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Environmental Management and Innovation in Argentine Industry

Determinants and Policy Implications

Daniel Chudnovsky and Germán Pupato
in collaboration with Verónica Gutman
Centro de Investigaciones para la Transformación (CENIT)

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Contents

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Abstract

After analyzing 716 manufacturing firms with data from the Second Innovation and Technological Behaviour Survey for 1998–2001, our econometric analysis found that firm size and spending on technology acquisition increased a firm's chance of undertaking environmental management activities (EMAs) and the quality of environmental management. In addition, we found environmental regulatory pressures made a positive impact on innovative behaviour. Despite that foreign ownership decreased the quality of environmental management, foreign firms were more prone to undertake EMAs and generate positive environmental spill-overs by using simple, clean production management in domestic firms with high absorption capabilities.

I. Introduction

Fostering a sustainable development process depends on the environmental management activities (EMAs) undertaken by firms. In industrialized countries these activities are mostly carried out in response to environmental regulations and to market incentives, however, this is often not the case in developing countries.

Enforcement of environmental regulations in most developing countries is rather weak and firms have limited innovative capabilities. With greater competition in the domestic market from trade and foreign investment liberalization, firms must devote more resources to innovation to survive and develop. They may have to pay more attention to EMAs to meet the requirements of buyers in export or even domestic markets and/or to respond to diffusion of EMAs among foreign firms.

In Argentina, the impact of the Convertibility program and structural reforms on economic and social-development issues in the 1990s has been analyzed, but only a few studies—based on limited data—have looked at environmental activities by private firms.

Data collected in the Second Survey of Innovation and Technological Behaviour, recently undertaken by the National Statistical Institute (INDEC-SECYT-CEPAL 2003), can fill the gap and illustrate the importance of EMAs performed by Argentine manufacturing firms during 1998–2001.

Considering most manufacturing firms perform similarly and many of them have not performed EMAs, it is essential to begin the analysis on the determinants of these activities in Argentine firms. In particular, it is important to assess whether manufacturing firms' innovation contributed to the diffusion and quality of EMAs. Therefore, our analysis begins by examining whether innovation efforts undertaken by firms led to improved quality of EMAs.

From a policy perspective, it is important to determine if the effect of greater innovation efforts is because of in-house research and development activities or from external technology acquisition. The Second Survey, as opposed to what was observed in 1992 to 1996, research and development expenditures were the fastest-growing innovation activity in the manufacturing industry during 1998 to 2001 (INDEC 1998). Conversely, technology acquisition decreased sharply in response to the recession during this time.

A second important issue is evaluating the role of environmental regulation, which has usually been employed by national governments to promote environmentally-friendly practices and reduce the environmental burden of firms' activities.

The introduction of environmental regulations has traditionally been seen as a cost-increasing factor, since enterprises must comply with them and incur additional investments and operative costs. However, it is suggested that market-based environmental regulations might not only promote better environmental quality and a decline in health risks associated with pollution, but also increase firms´ competitiveness by triggering innovations off-setting compliance costs (Porter 1991). This hypothesis has been well received in business circles although most economists have rejected it, arguing regulations cannot provide incentives for innovation and quality improvement beyond stimulating market competition.

Since available data do not allow evaluation of the effects of different environmental regulation schemes, we will not test the Porter hypothesis in this paper. Nevertheless, we can examine a "by-product" of the Porter hypothesis: whether environmental regulatory pressure has stimulated innovations (i.e., new products or processes launched to the market) undertaken at the firm level.

A third issue is evaluating how much the host country has benefited from intangible proprietary assets of transnational corporations (TNCs) to foster social and economic sustainable development goals, given the foreign direct investment (FDI) boom in Argentina during the 1990s. In particular, it is important to analyze the possibility of environmental technology diffusion to domestic firms through spill-overs. Environmental spill-overs are when domestic firms undertake EMAs (or upgrade their quality) because of TNCs not able to fully prevent environmental technology diffusion from their affiliates to domestic firms through human capital, imitation and other factors.

Recent research has suggested that for spill-overs to arise, local firms must have significant absorption capabilities, allowing them to reap benefits from the knowledge held by TNCs affiliates. Therefore, we assess whether spill-over effects are conditional on the absorption capabilities of domestic firms.

