentrated in sectors with high levels of air pollution (although the evidence was weak) but that foreign plants were significantly more energy efficient and used cleaner types of energy than domestic firms. In addition, they found no evidence that foreign investment in these developing countries was related to abatement costs in industrialized countries. Although this does not mean that 'pollution havens' cannot exist, the authors suggest that policy makers should pursue pollution control policy focusing on pollution itself, rather than on investment or particular investors. In China, Dean (2005) derived and estimated a model of FDI location choice of equity joint venture (EJV) projects in the presence of inter-provincial differences in environmental stringency using a sample of 2,886 manufacturing EJV. He found that Chinese-sourced EJV in highly polluting industries were deterred by relatively stringent pollution regulation. In contrast, EJV from non-Chinese sources were actually attracted to provinces with more stringent environmental regulations, regardless of pollution-intensity (the opposite of the pollution haven hypothesis). Therefore, he suggested the importance of accounting for firm heterogeneity in considering EJV behavior.

Overall, the evidence regarding TNC´s environmental behavior in LDCs is mixed. While the literature surveys and the descriptive studies find evidence both for and against TNCs´ clean practices, the few econometric works that have been undertaken show that TNCs tend to maintain high levels of environmental management in LDCs and, to a less extent, transfer advanced environmentally friendly technology to firms in host economies.

III. Overview of the Argentine economy and industry during the 1990s

In a period spanning from the late 1980s to the early 1990s, Argentina went through a process of fundamental change in its economic policy regime. After the hyperinflation crisis suffered between 1989 and 1990, price stabilization was achieved through a currency board scheme, which pegged the Argentine peso to the US dollar (the so called Convertibility Plan) from 1991 until the end of 2001. Besides, a far-reaching program of structural reforms was implemented very rapidly to bring the economy in line with a global trend toward liberalization. Among the measures implemented were the

liberalization of the trade and capital accounts, privatization of almost all state-owned firms, and deregulation of major sectors including banking and oil production.

As a consequence, Argentina had high GDP growth in 1991-1998 (interrupted by the Tequila crisis in 1995). During this period, the economy grew at an annual rate of 6% and investment augmented from 14.6% to 21% of GDP. In late 1998, the economy entered into a stagnation period that was followed by a deep fall in GDP in 2001 and 2002, in the middle of a huge financial and institutional crisis.

The rapid transition to a more open and competitive economic environment meant a great challenge for domestic enterprises. Whereas many indigenous entrepreneurs were not able to upgrade the organizational, productive and technological capabilities accumulated during the import substitution industrialization (ISI) stage and either broke or sold their businesses, a significant number of domestic enterprises were able to meet that challenge through restructuring and modernization processes.

Among firms that augmented their innovation expenditures, the bias in favor of technology imports over domestic innovation expenditures (e.g. in-house R&D) that had traditionally characterized the conduct of Argentine manufacturing firms in the past was, if anything reinforced. However, since the beginning of the recession in 1998, this trend was reversed. In-house R&D expenditures were the fastest growing innovation activity in the manufacturing industry during 1998-2001, while technology acquisition sharply decreased as a response to the intensifying recession during this period (INDEC-SECYT-CEPAL, 2003).

Nevertheless, technology acquisition expenditures still amounted to more than three quarters of innovation expenditures during 1998-2001, while in-house R&D represented less than 10%. In this way, technology acquisition was, besides foreign direct investment (FDI) inflows, the main source of technological modernization.

Chudnovsky, López and Pupato (2004) analyzed the determinants and impacts of innovative inputs and outputs on Argentine manufacturing firms' productivity performance during the 1990s, using micro data from the First and Second Innovation Surveys (INDEC, 1998 and INDEC-SECYT-CEPAL, 2003). Their econometric results indicated that R&D and technology acquisition expenditures had a positive payoff in terms of enhanced probability of becoming an innovator (i.e. introducing new products and processes to the market). Furthermore, innovators attained higher productivity levels than non-innovators. However, small firms had a lower probability of engaging in innovation activities and of innovating in products and/or processes.

In addition to innovation activities, technology modernization was stimulated by FDI, since Argentina was, throughout the past decade, one of the main destinations for inward FDI flows in the developing world. Between 1992 and 2001 more than U$S 76,000 million arrived to the country. Most FDI inflows were, initially, take over of public firms (privatizations) and then of private domestic enterprises. As a result of these take over, the number of foreign affiliates among the 1000 largest firms in Argentina increased from 199 to 472 and their share in the sales of those leading firms grew from 39% in

1992 to 67% in 2000. While services such as telecommunications, electricity, water and banks accounted for 41% of FDI inflows, the manufacturing sector received 22% of FDI inflows.

Chudnovsky, López and Rossi (2004) analyzed econometrically whether domestic firms reaped positive or negative productivity spillovers from the presence of TNCs affiliates in manufacturing industry during the nineties. Their main finding was that while TNCs affiliates have clearly higher productivity levels than domestic firms, the latter, on average, received neither positive nor negative spillovers from the growing presence of foreign firms. However, domestic firms with high absorption capabilities tended to reap positive spillovers while those with low absorption capabilities had been more likely to receive negative spillovers.

Regarding the environmental performance of Argentine industrial firms since the early 1990s, very little information is available since no official statistics exist on the resources devoted to environmental protection or the pollution levels generated by the manufacturing industry. Hence, it is not possible to examine the environmental performance of the Argentine industrial firms as such.

While the local environmental regulations are quite stringent, "the most critical constraint for improving the management of pollution in Argentina is the absence of clear institutional responsibility for environmental management and the lack of effective enforcement" (World Bank, 1995). While some progress has been made on the institutional responsibilities for environmental management, there is a wide consensus that their enforcement is weak due to a lack of political will and/or resources to adequately monitor the environmental performance of local firms. This situation is aggravated by the existence of a multiplicity of provincial and national regulations on the same resource (appendix I describes the main features of the Argentine environmental regulatory system). Nonetheless, because of regulations, pressures from domestic and foreign consumers, and pressure by local communities, the environmental management is more diffused in Argentine firms, especially in the case of large firms as reflected in the Second Innovation Survey. The fact that the number of ISO 14001 certifications rose from 9 in 1997 to 343 by April 2004 is also a reflection of this situation.

IV. Environmental management activities in the manufacturing industry

The Second Innovation and Technological Behavior Survey (INDEC-SECYT-CEPAL, 2003) constitutes the first representative sample of the universe of industrial firms to cover environmental management issues in Argentina. However, since there is no data regarding the types and/or levels of pollutants emitted by industrial firms in our country, it is not possible to study firms' environmental performance directly. For this reason, the focus of our analysis is on the EMA undertaken by the surveyed firms and the motivations that led them to adopt such practices.