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

1. What were the determinants of undertaking EMAs and their quality in the Argentine manufacturing industry?

2. Was the adoption of EMAs and their quality influenced by the innovative activities performed by manufacturing firms?

3. What types of EMAs were encouraged by environmental regulatory pressure on manufacturing firms?

4. Were innovation activities stimulated in firms under environmental regulatory pressure?

5. Were TNCs more prone to undertake EMAs than domestic firms?

6. Do TNCs' EMAs spill over to domestic firms?

7. Do spill-overs depend on the absorptive capabilities of domestic firms?

The paper is organized as follows. Section II contains a survey of recent research on these topics. Section III presents a brief description of the evolution of the Argentine economy and the main features of innovation, FDI and environmental management issues in the 1990s. Section IV discusses environmental management in Argentina. Sections V and VI comprise the empirical analysis and its main results. Section VII discusses policy implications of findings and suggests further research issues.

II. Previous research

Research about the three main issues analyzed in this paper are reviewed here. We focus on evidence from developing countries (LDCs) and consider only a few examples from developed countries.

First, we explore what determines the adoption of EMAs and the quality of environmental management, paying special attention to regulatory pressures through market incentives. Second, we analyze links between innovative activity and environmental management, focusing on the "private" relationship between being innovative (i.e., launching new products or processes) and engaging in environmentally-sound activities, especially adoption of proactive pollution-prevention (PP) practices, and whether environmental regulatory pressure stimulates innovation. Finally, as TNCs are one of the main ways developing economies close the "technology gap" with the developed world, we review literature on environmental-technology diffusion to domestic firms from TNCs' spill-overs.

a) Determinants for adopting EMAs and quality of environmental management

Several studies have examined the adoption of EMAs and environmental management quality. Deltas and Khanna analyzed the variability of environmental management systems (EMS) quality adopted by U.S. manufacturing companies, using a sample of S&P 500 firms. They found that firms were more likely to adopt higher quality EMSs when faced by threats of future liabilities, consumer pressures, high capital-output ratios and a large number of overseas facilities—meaning more exposure to global competition (Deltas and Khanna 2004).

Khanna and Anton tested factors influencing U.S. firms to take proactive environmental management using a sample of S&P 500 firms. They found the threat of environmental liabilities, high costs of regulation compliance and market/public pressures played a significant role in inducing corporate environmentalism (Khanna and Anton 2002). Khanna and Damon used a sample of publicly-traded firms in the chemical sector to examine firms' motivation to participate in the voluntary 33/50 Program.[1] They demonstrated that benefits from public recognition and from having the regulatory framework impose penalties on firms not proactively self-regulating, provided strong incentives for participation (Khanna and Damon 1999).

In Japan, Nakamura, Takahashi and Vertinsky examined 193 firms and several sources of published data on financial, economic and environmental variables, to determine how Japanese manufacturers incorporated environmental goals into their decisions. They found that the size, average age of employees, export ratios and debt ratios of firms were significant. On the contrary, intangible assets (such as advertising, and research and development) were important to only a few processes (Nakamura, Takahashi and Vertinsky 2001).

When analyzing developing countries, there is an important difference in regulatory pressures, since the enforcement of environmental regulations in LDCs is weaker. Nevertheless, the importance firms place on potential regulations should not be underestimated, since a possible closure threat—which affects the firm's image—and even the remote possibility of penal sanctions are making companies in LDCs more concerned with environmental behaviour.

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.

Dasgupta, Hettige and Wheeler studied the determinants of environmental management in a large sample of Mexican factories. They found that environmental performance is mainly determined by regulatory pressures, implementation of ISO 14000 standards and the general environmental education of plant employees (Dasgupta, Hettige and Wheeler 2000).

Otero, Peterson Zwane and Panayotou investigated environmental investments in Venezuela, using survey data from a sample of manufacturing firms. They found that despite relatively weak regulation, past penalties and environmental permit-status were strongly related to environmental investment and whether firms exporting to rich countries invested more. However, they found little evidence of community pressure impacting on firms' environmental decisions (Otero, Peterson Zwane and Panayotou 2002).

Ferraz *et al*. surveyed data from manufacturing firms in Brazil, finding that past inspections, formal sanctions and public market pressures were strongly correlated with present environmental investment. However, they found little evidence of informal regulation affecting firms' decisions through direct community complaints (Ferraz *et al*. 2002).