The dataset we employed for analyzing environmental practices in the Argentine manufacturing industry collects information of 716 firms for the period 1998-2001. Most of them (69% of our dataset) were created before 1975 –and, therefore, were born during the import-substitution phase-, while only 7% were created during the 1990s. Small and medium enterprises (SMEs) and domestic firms account for the majority of our panel: 83% of the sample (593 firms) employed less than 300 employees in 2001. In turn, as shown in table 1, the share of foreign firms (i.e. firms with a participation of foreign capital higher than 10%) increased from 18% in 1998 to 20% in 2001. The latter is explained by the acquisition of indigenous firms by TNCs.

Expectedly, as table 1 show, the adverse macroeconomic context during the final years of the last decade, reflected in the performance of manufacturing firms during these years. During 1998-2001, average total sales decreased by 14%. In turn, total employment showed a decreasing trend. In 2001, the average number of employees in manufacturing firms was 9.5% smaller than in 1998.

TABLE 1 – Basic statistics for manufacturing firms. 1998-2001

	Average	
	1998	**2001**
Total Sales (1998=100)	100	86
Total employees	242	219
Percentage of foreign firms in the sample	18	20

Turning to environmental issues in the manufacturing industry, the Survey included the following questions:

i) What types of environment management activities did the firms undertake during 1998-2001?

ii) Which were the main motivations for engaging in environmental management activities?

TABLE 2 – Sectoral distribution of surveyed firms in 1998-2001

Sector	Number of Firms	Firms that undertook EMA (%)
Food & beverages	145	62
Tobacco	1	100
Textile & apparel	67	30
Clothing	15	13
Leather & footwear	13	62
Wood & wood products & cork processing, except furniture	20	35
Pulp, paper & paper products	21	57
Publishing & printing	38	42
Petroleum	7	100
Chemicals	75	71
Rubber & plastics	45	64
Non-metallic minerals	38	58
Steel & aluminum	24	71
Metal products, except machinery & equipment	39	41
Machinery & equipment	59	54
Electrical machinery & apparatus	24	58
Radio, TV & communication equipment	8	50
Medical, precision & optical instruments	10	30
Automotive & transport equipment	30	53
Other transport equipment	10	20
Manufacture of furniture & other industrial activities	27	41
TOTAL	**716**	**53**

Regarding the first of these questions, as shown in table 2, 53% of the firms in our dataset engaged in environmental activities[2]. Notably, there is a significant dispersion around this average across sectors. The latter might reflect sectoral differences in regulation enforcement or technological opportunities. Among the largest sectors of the manufacturing industry (food and beverages, chemicals, textiles, and machinery and equipment, which accounted for almost one half of the firms), only the textile sector presented a proportion of firms undertaking EMA smaller than the industry average.

[2]. Although we do not have international benchmarks regarding specifically the undertaking of environmental activities at firm-level, it could be inferred from previous papers on Mexico and Indonesia (Dasgupta et al, 2000; Afsah et al, 1996) that this percentage -53%- is around the average for developing countries.

TABLE 3 – Descriptive statistics for firms with and without EMA

		Firms that undertook EMA	**Firms that did not undertake EMA**
Total sales (millions of dollars)	1998	61.6	10.7
	2001	54.2	7.5
	% change	-12.0	-29.9
Total employees	1998	343	125
	2001	317	107
	% change	-7.6	-14.4
Skilled employees (%)	1998	40	27
	2001	43	29
	% change	7.5	7.4
Foreign firms (%)	1998	27	9
	2001	29	9
R&D / sales (%)	1998	0.33	0.08
	2001	0.37	0.14
	% change	12.1	75.0
Technology acquisition / sales (%)*	1998	1.92	0.75
	2001	1.38	0.32
	% change	-28.1	-57.3
Innovators (%)**		84	31
* Technology acquisition includes expenditures in capital goods (related to innovation activities within the firm) and technology transfer (patent rights, licenses, trademarks, and designs) acquired domestically or abroad in 1998.			
** Firms that introduced new products or processes during 1998-2001.			

Table 3 shows that there are sharp differences among firms that had and had not undertaken EMA during 1998-2001. The former were larger and better performing firms, as measured by the number of employees and total sales, respectively. In addition, they employed more skilled labor and engaged in innovation expenditures more intensively (as shares of sales) both in 1998 and in 2001. Therefore, it is unsurprising to find that while 84% of the firms that undertook EMA became innovators (i.e. introduced new products or processes) during that period, less than a third of the firms without EMA managed to do so.

Finally, the presence of foreign firms was markedly higher among firms that undertook EMA. Moreover, as shown in table 5 (see below), while almost half of the domestic firms undertook EMA, almost 80% of the foreign firms did so.

The types of environmental activities covered by the innovation survey are shown in table 4. Efficiency improvements in the use of water, energy and other resources were

the most widespread environmental activity (36% of the firms), followed by effluent treatment (31%) and recycling (26%).

TABLE 4 – Type of EMA in surveyed firms. 1998-2001

EMA type	Firms (%)
Incorporated treatment and waste disposal systems	31
Implemented environment remediation actions	18
Improved water, input and energy use efficiency	36
Established in-site or off-site recycling	26
Replaced or modified pollutants processes	21
Substituted pollutant inputs or raw materials	18
Developed more environment-friendly products	11
Achieved Environmental Management certification*	8
Other EMA	5
* ISO 14001, IRAM 3800, OHSAS	

With the purpose of analyzing the determinants of the quality of the environmental management in the manufacturing industry, the information in table 4 was used to group the firms into four mutually exclusive categories, according to the quality of the EMA they undertook during 1998-2001 (see Chidiak and Gutman, 2004):

Complex clean production management: firms that undertook at least one of the following activities:

- Replaced or modified pollutants processes;
- Substituted pollutant inputs or raw materials;
- Developed more environment-friendly products;
- Achieved Environmental Management certification.

Simple clean production management: firms that were engaged in at least one of the following EMA, but did not undertake complex CP management activities:

- Improved water, input and energy use efficiency;
- Established in-site or off-site recycling**.**

End-of-pipe´ management: firms that were engaged in at least one of the following EMA, but did not undertake any other activity mentioned in table 4:

- Incorporated treatment and/or effluent and waste disposal systems and equipment into the facility;
- Implemented environment remediation actions;
- Other EMA.

No environmental management: Firms that have not undertaken EMA.

In this way, the category `End-of-pipe´ refers to a set of corrective practices based on the identification, processing and disposal of discharges or wastes after they have been

generated. In general, this kind of activities imply the use of retrofit technologies, pollution management and contract services (on-site or off-site) designed to change the physical, chemical, or biological character or composition of any hazardous pollutant that enters any waste stream or that is released to the environment (including fugitive emissions), in order to render it non hazardous (or less hazardous) and, therefore, safer to transport, store or dispose. This category also includes waste disposal, which refers to the final placement, destruction or disposition of wastes, e.g. solid waste management by landfill disposal or liquid effluents disposal by injection wells.

In turn, firms grouped under `Simple clean production´ have managed to establish a preventive approach that aims at increasing overall efficiency and reducing risks to humans and the environment. Specifically, `clean production´ refers to a conceptualization of goods and services production that encompasses the minimum environmental impact under present technological and economic limits[3]. This category includes recycling, i.e. the off-site processing or on-site (post-process) processing of waste for an alternative use, comprising the recovering of liquid, solid, or gaseous wastes and their reuse in the same or another production process.

Finally, `Complex clean production´ also implies a forward-looking, 'anticipate and prevent' philosophy aimed at protecting the environment, the consumer and the worker while improving profitability and competitiveness. But, in addition, firms grouped in this category have selected and used new technologies, inputs or practices for reducing or eliminating the creation of pollutants at the source and increasing industrial efficiency at the same time, as well as the achievement of Environmental Management Certifications[4].

The distribution of the firms in our dataset according to the quality of their environmental management and nationality is summarized in table 5. In general, it is clear that although 47% of the firms were not engaged in EMA, there is a concentration of firms around higher quality environmental management among those facilities that were engaged in EMA. For example, considering the whole sample, the number of firms that undertook complex CP (30%) was five times larger than those that undertook EOP management (6%). At the same time, foreign firms have introduced complex CP far more often than domestic firms.

3. See http://www.unep.org

4. Environmental management certifications comprise a set of internationally accepted standards that help firms improve their environmental performance, enhance compliance, prevent pollution, conserve resources, reduce and/or mitigate risks, increase efficiency and enhance image with public, regulators, lenders and investors. Certification of ISO 14001 standard, for example, implies the acceptance of the world's most recognized framework for implementing Environmental Management Systems, which are standardized cycles of planning, implementing, reviewing and improving processes and actions that help organizations meet their business and environmental goals and address all three dimensions of sustainable development: social, economic and environmental. See http://www.epa.gov/ems/info/index.htm

TABLE 5 – Quality of EMA and firm nationality

EMA	Firms (%)		
	All	Domestic	Foreign
No environmental management	47	52	22
End-of pipe	6	6	5
`Simple´ clean production	18	18	18
`Complex´ clean production	30	24	55

As regards the second question included in the innovation survey -the motivations for undertaking the EMA described in table 4-, we pay attention to a subset of the motivations enquired in the survey, presented in table 6. Our interest lies in the need to comply with local environmental regulations (or, "regulatory pressure"), which was identified as a motivation for undertaking EMA by 33% of the firms in the sample. In turn, as a benchmark for comparison, improving the firms' environmental image (which is a source of "market pressure") was a motivation for undertaking EMA in 29% of the firms in our dataset.

TABLE 6 – Motivation for undertaking EMA in surveyed firms. 1998-2001

Motivation	Firms (%)
Comply with local environmental regulations	33
Improve the firm's environmental image	29

V. Empirical analysis

In order to answer the research questions presented in the introduction of this study, this section analyses econometrically the impact of environmental regulation and the determinants of the EMA in Argentine manufacturing firms during 1998-2001. The econometric exercises are based on the dataset of 716 firms described above.

Two regressions were estimated. First, we intend to explain the determinants of both the probability of undertaking EMA and of their quality. A natural approach was to estimate a multinomial logit (MNL) model, where the dependent variable indicated the type of environmental management in each firm, according to the categories presented in table 4. Therefore, the response probabilities in this model are:

$$P\left(EM_{ij} = k_{ij} \mid I_i, X_{ij}\right) = \frac{\exp\left(\beta^k I_i + \gamma^k X_{ij}\right)}{1 + \sum_k \exp\left(\beta^k I_i + \gamma^k X_{ij}\right)}, \qquad k = E, S, C \tag{1}$$

In addition, a usual identification restriction in the MNL model is to define a base category or "comparison group", by setting its parameters equal to zero. In our case, the

comparison group is the set of firms without environmental management. Thus, $b^N \equiv j^N \equiv 0$, and

$$P\left(EM_{ij} = N_i \mid I_i, X_{ij}\right) = \frac{1}{1 + \sum_k \exp\left(b^k I_i + j^k X_{ij}\right)}, \qquad k = E, S, C \qquad (1')$$

Where

EM_{ij}: dependent variable indicating the environmental management quality in firm i in sector j, classifying it either as a EOP (E), simple CP (S), complex CP (C), or no environmental management (N)

I_i: $I_i^k = b_1^k RD_i + b_2^k TA_i + b_3^k OWN_i + b_4^k PRES_i + b_5^k OWN_i * PRES_i + b_6^k REG_i$, is the vector of variables of interest

RD_i and TA_i are R&D and technology acquisition expenditures in firm i, as shares of total sales in 1998.

OWN_i is a dummy variable equal to one if firm i is foreign (i.e. it has a share of foreign capital larger than 10%).

$$PRES_j = \frac{\sum_j Sales_{ij}\, I(OWN_{ij} \geq 10\%) I(EMA_{ij} = 1)}{\sum_j Sales_{ij}},$$

is the foreign EMA presence in sector j (53 sectors, at the three-digit level of aggregation)[5], indicating the share of 1998 sectoral sales of foreign firms that were engaged in EMA during 1998-2001[6].

REG_i is a dummy equal to one if firm's i EMA were motivated by local environmental regulations.

X_{ij}: vector of firm specific control variables in 1998 (size, labor skills, exports, image), a constant term, and 20 industry dummies to include sectoral fixed effects (see table 2) [7].

Whenever possible, we try to measure the explanatory variables at the beginning of the period during which EMA where surveyed (1998-2001). In this way, we intend to assess

[5]. In this way, as opposed to the descriptive statistic presented in table 3, which described sectors at the two-digit level, the variable included in the regression is measured at a more disaggregated level. Otherwise, this variable would be linearly dependent with the two-digit sectoral dummies that were also included in the regression.

[6]. *I(?)* is an indicator function equal to one if condition *?* is met. EMA_{ij} is a dummy variable equal to one if firm i engaged in EMA during 1998-2001.

[7]. The exact definition of these variables is provided in the appendix II.

if the explanatory variables at the beginning of the period (1998) affected EMA undertaken in subsequent years. This approach is convenient to mitigate the endogeneity or reverse causality problems in the estimation.

Turning to the specification of the MNL model, we include firm-specific characteristics such as size, skilled labor, export intensity and two-digit sectoral dummies as explanatory variables, in order to control for observed heterogeneity and proxy for unobservable factors that affected EMA at the firm level.

According to the research questions posed in the introduction, our focus is, however, on the effect of innovation expenditures, the foreign ownership and foreign EMA presence variables and, finally, on the environmental regulatory pressure indicator. We describe these interest variables in turn.

As mentioned in the introduction, from the perspective of the Argentine development process during the 1990s, it is relevant to assess whether manufacturing firms' investments in technology modernization contributed to the quality and diffusion of EMA. Therefore, our analysis intends to shed light on whether the intensity of in-house R&D and external technology acquisition expenditures (RD_i and TA_i) undertaken by local firms affected the probability of undertaking EMA and/or their quality during 1998-2001.

In table 5, we can see that there is a concentration of foreign firms around higher quality environmental management. Nevertheless, this observation may hide the fact that foreign firms might also be larger or more skill intensive. Therefore, the foreign ownership variable (OWN_i) provides further insight to evaluate whether foreign firms have, *ceteris paribus*, greater probabilities of engaging in higher quality environmental management than domestic firms.