Borregaard and Dufey analyzed the environmental management practices in the mining sectors in Chile and Peru, based on a literature review, interviews of experts and a survey of 50 Chilean mining companies. They found firms' environmental practices were influenced by environmental regulations of foreign investment (or often just production in general); consumers' requirements; local image; international financial markets; pressures from competitors, national and international non-governmental agencies (NGOs); and environmental guidelines by parent companies located abroad. However, they concluded that pressures for improved environmental performance came primarily from international factors (Borregaard and Dufey 2002).

Dasgupta, Laplante and Mamingi studied firms traded in local capital markets in Argentina, Chile, Mexico and the Philippines. They concluded that if properly informed, capital markets may provide financial and reputational incentives for firms engaging in environment protection activities. Given this and the well-known financial difficulties governments face on LDCs, they suggested that instead of enforcing compliance, public resources should be devoted to disseminating information allowing stakeholders to make better-informed decisions (Dasgupta, Laplante and Mamingi 1997).

Kaiser and Schulze examined 22,000 large- and medium-scale manufacturing establishments in Indonesia to study manufacturing firms engaged in environmental abatement expenditures. They found that exporting and foreign-owned firms were much more likely to incur environmental expenses. Therefore, they suggested the most effective form of pollution abatement may not be through bureaucratic enforcement but through the encouragement of "voluntary" good practices (Kaiser and Schulze 2003).

Bartzokas studied the fertilizer industry in China and Turkey, finding that in spite of enforcement difficulties, environmental regulations increasingly influenced the adoption of environmental practices and the investment behaviour in environment-clean technologies. In addition, the author noted that increasing public concern about environmental deterioration was also a factor (Bartzokas 2002).

In Argentina, there have been at least two relevant studies. First, Chudnovsky, López and Freylejer analyzed the environmental management practices of Argentine industrial firms, focusing on the adoption of PP measures during the 1990s. A questionnaire answered by 32 large enterprises and 120

SMEs shed light on these issues until the Second Survey of Innovation was undertaken. Overall, they found there has been progress in adopting more advanced environmental practices within the Argentine industry but it has been concentrated in a small group of firms, especially large, export-oriented ones or TNC subsidiaries. On the contrary, most domestic firms have made little progress in this field. Their results showed that EMA evolution in the 1990s has been mainly affected by local environmental regulations and pressures, external market demands, TNC strategies and changes in local competitive conditions. They found a positive relationship between innovatory/quality capabilities and EMAs adoption (especially PP). However, they also discovered that environmental regulations did not generate improved competitiveness through innovation but rather they reinforced the initial competitiveness conditions of each firm or industry (Chudnovsky, López and Freylejer 1997).

Chidiak and Gutman analyzed the decision by firms to undertake environmental activities and the intensity of their environmental practices using data from the Second Survey of Innovation for 1998 to 2001. Their results revealed that large firms with important shares of foreign capital that had technical, innovative and quality management capacities and regulatory and market pressures, tended to have better environmental management. In contrast, variables such as "innovation expenditures," "exports," "capital investment" and "belonging to a pollutant sector" were either very slightly or not at all significant. The study showed that "regulatory pressure" was significant, but irrelevant concerning the quality of the environmental management practices adopted by firms (Chidiak and Gutman 2004).

Summing up, in developing countries, the main reasons for adopting EMAs and for the quality of a firm's environmental management seem to be local environmental regulations, image, consumer demands, financial market pressures, size and foreign ownership. Despite enforcement difficulties faced by LDC governments, regulatory pressures continue to be the main motivation for firms to engage in environmental practices.

b) Links between innovative activity and environmental management

The second issue refers to the relationship between innovation and environmentally sound and proactive practices, and between regulatory pressures and innovation. Michael Porter in 1991, and Porter and van der Linde in 1995, argued that market-based environmental standards can trigger innovations that offset compliance costs, thereby improving firms' productivity and competitiveness levels.

Jaffe and Palmer examined environmental expenditures and innovation in a panel of U.S. manufacturing industries from 1973 to 1991. They found that investment in environmental compliance also increased investment in research and development but, on the other hand, industries' inventive output (as measured by successful patent applications) was not significantly related to compliance costs (Jaffe and Palmer 1997).