The foreign EMA presence variable ($PRES_i$) captures firm-level externalities on the type of EMA undertaken in firm *i* during 1998-2001, derived from the presence of foreign firms in the sector where firm *i* is producing. This is the standard way in which a large and recent literature (normally focused in the analysis of firm productivity) has intended to estimate horizontal spillover effects[8]. In order to capture spillovers on domestic firms, the foreign EMA presence variable is interacted with the foreign ownership dummy (*OWN*). In addition, as mentioned in the introduction, our analysis attempts to assess if the existence of spillovers effects is conditional on the absorption capabilities of domestic firms. Therefore, following the usual practice in the received literature on productivity spillovers, the MNL model regression also included an additional interaction between foreign EMA presence and a binary indicator of the level of absorption capabilities at the firm level. This indicator depends on the index of absorption capabilities, which is based, among other things, on the availability of skills

[8]. See Chudnovsky, López and Rossi (2004), for a survey of productivity spillovers and an econometric analysis of the Argentine case.

and technical competences and on the magnitude and nature of the innovative activities performed by domestic firms (see appendix III)[9].

Regarding the analysis of regulation, our focus is on the comparison between firms whose EMA are motivated by local environmental regulations and firms that are not (variable *REGi*). Summarized in table 6, this is the only information concerning environmental regulation available in the Innovation Survey. It is worth emphasizing that this approach does not allow us to draw any conclusions regarding the effects of different environmental regulation schemes *per se*, since we are not comparing regulated and non-regulated firms (or, alternatively, firms exposed to different regulatory schemes) but only considering self-reported motivations for undertaking EMA. This means that we test the impact of *perceived* regulation pressure (i.e. regulations that have been perceived as enforced or enforceable at the firm level) on the quality of manufacturing firms' EMA (EOP or CP management). This is an important point since, as frequently documented in developing countries, in Argentina local environmental regulations are quite stringent, although enforcement is rather loose (see appendix I). As a benchmark for the effect of regulatory pressure, we also include a dummy variable indicating a firm's EMA motivated by the desire to improve its environmental image (variable *IMAGEi*), which is also presented in table 6. This variable is intended to capture the effect a source of "market pressure" on environmental management.

Beyond assessing the impact of environmental regulatory pressure on the quality of environmental management of Argentine manufacturing firms, we also test whether regulation pressure stimulated innovations at the firm level, which is a `byproduct´ hypothesis from the above-mentioned "Porter Hypothesis" debate. The survey provides binary data on the introduction of new (or improved) product and/or process innovations during 1998-2001 (shown in table 3). Therefore, we estimate a probit model in order to explain the probability of obtaining innovations in manufacturing firms during 1998-2001. The usual specification for this model for firm *i* in sector *j* is

$$P(INN_{ij} = 1 \mid REG_i, X_{ij}) = \Phi(bREG_i + jX_{ij}) \qquad (2)$$

Where,

F is the standard normal distribution

INN_{ij} is a dummy equal to one if firm *i* in sector *j* introduced of new (or significantly improved) product and/or process innovations during 1998-2001

REG_i is a dummy equal to one if firm's *i* EMA are motivated by local environmental regulations.

[9]. Using the binary indicator instead of the index of absorption capabilities is conceptually convenient, since it allows a relevant comparison between groups of firms (those with high and low absorption capabilities) and because it would reduce measurement errors derived from the construction of the index.

X_{ij}: vector of firm specific control variables in 1998 (size, labor skills, exports, innovation expenditures, image) [10], a constant term, and 20 industry dummies to include sector fixed effects (see table 2)

Besides including firm and industry level control variables in this regression, we are interested in evaluating if a firm that faced environmental regulatory pressure has, *ceteris paribus*, a higher probability of innovating that a firm that is not subject to such pressure. This requires testing the hypothesis $b > 0$ in equation 2.

VI. Results

In this section, we report the basic findings of the econometric analysis[11]. Further details can be found in appendix II.

Regarding the first of our research questions, the results of the MNL model estimation provided evidence supporting that, after controlling for sectoral effects, the intensity of technology acquisition expenditures, size and firm nationality are important determinants of the diffusion and quality of EMA in the manufacturing industry. In addition, environmental management quality also varies in response to the type of motivation with which firms undertook EMA. These findings are shown in table 7.

[10]. The exact definition of these variables is provided in appendix II.

[11]. Throughout this section, we characterize a variable as "statistically significant" if the p-value of its associated coefficient is smaller than 10%. The definitions of the variables involved in the estimation and a brief explanation of the interpretation of the MNL model estimates are provided in appendix II.

TABLE 7 – Econometric estimations

	Multinomial logistic regression			Multinomial logistic regresión			Probit	
	Environmental management quality			Environmental management quality			Innovation output	
Explanatory Variable	**End of Pipe**	**Simple CP**	**Complex CP**	**End of Pipe**	**Simple CP**	**Complex CP**	**Coeffi-cients**	**Marginal Effects**
Regulatory Pressure (REG)	6.370*** (0.858)	5.365*** (0.793)	5.940*** (0.802)	6.355*** (0.859)	5.342*** (0.796)	5.928*** (0.804)	0.631*** (0.145)	0.202*** (0.042)
Image	4.263*** (0.778)	4.709*** (0.7020916)	5.814*** (0.711)	4.229*** (0.781)	4.669*** (0.705)	5.781*** (0.714)	0.710*** (0.154)	0.220*** (0.043)
OWN	1.943* (1.159)	0.165 (0.797)	-1.141 (0.825)	1.963* (1.158)	0.174 (0.796)	-1.109 (0.826)	-0.090 (0.174)	-0.032 (0.061)
PRES x OWN	-1.797 (3.155)	2.009 (1.741)	5.387*** (1.710)	-1.115 (3.253)	3.090* (1.878)	5.844*** (1.852)	-	-
PRES x HIGHAC	-	-	-	1.137 (1.228)	1.588* (0.945)	0.868 (0.989)	-	-
PRES	1.792 (1.538)	1.290 (1.070)	-0.436 (1.030)	1.141 (1.691)	0.328 (1.246)	-0.895 (1.215)	-	-
Size	0.267 (0.206)	0.363** (0.144)	0.740*** (0.157)	0.240 (0.209)	0.328** (0.147)	0.719*** (0.160)	0.281*** (0.055.)	0.097*** (0.019)
Skills	-.392 (0.891)	0.702 (0.598)	1.046* (0.611)	-0.512 (0.907)	0.538 (0.612)	0.950 (0.623)	0.507** (0.235)	0.174** (0.081)
R&D (RD)	29.393 (36.901)	37.695 (32.956)	38.887 (33.092)	27.929. (35.998)	36.331 (31.866)	37.487 (31.997)	92.429*** (24.201)	31.799*** (7.861)
Technology Acquisition(TA)	5.772 (5.742)	9.264** (3.650)	8.205** (4.097)	5.298 (5.766)	8.804** (3.659)	7.766* (4.107)	19.576*** (3.800)	6.735*** (1.235)
Exports	-3.479** (1.593)	-1.712* (0.964)	-1.510 (0.978)	-3.544** (1.595)	-1.806* (0.964)	-1.586 (0.980)	0.300 (0.328)	0.103 (0.113)

*, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.
NOTE: These regressions include 20 industry dummies that control for sector fixed effects. The estimation results associated to this set of variables are not reported.

As shown in table 7, the estimated impact of innovation activities on EMA is not homogeneous. On one hand, higher intensities of technology acquisition expenditures increases the likelihood of simple and complex CP management with significance levels smaller than 5%. As a consequence, these expenditures boost both the probability of undertaking EMA and the quality of the environmental management at the firm level. On the other hand, in house R&D intensity is not a statistically significant variable in the MNL regression.

Second, the effect of regulatory pressure on environmental management quality is to induce EOP *vis a vis* CP management (although this effect is statistically significant only for "simple" CP). Nevertheless, regarding the effect on clean production activities, regulation pressure makes complex CP a more likely outcome than simple CP. In turn, the other motivation for undertaking EMA considered in this study, i.e. to improve the

firm's environmental image, enhances the quality environmental management, by increasing the relative likelihood of complex CP against simple CP and EOP management. These results are obtained by comparing the magnitude of the estimated coefficients associated to a given explanatory (e.g. the coefficients associated to regulatory pressure) in table 7 and evaluating if their difference is statistically significant[12] (see Appendix II for the results of the tests).

Third, the effect of environmental regulatory pressure on the innovative output of manufacturing firms is to increase the probability of innovating by 20%. This result is statistically significant at the 1% level. In this way, our probit estimations provide evidence that innovative performance in manufacturing firms is stimulated in firms whose EMA are motivated by local environmental regulations. As a comparison to this finding, the effect of undertaking EMA motivated by the desire to improve the firm's environmental image increased the probability of innovating by 22%.

Fourth, turning to the environmental behavior of TNCs, after comparing averages in table 5, we have seen that in relation to domestic firms, foreign firms are more involved in EMA, particularly in complex CP management. These observations are driven, at least in part, by the fact that TNCs are different from domestic firms in several aspects, such as being larger firms with specific scale economies, concentrated in industries which are generally rich in intangible assets and technological opportunities, and so on. However, our econometric analysis enables us to control for these observable firm characteristics, in order to isolate the effects of the ownership status. The MNL model estimation suggests that foreign firms are, *ceteris paribus*, more likely to undertake EMA than domestic firms during 1998-2001. Nevertheless, foreign ownership is also associated to a decrease in the quality of EMA since, in comparison to domestic firms, EOP is relatively more likely than simple and complex CP management. This finding is significant at a 10% confidence level.

Regarding our last research question, the MNL estimation results in table 7 show that the sectoral presence of foreign firms undertaking EMA is a significant determinant of the decision to undertake EMA and of their quality only when domestic firms are classified according to their absorption capabilities. In particular, the spillover effect of foreign presence is to induce, with a statistical significance of 10%, simple CP management in firms with high absorption capabilities. On the contrary, there is no significant effect on environmental management spillovers on domestic firms with low absorption capabilities.

Finally, among the control variables included in the MNL estimation, firm size is an important determinant of the EMA in the manufacturing industry, since larger firms had higher probabilities of undertaking EMA during 1998-2001[13]. In addition, the types of environmental management stimulated by firm size are simple and complex CP

[12]. This procedure is employed repeatedly throughout this section and the interpretation of the results of the MNL model is based on the explanation provided in appendix II.

[13]. Export intensity was also a significant variable in the regression. However, unexpectedly, it had a negative sign, suggesting a negative influence of exporting activities on EMA. This result requires further research.

activities. In turn, it is worth pointing out that, although not reported in table 7, the sectoral dummies included in the regressions are, in general, significant explanatory variables of EMA and their quality. Although our analysis cannot determine which sectoral characteristics explain these results (this explains why we do not deepen our analysis into this issue), it suggests that there is substantial heterogeneity in environmental management across industrial sectors.

VII. Concluding remarks

In this paper, we have analyzed the determinants of the decision to undertake EMA and the quality of environmental management in the Argentine manufacturing industry during 1998-2001. We provide firm level econometric evidence on relevant issues regarding the sustainable development process in Argentine industry.

Briefly, we find that firm size and technology acquisition expenditures increase both the probability of undertaking EMA and the quality of environmental management. In addition, we find a positive impact of environmental regulatory pressure on innovative behavior, though such regulatory pressure induces EOP at the expense of simple CP management. Finally, despite the fact that foreign ownership is associated to a decrease in the quality of environmental management, foreign firms are more prone to undertake EMA and generate positive environmental spillovers, by inducing simple CP management in domestic firms with high absorption capabilities.

In any case, it is of vital importance to handle the reported results with due caution. Although we have measured the explanatory variables at the beginning of the period covered by our dataset and included sector fixed effects in our regressions in order to obtain more robust estimations, endogeneity problems still remain. The latter may stem from the impossibility, given data availability, of controlling for firm fixed effects and other unobservable that may be correlated with both the regressors and the dependent variables. For these reasons, the reported should be interpreted with caution. We prefer to view our findings as indicating conditional correlations between variables, rather than proper causal relationships.

With these caveats, it is still possible to suggest several policy implications that could be drawn from our findings. To begin with, the fact that the frequency and quality of EMA decrease in smaller firms clearly suggests that environmental management policies should be an integral part of the public policies geared towards SMEs. Unfortunately, this is not yet the case in Argentina.

The finding that technology acquisition expenditures (that were composed mostly of imported inputs), but not local R&D outlays, enhance EMA and their quality gives support to the view that developing countries should favor imports to access a larger stock of technology and resources available in the rest of the world in order to enhance environmental management at the firm level.

However, from our finding it is not possible to conclude that liberalization is, at least by itself, the most effective innovation policy instrument to promote environmental management in the manufacturing industry. To assess the importance of policy instruments to foster innovation activities that would complement technology acquisition expenditures, more research is required.

Since many firms (especially SMEs) often make expenditures in innovation activities that are not considered R&D, it would be important to extend our proxy for in-house innovation beyond R&D measures, to include in-house management, design and engineering expenditures related to innovation activities. Further research is needed to investigate to what extent R&D and/or management, design and engineering expenditures related to innovation activities have been a complement or a substitute for technology acquisition.

In turn, it is important to remark that, although most environmental regulations in Argentina are of command and control type, our finding that regulatory pressure induces EMA and innovation in manufacturing firms does not necessarily support this type of regulations as an effective policy instrument. As mentioned in the introduction, due to data constraints, we have not compared firms exposed to different regulatory schemes; instead, we test the impact of perceived regulatory pressure. Therefore, our finding does not give support to a particular regulatory scheme, but rather to the importance of the actual enforcement of prevailing regulations to promote EMA.