There are a number of studies on these issues. Hesselberg and Knutsen researched the tanning industries in Germany, Italy, Portugal, Poland, the Czech Republic, Brazil, Mexico and India. They found that stricter environmental requirements have not been an engine of process-innovation and product-innovation offsets as Porter found in developing countries (Hesselberg and Knutsen 2002). However, they found that the "profit squeeze" is leading northern European firms to externalize most of the polluting processes to southern Europe, eastern Europe and other LDCs. This outsourcing is not enhancing innovative environmental behaviour in recipient economies. The technology transferred is good enough that it is possible to have good quality production without process changes to improve environmental practices. Barton studied environmental management in the iron and steel industries in

Spain, the U.K., Belgium, South Korea, Brazil, the Czech Republic and Poland. He found that in developed countries, management standards—such as ISO 14000 series and the adoption of more proactive EMAs—do not always ensure clean technology use is maximized, and that estimated performances of technologies are realized (Barton 2002).

For developing nations, the demands of environmental compliance and innovation seemingly go together. In Brazil, for example—where post-privatization has brought environmental protection into line with firms in the EU— technology advances have had environmental benefits with a shift towards PP and not only end-of-pipe systems. Borger and Kruglianskas studied three Brazilian enterprises and the impact of an integrated corporate social responsibility strategy on the innovation capacity and environmental management of the firms.[2] They found a strong relationship between such strategies and effective environmental and innovative performance (Borger and Kruglianskas 2004).

Lustosa examined the environmental and innovative behaviour of Brazilian industrial firms from a large-scale innovation survey.[3] Her main finding was that companies with the highest research and development were most likely to adopt environmental innovations. She also found environmental conservation as an incentive for innovation was more prevalent in companies more committed to their internal research and development departments (Lustosa 2001).

To sum up, research on links between innovation and environmental management in developing countries is mostly descriptive. Although results are not conclusive, data seem to show that in LDCs, there may exist a positive relationship between being innovative and being environmentally sound.

c) TNCs' environmental behaviour and environmental spill-overs

The environmental behaviour of TNCs in developing countries and "spill-overs" 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 publicize successful cases where TNCs employ clean technologies and practices worldwide. With regards to the empirical evidence, only a few researchers have actually conducted detailed case studies of the environmental management policies and procedures of TNC-affiliated units in developing countries.

Meyer reviewed literature on the subject and concluded 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, others are concerned that TNCs transfer outdated technology to locations with fewer environmental regulations, thus fostering a "pollution haven" effect (Meyer 2003).

Chudnovsky and López also surveyed literature on environmental practices of TNCs. They suggested it would be advantageous for these companies to comply with home-based standards and regulations that are stricter than the host country's, because a single set of practices and standards is more efficient than reducing environmental investments in overseas facilities. In addition, the greater scrutiny applied to TNCs and the liability for failing to meet standards force firms to meet higher requirements than those that might be imposed by local regulations. Nevertheless, they suggest the actual development impact

2 Daimler-Chrysler, De Nadai and Natura.

3 The Survey of Economic Activity in the state of São Paulo (PAEP).

depends on the volume and "quality" of FDI, and the specific characteristics of the host country, especially its capability to take advantage of foreign technology inputs—i.e., their "absorptive capability" (Chudnovsky and Lopez 2002).

Zarsky showed there is little evidence of either a "pollution haven" or a "pollution halo" for FDI in general. She found cases of local and even national ecological degradation where foreign firms acted like environmental renegades but also cases where foreign firms brought better standards, management practices and technologies. They were often first to respond to consumer pressures for "greener" products or production processes (Zarsky 1999). In 1999, Hansen argued that many TNCs adopt cross-border pollution-control practices because they gain scale advantages and can recoup costs. However, he found some TNCs continue to opt for local adaptation of their environmental management set-up because of economic and political advantages for complying with local regulatory systems, market structures and cultures (Hansen 1999).

There is vast literature on analysis of certain developing countries. For example, in India, Bhattacharya analyzed the industrial production and international trade of pollution-intensive industries. He found that because India was opening up to global markets over the last decade and the consequent increase in multinational activities and their share in trade and industrial production, India has become a "pollution haven" (Bhattacharya 2002). Also in India, Ruud studied local environmental practices of TNCs based on an evaluation of 53 affiliated Indian units and detailed case studies finding significant evidence that environmental management at TNC-affiliated units was strongly influenced by their parents' polices and standards. However, he also found that local contextual factors counted with the content and nature of the environmental measures adopted by TNC affiliates and that local performance did not necessarily replicate headquarters' practices (Ruud 2001).

Wheeler analyzed the FDI "race-to-the-bottom" prediction—that polluters in high-income economies relocate their facilities in low-income countries to remain competitive. Wheeler looked at China, Mexico and Brazil and concluded that the basic assumptions of the model were invalid. There is no environmental "race to the bottom" for two main reasons. First, communities in developing countries are neither passive agents nor focused exclusively on material gains and, therefore, will protect their own interests. Second, consumers and investors assign significant value to environmental performance and, if well-informed, their market decisions will 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 (Wheeler 2000).

Gentry studied the links between private capital flows and the environment in 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 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 (Gentry 1998).

Dowell, Hart and Yeung researched a sample of U.S. S&P 500 and found that TNCs' adopting strict global environmental standards were 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 (Dowell, Hart and Yeung 2000).

Eskeland and Harrison studied the Ivory Coast, Morocco, Mexico and Venezuela, to determine if multinationals flocked to developing countries to take advantage of lax environmental standards. Using many different measures of pollution, they found some weak evidence that foreign investors were concentrated in sectors with high levels of air pollution 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 related to abatement costs in industrialized countries. Although this does not mean that "pollution havens" cannot exist, they suggest that policy-makers should pursue pollution control policy focusing on pollution itself, rather than on investment or particular investors (Eskeland and Harrison 2002).

In China, Dean created a model of FDI location choice for equity joint venture (EJV) projects when there were differences in inter-provincial environmental regulations. After examining 2,886 EJVs, he found that Chinese-sourced EJVs in highly-polluting industries were deterred by relatively strict pollution regulation, consistent with the "pollution haven" hypothesis except that "pollution havens" are supposedly created by industrial-country investors. In contrast, EJVs from non-Chinese sources were actually attracted to provinces with stricter environmental regulations regardless of pollution-intensity—the opposite of the pollution haven hypothesis. Therefore, he suggested the importance of accounting for firm differences when considering EJV behaviour (Dean 2005).

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

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

From the late 1980s to the early 1990s, Argentina fundamentally changed its economic policy regime. After the hyper-inflation crisis in 1989 and 1990, price stabilization was achieved through a currency board scheme, which pegged the Argentine peso to the U.S. dollar (the so-called Convertibility Plan) from 1991 until the end of 2001. A far-reaching structural reform program was rapidly implemented 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 to 1998 (interrupted by the Tequila crisis in 1995). During this period, the economy grew at an annual rate of six per cent and investment increased from 14.6 per cent to 21 per cent of GDP. In late 1998, the economy stagnated, followed by a deep fall in GDP in 2001 and 2002 and was 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. While many local entrepreneurs were unable to upgrade 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 met that challenge through restructuring and modernization.

Among firms that increased their innovation spending, the bias towards technology imports over the more traditional method of in-house research and development was, if anything, reinforced. However, since the beginning of the recession in 1998, this trend was reversed. In-house research and development spending was the fastest growing innovation activity in the manufacturing industry during 1998 to 2001, while technology acquisition sharply decreased as a response to the intensifying recession during this period.[4]

Nevertheless, technology acquisition spending still amounted to more than three-quarters of innovation expenditures during 1998 to 2001, while in-house research and development represented less than 10 per cent. In this way, technology acquisition was, besides FDI inflows, the main source of technological modernization.

Chudnovsky, López and Pupato analyzed the determinants and impacts of innovative inputs and outputs on Argentine manufacturing productivity performance during the 1990s, using the First and Second Innovation Surveys. They found that research and development and technology acquisition spending paid-off by enhancing the chances of a firm becoming an innovator. Furthermore, innovators had higher productivity levels than non-innovators. However, small firms had a smaller chance of engaging in innovation activities or innovating products and/or processes (Chudnovsky, López and Pupato 2004).

In addition to innovation activities, modernization of technology was stimulated by FDI, since Argentina was one of the main destinations for inward FDI flows in the developing world. Between 1992 and 2001, more than US$76,000 million arrived to the country. Most FDI inflows were initially the privatization of public firms and then of private domestic enterprises. As a result, the number of foreign affiliates among the 1,000 largest firms in Argentina increased from 199 to 472 and their share in sales grew from 39 per cent in 1992 to 67 per cent in 2000. During the same period, the number of TNCs among the 1,000 largest firms increased from 199 to 472. While services such as telecommunications, electricity, water and banks accounted for 41 per cent of FDI inflows, the manufacturing sector received 22 per cent of FDI inflows.