Furthermore, it is promising to have found a strong and positive conditional correlation between regulatory pressure and innovation output at the firm level. This finding suggests that regulatory pressure has the potential to provide incentives for innovation and quality improvement which are necessary, although may not be sufficient, to offset a reduction in firm competitiveness stemming from environmental regulations. Deepening our understanding of the possible impacts of environmental regulation requires, however, enhancing the quality of available data.

The contribution of TNCs to the diffusion of environmental practices in the manufacturing industry appears to have been, overall, positive. Although, our econometric analysis suggests that foreign ownership might induce, *ceteris paribus*, lower quality environmental management, TNCs also differ from domestic firms in other respects that enhance EMA (e.g. being larger firms with higher intensities of technology acquisition). In fact, compared to local firms, a larger share of foreign firms undertook EMA, which were, on average, more concentrated around higher quality environmental management. This overall effect is probably what policy makers are actually interested in.

In addition, an important policy lesson that arises from our analysis of spillovers is that developing countries which attract significant FDI inflows should not take for granted that domestic firms will benefit from TNCs presence, since this will mainly happen when absorption capabilities are present to receive spillover effects. Hence, policies aimed at fostering in a sustained and continuous manner those capabilities (i.e., to

promote the use of skilled personnel in SMEs, the undertaking of in house innovative activities, etc.) need to be considered as part of the policy agenda in this area.

Needless to say, it is relevant to extend our empirical analysis of spillovers to include inter-industry (backward) spillovers. On one hand, it is not surprising to find limited evidence of horizontal spillovers (TNC presence stimulating only simple CP management in domestic firms with high absorption capabilities) since foreign firms have an incentive to avoid technology leakages to competitors in the local market. Nevertheless, this situation should not be expected to hold with respect to suppliers of TNCs and explains a greater potential for finding backward spillovers to domestic firms.

References

Anton, W., Deltas G. & M. Khanna (2004): "Incentives for environmental self-regulation and implications for environmental performance", *Journal of Environmental Economics and Management*, vol. 48, issue 1, pages 632-654.

Barton, J. (2002): "The iron and steel sector", in Jenkins, Barton, Bartzokas, Hesselberg and Knutsen: Environmental regulation in the new global economy: The impact on industry and competitiveness, Edward Elgar.

Bartzokas, A. (2002): "Environmental Regulation and Industrial Restructuring: The Case of the Fertilizer Industry", in Jenkins et al op cit.

Bhattacharya, A. (2002): "Environmental Technology Diffusion in a FDI Regime: A developing Country Perspective", University of Mumbai, Department of Economics, Mumbai, India. Paper prepared for the presentation at the CSI Conference 2002; International Institutions and Multinational Enterprises: Global Markets, Global Players; at the University of Innsbruck; Innsbruck, Austria 20-22 November.

Borger, G. and I. Kruglianskas (2004): "Corporate social responsibility and environmental and technological innovation performance: case studies of Brazilian companies", *International Journal of Technology, Policy and Management: Special Issue on Systems and Policies Fostering.*

Borregaard, N. and A. Dufey (2002): "Environmental effects of foreign investment versus domestic investment in the mining sector in Latin America", document presented at the OECD Global Forum on International Investment, Conference on `Foreign Direct Investment and the Environment: Lessons to be Learned from the Mining Sector´, 7 - 8 February 2002, Paris, France

Cetrángolo, O.; Chidiak, M.; Curcio J. & V. Gutman (2004): "Política y gestión ambiental en Argentina: gasto y financiamiento", CEPAL, *Serie Medio ambiente y desarrollo* No. 90 LC/L.2190-P, octubre.

Chidiak M. & V. Beláustegui (2002): "Revisión de políticas vinculadas a tema ambientales y tecnológicos en Argentina", Informe del Proyecto `Estrategia Nacional de Producción Limpia´, UNDESA-SAyDS, Buenos Aires

Chidiak M. & Gutman V. (2004): "Características, motivaciones y obstáculos a la gestión ambiental en la industria argentina: resultados de la Segunda Encuesta de Innovación y Conducta Tecnológica", mimeo, CEPAL.

Chudnovsky D & M. Chidiak (1995): "Competitividad y medio ambiente. Claros y oscuros en la industria argentina", CENIT, *DT 17*, Abril.

Chudnovsky D. and A. López (2002): "The literature on environmental practices of TNCs", in M. Hansen (ed), Managing the environment across borders: A study of environmental management practices at affiliates of transnational corporations in China, Malaysia and India, Copenhagen, Samfundslitteratur.

Chudnovsky D., López A. and V. Freylejer (2000): "The diffusion of pollution prevention measures in LDCs: environmental management in Argentine industry", in Industry and Environment in Latin America (ed. by Rhys Jenkins), Routledge, London.

Chudnovsky D., López A. and Pupato G. (2004) "Innovation and productivity: A study of Argentine manufacturing firms' behavior (1992-2001)", Working paper number 70, Department of Economics, UDESA. May.

Chudnovsky D., López A. and Rossi G. (2004), "Foreign Direct Investment spillovers and the absorption capabilities of domestic firms in the Argentine manufacturing sector (1992-2001)", Working paper number 74, Department of Economics, UDESA, July.

Dasgupta, S., H. Hettige and D. Wheeler (2000). "What Improves Environmental Compliance? Evidence from Mexican Industry", *Journal of Environmental Economics and Management* 39, pages 39-66.

Dasgupta, S., Laplante, B. and N. Mamingi (1997): "Pollution and Capital Markets in Developing Countries", World Bank Development Research Group, Working Paper Series (available at http://www.worldbank.org/nipr/work_paper/market/)

Dean, J. (2005): "Are foreign investors attracted to weak environmental regulations? Evaluating the evidence from China", World Bank Policy Research Working Paper 3505, February.

Di Paola, M. (2002): "Governmental Coordination and Hazardous Waste Enforcement in Argentina", presented at the `6th International Conference on Environmental Compliance and Enforcement´, organized by INECE (International Network on Environment Compliance and Enforcement), San José, Costa Rica, April 15-19, 2002.

Dowell, G., S. Hart and B. Yeung (2000): "Do corporate global environmental standards create or destroy market value?, *Management Science* 46 (8), pages 1059-74.

Eskeland, G and A. Harrison (2002): "Moving to greener pastures? Multinationals and the pollution haven hypothesis", National Bureau of Economic Research, Working Paper 8888, available at http://www.nber.org/papers/w8888

Ferraz, C.; Peterson Zwane, A.; Seroa da Motta, R. and T. Panayotou (2002): "How do firms make environmental investment decisions? Evidence from Brazil", *Center for International Development at Harvard University.*

Gentry, B. (1998): Private Capital Flows and the Environment: Lessons from Latin America, Edward Elgar Publishing Inc.

Hansen, M. (1999): “Cross border environmental management in transnational corporations. An analytical framework”, Report as part of UNCTAD /CBS Project: `Cross Border Environmental Management in Transnational Corporations´, Occasional paper no. 5.

Hesselberg, J. and H. Knutsen (2002): “Leather Tanning: Environmental Regulations, Competitiveness and Locational Shifts”, in Jenkins, Barton, Bartzokas, Hesselberg and Knutsen: Environmental regulation in the new global economy: The impact on industry and competitiveness, Edward Elgar.