Chudnovsky, López and Rossi analyzed whether the presence of TNCs affiliates in the manufacturing industry during the 1990s produced positive or negative productivity spill-overs for domestic firms. They found that while TNCs' affiliates have higher productivity levels than domestic firms, domestics generally received neither positive nor negative spill-overs from the growing presence of foreign firms. However, domestic firms with high absorption capabilities tended to reap positive spill-overs while those with low absorption capabilities were more likely to receive negative spill-overs (Chudnovsky, López and Rossi 2004).

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

Although local environmental regulations are quite strict, "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

4 See INDEC-SECYT-CEPAL, 2003.

progress has been made on institutional responsibilities for environmental management, consensus in their enforcement is weak from a lack of political will and/or resources to properly monitor the environmental performance of local firms. This situation is aggravated by the overlap 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, environmental management is more diffused in Argentine firms. This is especially true in large firms, as reflected in the Second Innovation Survey and that the number of ISO 14001 certifications rose from nine in 1997 to 343 by April 2004.

IV. Environmental management activities in the manufacturing industry

The Second Innovation and Technological Behaviour Survey is the first representative sample of Argentine industrial firms to examine environmental management issues. However, since there are no data on types and/or levels of pollutants emitted by industrial firms in Argentina, it is not possible to directly study firms' environmental performance. For this reason, the focus of our analysis is on EMAs undertaken by the surveyed firms and the motivations that led them to adopt such practices.

We collected information on the environmental practices of 716 Argentine manufacturers from 1998 to 2001. Sixty-nine per cent of them were created before 1975—during the ISI phase—while only seven per cent were created during the 1990s. Small and medium enterprises (SMEs) and domestic firms, accounting for 83 per cent of the sample (593 firms), employed fewer than 300 employees in 2001. In turn, the share of foreign firms (i.e., firms with more than 10 per cent foreign capital) increased from 18 per cent in 1998 to 20 per cent in 2001. The latter is explained by the acquisition of indigenous firms by TNCs.

As Table 1 shows, the adverse macroeconomic context during the end of the last decade, was reflected in the performance of manufacturing firms. From 1998 to 2001, average total sales decreased by 14 per cent. In 2001, the average number of employees in manufacturing firms was 9.5 per cent less than in 1998.

Table 1: Basic Statistics for Manufacturing Firms, 1998 to 2001

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

Regarding environmental issues in the manufacturing industry, the survey included the following questions:

i) What types of environmental management activities did the firms undertake during 1998 to 2001?

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

Table 2: Sectoral Distribution of Surveyed Firms, 1998 to 2001

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

Regarding the first questions, as shown in Table 2, 53 per cent of firms engaged in environmental activities.[5] Notably, there is a significant dispersion around this average across sectors, perhaps reflecting differences in regulation enforcement or technological opportunities. Of the largest manufacturing sectors (food and beverages, chemicals, textiles, and machinery and equipment, accounting for almost one-half of all firms), only the textile sector showed a less-than-average number of firms undertaking EMAs.

Table 3 shows the sharp differences among firms that have and have not undertaken EMAs during 1998–2001. The former were larger and better-performing firms as measured by the number of employees and total sales. They also employed more skilled labour and spent more on innovation (as shares of sales) both in 1998 and in 2001. Therefore, it is not surprising to find that while 84 per cent of firms that undertook EMAs became innovators, less than one-third of firms without EMAs became innovators.

Finally, the presence of foreign firms was markedly higher among firms undertaking EMAs. As shown in Table 5, almost half of the domestic firms undertook EMAs, while almost 80 per cent of the foreign firms did.

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 per cent), followed by effluent treatment (31 per cent) and recycling (26 per cent).

5 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 53 per cent is average for developing countries.

Table 3: Descriptive Statistics for Firms With and Without EMAs

		Firms that Undertook EMAs	Firms that Did Not Undertake EMAs
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
Research and development/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, licences, trademarks, designs) acquired domestically or abroad in 1998.

** Firms that introduced new products or processes during 1998–2001.

Table 4: Type of EMAs 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 EMAs	5

* ISO 14001, IRAM 3800, OHSAS

To analyze what determined the quality of the environmental management in the manufacturing industry, the information in Table 4 was used to group firms into four categories, according to the quality of the EMAs 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; and
- achieved Environmental Management Certification.

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

- improved water, input and energy use efficiency; and
- established on-site or off-site recycling.

"End-of-pipe" management: firms engaged in at least one of the following EMAs, 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; and
- other EMAs.

No environmental management: Firms that have not undertaken EMAs

The category "end-of-pipe" refers to corrective practices based on the identification, processing and disposal of wastes after they have been generated. In general, this kind of activity implies use of retrofit technologies, pollution management and contract services to change the physical, chemical, or biological composition of hazardous pollutants entering a waste stream or released into the environment (including fugitive emissions). These are designed to render waste less- or non-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, such as solid waste management by landfill or liquid effluent disposal by injection wells.

In turn, firms grouped under "simple clean production" have established preventive approaches aimed to increase overall efficiency and reduce risks to humans and the environment. Specifically, "clean production" refers to goods and services production encompassing the minimum environmental impact under present technological and economic limits.[6] This category includes recycling in the form of off-site processing or on-site (post-process) processing of waste to recover liquid, solid or gaseous wastes and reuse them in the same or another production process.

Finally, "complex clean production" implies a forward-looking, "anticipate and prevent" philosophy aimed at protecting the environment, the consumer and the worker while improving profitability and competitiveness. However, firms in this category have selected and used new technologies, inputs or practices to reduce or eliminate pollutants at the source while also increasing industrial efficiency, as well as the achievement of Environmental Management Certifications.[7]

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6 See http://www.unep.org

7 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

The distribution of the firms according to the quality of their environmental management and nationality is summarized in Table 5. In general, although 47 per cent of firms were not engaged in EMAs, there is a concentration of firms around higher quality environmental management of facilities engaged in EMAs. For example, the number of firms that undertook complex CP (30 per cent) was five times larger than those that undertook EOP management (six per cent). At the same time, foreign firms have introduced complex CP far more often than domestic firms.

Table 5: Quality of EMAs 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

Regarding motivations for undertaking the EMAs described in Table 4, we will focus on a subset of the motivations enquired in the survey, presented in Table 6. Our interest lies in compliance with local environmental regulations (regulatory pressure), which was identified as a motivation for undertaking EMAs by 33 per cent of firms. As a benchmark for comparison, improving the firms' environmental image (a source of market pressure) was a motivation for 29 per cent of firms to undertake EMAs.

Table 6: Motivation for Undertaking EMAs in Surveyed Firms, 1998–2001

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

V. Empirical analysis

To answer our research questions, this section analyses the impact of environmental regulation and the determinants of the EMAs in Argentine manufacturing firms during 1998–2001. The econometric exercises are based on data from the 716 firms described above.

Two regressions were estimated. First, we intended to explain the determinants of both the probability of undertaking EMAs and of their quality. A natural approach was to estimate a multi-nomial 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:

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

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,

$$\beta^N \ldots \varphi^N \ldots 0 \quad ,$$

and

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

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$_i$: $I_i^k = \beta_1^k RD_i + \beta_2^k TA_i + \beta_3^k OWN_i + \beta_4^k PRES_i + \beta_5^k OWN_i * PRES_i + \beta_6^k REG_i$,

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 per cent).

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

is the foreign EMA presence in sector *j* (53 sectors, at the three-digit level of aggregation),[8] indicating the share of 1998 sectoral sales of foreign firms that were engaged in EMAs during 1998–2001.[9]

REG$_i$ is a dummy equal to one if firm's *i* EMAs were motivated by local environmental regulations.

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

Whenever possible, we opted to measure the explanatory variables at the beginning of the period during which EMAs where surveyed (1998 to 2001). In this way, we intended to assess if the explanatory variables at the beginning of the period (1998) affected EMAs undertaken in subsequent years. This approach is convenient for avoiding endogeneity or reverse-causality problems in the estimation.

8 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.

9 *I*(Θ) is an indicator function equal to one if condition Θ is met. *EMA*$_{ij}$ is a dummy variable equal to one if firm *i* was engaged in EMAs during 1998–2001.

10 The exact definition of these variables is provided in Appendix II.

For the MNL model, we included firm-specific characteristics such as size, skilled labour, export intensity and two-digit sectoral dummies as explanatory variables, in order to control for observed differences and as proxy for unobservable factors that affected EMAs at the firm level.

Our focus, however, is on the effect of innovation expenditures, foreign ownership and foreign EMA presence variables and the environmental regulatory pressure indicator. We describe these interest variables in turn.