INDEC (1998): Encuesta sobre la conducta tecnológica de las empresas industriales argentinas, *Serie Estudios* No. 31, Buenos Aires.

INDEC-SECYT-CEPAL (2003): Segunda Encuesta Nacional de Innovación y Conducta Tecnológica de las Empresas Argentinas, Serie Estudios No. 38, Buenos Aires.

International Standard Organization – ISO: http://www.iso.org

International Standard Organization - ISO (2002): Environmental Management: the ISO 14000 Family of International Standards, ISO Publications

Jaffe A. & K. Palmer (1997): “Environmental regulation and innovation: a panel data study”, *Review of Economic and Statistics*, Vol. 79, pages 610-19.

Kaiser, K. and G. Schulze (2003): “International Competition and Environmental Expenditures: Empirical Evidence from Indonesian Manufacturing Plants”, Hamburg Institute of International Economics, HWWA Discussion Paper 222.

Khanna M. & L. Damon (1999): "EPA´s voluntary 33/50 program: impact on toxic releases and economic performance of firms", *Journal of Environmental Economics and Management*, 37(1), pages 1-25, January.

Khanna M. and R. Anton (2002): "Corporate environmental management: regulatory and market-based incentives", *Land Economics* November, vol. 78, No. 4, pages 539-558

Lustosa, M (2001): “Innovation and environment under an evolutionary perspective: evidence from Brazilian firms”, Danish Research Unit for Industrial Dynamics, Electronic paper BoA-237, available at http://www.druid.dk/conferences/nw/conf-papers.html

Meyer, K. (2003): “FDI Spillovers in Emerging Markets: A Literature Review and New Perspectives”, Center for new and emerging markets, London Business School, DRC Working Paper Nº 15.

Nakamura, M.; Takahashi and I. Vertinsky (2001): "Why Japanese Firms Choose to Certify: A Study of Managerial Responses to Environmental Issues", *Journal of Environmental Economics and Management*, vol. 42, issue 1, pages 23-52.

Otero, I.; Peterson Zwane, A. and T. Panayotou (2002): "How do firms make environmental investment decisions? Evidence from Venezuela", *Center for International Development at Harvard University* .

Porter M. (1991):"America´s green strategy", *Scientific American*, Vol. 264, 186.

Porter, M. & C. van der Linde (1995): "Towards a new conception of the environment-competitiveness relationship", *Journal of Economic Perspectives*, Vol. 9, No. 4, Fall.

Ruud, A. (2001): "Environmental Management of Transnational Corporations in India: Are TNCs Creating Islands of Environmental Excellence in a Sea of Dirt?", University of Oslo, Centre for Development and the Environment, Working Paper No. 1/01.

U.S Environmental Protection Agency (EPA): http://www.epa.gov

Wheeler, D. (2000): "Racing to the Bottom? Foreign Investment and Air Quality in Developing Countries", Development Research Group, World Bank.

World Bank (1995) "Argentina. Managing Environmental Pollution: Issues and Options", Environmental and Urban Development Division Washington DC.

Zarsky, L. (1999): "Havens, halos and spaghetti: untangling the evidence about foreign direct investment and the environment", Conference on `Foreign Direct Investment and the Environment, The Hague, Netherlands, 28-29 January´.

Appendix I - Main features of the Argentine environmental regulatory system

Environmental regulations in Argentina –like in almost every country of the world- are mostly based on *command-and-control* instruments, i.e. environmental management standards -such as emission standards, technological standards, product standards, input standards, and etc.- with which polluters must comply. The most common ones are environmental quality standards and emission regulations[14], which are usually combined with incompliance sanctions (e.g., fines). Nevertheless, the latter have been rarely implemented due to, on the one hand, the scarce dissuasion power during the high inflation period (fines lost real value) and on the other hand, the multiple administrative procedures required for implementation (e.g., for verifying polluter's incompliance) (see Cetrángolo et al, 2004; Chidiak & Beláustegui, 2002).

In turn, the use of economic incentives in Argentina is scarce. It is worth mentioning, for example, Law Nº 3.966, which establishes a differential tax on lead fuel in order to reduce its content; Decree 674/89, which imposed a special fine –not effectively implemented- for firms whose liquid effluents were above a permitted limit; a subsidy system for reconverting taxis into CNG[15] and a levy that hazardous wastes generators and operators must pay (this is the clearest case of implementation of an economic instrument in Argentina) (see Cetrángolo et al, 2004).

With regards to voluntary agreements, the main examples refer to the agreements signed, on the one hand, among some oil companies and the national and local governments in order to implement an environmental management plan aimed at reducing pollution in Colorado River and, on the other hand, the cleaner production agreements signed by the authorities (both provincial and national) and the firms located in Salí Dulce River watershed, aimed at the firms´ productive conversion (Chidiak & Beláustegui, 2002).

Finally, there do not exist in our country neither `dissemination systems of negative information´ nor tradable permits systems[16].

With regards to `sectoral´ environmental legislation, unlike developed countries, in Argentina there are almost no specific considerations affecting each productive sector. On the contrary, environmental regulation is defined, basically, according to the types of effluent emanated from productive processes in general (liquid, solid, gaseous, hazardous[17] wastes) and the media affected by the discharges (air, water, soil).

[14]. For example, Law Nº 20.284 has settled air quality standards, while decrees 674/89 and 776/92 established emission standards for industrial facilities located in and around Buenos Aires City.
[15]. Compressed Natural Gas
[16]. Nevertheless, these systems are not massively implemented worldwide, with some exceptions, such as U.S.A.
[17]. It was not until 1992 that hazardous wastes management was included into national environmental legislation, specifically, with the sanction of Law Nº 24.051/92.

Historically, Argentine environmental regulatory framework has been limited to requiring EOP treatment of emissions, therefore imposing few stimuli for firms´ adopting `clean production´ strategies. However, in 2002, four Minimum Standards[18] laws for environment protection were sanctioned[19], introducing the `prevention´ principle in our legislation and the possibility of applying penal sanctions if an environmental crime is committed. Regarding prevention, Law Nº 25.675/02 establishes that instead of focusing on *a posteriori* pollution effects, firms must be concerned with the causes and sources of their environmental contamination, trying to impede the negative effects that their productive activities impose on the environment.

However, it is worth mentioning that environmental enforcement in Argentina suffers from several problems, mainly the lack of enforceable legislation and concurrent, divergent, and overlapping responsibilities of the federal government and the provinces. This generates intergovernmental tensions generally related to power allocation, coordination, implementation oversight, resource distribution, and institutional weakness (Di Paola, 2002). In fact, some authors argue that regulatory pressure is potential rather than real, given that authorities know that forcing compliance to current norms -which are highly exigent- could create, in the short run, critical situations for the majority of installed firms (Chudnovsky & Chidiak, 1995).

Nevertheless, the importance that firms assign to these potential regulatory pressures should not be underestimated. In fact, during the nineties, some judicial procedures determined the closure of some industrial facilities. The threat of a possible closure -which clearly affects a firm's image- as well as the possibility of having the penal sanctions contemplated in the new legislation applied, are tending to make local managers, in general, more concerned about implementing environmental management practices in manufacturing firms in our country (Chudnovsky & Chidiak, 1995; Chudnovsky, López & Freylejer, 2000).

[18]. A `minimal standard´ refers to any norm that establishes uniform or common environmental precepts for the whole national territory with the aim of assuring environmental protection.

[19]. Law Nº 25.675/02 (Environment Sustainable Management); Law Nº 25.612/02 (Industrial and Services Activities Wastes Integral Management); Law 25.688/02 (Water Environmental Management) and Law Nº 25.670/02 (PCBs (Polychlorinated Biphenyls) Management and Elimination).

Appendix II – Econometric analysis

TABLE A1 – Definition of variables

VARIABLE	DEFINITION
Environmental management quality (EM)	Indicator of environmental management quality, classifying it either as a EOP (E), simple CP (S), complex CP (C), or no environmental management (N)
Innovation output (INN)	dummy equal to one for firms that introduced of new (or significantly improved) product and/or process innovations during 1998-2001
R&D (RD)	Share of R&D expenditures in total sales in 1998
Technology acquisition (TA)	Share of technology acquisition expenditures in total sales in 1998. Technology acquisition includes expenditures in capital goods (related to innovation activities within the firm) and technology transfer (patent rights, licenses, trademarks, designs) acquired domestically or abroad
Regulatory pressure (REG)	Dummy equal for firms whose EMA were motivated by coping with local environmental regulations
Image	Dummy equal for firms whose EMA were motivated by enhancing the firm's coping with local environmental regulations
Foreign Ownership (OWN)	Dummy equal to one if foreign capital share is equal or greater than 10%
PRESj	Foreign EMA presence in sector j (53 sectors, at the three-digit level of aggregation) , indicating the share of 1998 sectoral sales of foreign firms that were engaged in EMA during 1998-2001. See the formula definition in Section V.
PRES x OWN	Interaction term between PRESj and OWN
High absorption capabilities (HIGHAC)	Dummy equal to one for domestic firms with an absorption capabilities index higher than the median for domestic firms (see appendix III)
PRES x HIGHAC	Interaction term between PRESj and HIGHAC
Size	Total employees in 1998 (in log)
Skills	Average share professional and technical labor in 1998
Exports (Expo)	Share of exports in total sales in 1998

Interpretation of the MNL model estimations

The relative magnitudes of the effects of the explanatory variables on the environmental management outcomes are shown by the difference in the coefficients reported in table 7. Specifically, for a given explanatory variable I, the difference in the coefficients captures the change in the logarithm of the odds ratio (quotient of probabilities) between two outcomes –i.e. $\log\left[\frac{p_j(I,b)}{p_h(I,b)}\right] = I\left(b^j - b^h\right)$, where I is the variables of interest and P and ß are, respectively, the probabilities and coefficients for the environmental

management outcomes j and h[20] (see equation 1 and 1'). The intuition is that if, for a given explanatory variable, the difference between two coefficients is not statistically significant, then that variable does not differentiate the two outcomes (in the sense that their relative likelihood is not altered).

[20]. Note that such change does not depend on a particular set of values of the independent variables.

Test of coefficient equality (from the multinomial logit regression in table 7)

	End of Pipe vs. Simple CP	**End of Pipe vs. Complex CP**	**Simple CP vs. Complex CP**
Regulatory Pressure (REG)	chi2(1) = 5.73 Prob>chi2=0.0166	chi2(1) = 0.99 Prob>chi2=0.3186	chi2(1) = 4.39 Prob>chi2=0.0362
Image	chi2(1) = 1.14 Prob>chi2=0.247	chi2(1) = 13.33 Prob>chi2=0.0003	chi2(1) = 15.74 Prob>chi2=0.0001

Appendix III - The indices of absorption capabilities and technological behavior

The Absorption Capabilities Index (ACI) was built on the basis of different variables related to quantitative, qualitative and qualitative-quantitative technological factors that the firms answered in the survey. Following Yoguel and Rabetino (2002), for each variable a ranking was constructed with values ranging between 1 and 5, and then the index was calculated weighting those values[21]. In this way, a firm with an ACI near to 5 has high absorption capabilities, while its capabilities are low if the ACI is close to 1 (which are, respectively, the maximum and the minimum value for the index):

$$ACI = (0.3 * Quantitative) + (0.5 * Qualitative) + (0.2 * Quantitative \& Qualitative) \quad ; 1 \leq ACI \leq 5$$

In the case of foreign firms, we built an Index of Technological Behavior (ITB) taking into account only the quantitative variables (the procedure was similar to that described above for the ACI index).

[21]. In order to test the sensibility of the index, we used another set of weights (also proposed by Yoguel and Rabetino), finding that the distribution of the firms was very similar in all cases.

1) Quantitative aspects

	Weight	Level 1	Level 2	Level 3	Level 4	Level 5
R&D employees relative to total employment	0.30	0	Until 4%	4% - 7.8%	7.8% - 11.9%	Higher than 11,9%
Expenditures in consultancy relative to sales	0.15	Non-existent	Until 0.5%	Until 1%	Until 5%	Higher than 5%
Expenditures in innovations activities relative to sales	0.25	Non-existent	Until 0.1%	Until 0.3%	Until 1%	Higher than 1%
Payments for technology transfer relative to sales	0.05	Non-existent	Until 0.3%	Until 0.4%	Until 0.5%	Higher than 0.5%
Expenditures in capital goods related to new process or new products relative to sales	0.25	Non-existent	Until 1%	Until 2.5%	Until 5%	Higher than 5%

2) Qualitative aspects

	Weight	Level 1	Level 2	Level 3	Level 4	Level 5
Degree of formalization of R&D activities	0.35	Neither formal nor informal	Informal	Formal	-	Formal and Informal
Use of modern organizational techniques	0.10	None	One or two techniques not included in the following combinations	*Manufacturing Resources Planification* (MRP) and *Just in Time* (JIT) or both and one of those include in level 4	Production cells and/or U shaped lines and teamworks	*Manufacturing Resources Planification* (MRP), *Just in Time* (JIT), production cells and/U shaped lines and teamworks
Importance assigned to product innovation in firms' strategies	0.35	Until 1	2	3	4	5 and 6
Use of information technology in the relationships with customers and suppliers	0.05	Non-existent	-	Internet	Internet and connection with suppliers **OR** clients	Internet and connection with suppliers **AND** clients
The importance of tacit and codified sources of technological information	0.15	0	Until 0.35	Until 0.45	Until 0.55	Higher than 0.55

3) Quantitative-Qualitative aspects:

	Weight	Level 1	Level 2	Level 3	Level 4	Level 5
Expenditures in training activities relative to sales	1	No training activity	Training activity without expenditures	Training expenditures lower than 0.5%	Training expenditures lower than 5%	Training expenditures higher than 5%