It is relevant to see if manufacturing firms' investments in technology modernization in the 1990s contributed to the quality and diffusion of EMAs. Our analysis intends to demonstrate if the intensity of in-house research and development and external technology acquisition (RD_i and TA_i) by local firms affected the probability of undertaking EMAs and/or their quality during 1998–2001.

In Table 5, we saw a concentration of foreign firms around higher-quality environmental management. Nevertheless, this observation may hide that foreign firms might also be larger or more skill-intensive. Therefore, the foreign ownership variable (OWN_i) will help evaluate if foreign firms had 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 recent literature has captured *horizontal spill-over* effects.[11] To capture spill-overs on domestic firms, the foreign EMA presence variable was interacted with the foreign ownership dummy (*OWN*). In addition, our analysis will assess if the existence of spill-over effects is conditional on the absorption capabilities of domestic firms. Therefore, the MNL model regression also included an interaction between foreign EMA presence and a binary indicator of the level of absorption capabilities in firms. This indicator depends on the index of absorption capabilities, which is based on the availability of skills and technical competences, and on the magnitude and nature of the innovative activities performed by domestic firms (see Appendix III).[12]

To analyze regulation, we focus on comparing firms whose EMAs were motivated by local environmental regulations and firms that were not (variable *REGi*). Summarized in Table 6, this is the only information on environmental regulation available in the Innovation Survey. We emphasize that this approach will not allow us to draw conclusions on the effects of different environmental regulation schemes, since we are not comparing regulated and non-regulated firms but only self-reported motivations for undertaking EMAs. This means we will 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' EMAs (EOP or CP management). This is an important point because Argentine local environmental regulations are quite strict, although enforcement is rather loose (see Appendix). As a benchmark for regulatory–pressure effects, we included a dummy variable indicating a firm's EMAs motivated by the desire to improve its environmental image (variable *IMAGEi*), also presented in Table 6. This variable is intended to capture the effect a source of "market pressure" on environmental management.

11 See Chudnovsky, López and Rossi (2004), for a survey of productivity spill-overs and an econometric analysis of the Argentine case.

12 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.

Besides assessing the impact of environmental regulatory pressure on the quality of environmental management of argentine manufacturing firms, we also tested whether regulation-pressure stimulated innovations, which is a "by-product" hypothesis from the "Porter Hypothesis" debate. The survey provides data on new or improved product and/or process innovations during 1998–2001 (shown in Table 3). Therefore, we estimated a probit model 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

$$P(INN_{ij} = 1 \mid REG_i, X_{ij}) = \Phi(\beta REG_i + \varphi X_{ij}) \quad (2)$$

Where,

ϕ 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 EMAs were motivated by local environmental regulations.

X_{ij}: vector of firm specific control variables in 1998 (size, labour skills, exports, innovation expenditures, image),[13] a constant term, and 20 industry dummies to include sector fixed effects (see Table 2).

Besides including firm and industry level control variables, we are interested in evaluating if firms facing environmental regulatory pressure had a higher probability of innovating than firms not subject to such pressure. This requires testing the hypothesis β>0 in equation 2.

VI. Results

In this section, we report the basic findings of the econometric analysis.[14] Further details can be found in Appendix II.

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

As shown in Table 7, the estimated impact of innovation activities on EMAs, our second research question, was not homogeneous. On one side, increased technology-acquisition expenditures increased the likelihood of simple and complex CP management with significance levels smaller than five per cent. As a consequence, these expenditures boosted both the probability of undertaking EMAs and the quality of the environmental management at the firm level. On the other side, in-house research and development intensity was not statistically significant in the MNL regression.

13 The exact definition of these variables is provided in Appendix II.

14 Throughout this section, we characterize a variable as "statistically significant" if the p-value of its associated coefficient is smaller than 10 per cent. 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 Regression			Probit
Explanatory Variable	Environmental Management Quality			Environmental Management Quality			Innovation Output
	End of Pipe	Simple CP	Complex CP	End of Pipe	Simple CP	Complex CP	
Regulatory Pressure (REG)	6.369915*** (0.8576978)	5.364701*** (0.7934832)	5.940439*** (0.8024595)	6.355099*** (0.8597322)	5.341977*** (0.7955072)	5.927992*** (0.8043269)	0.6311571*** (0.1445277)
Image	4.262863*** (0.7784418)	4.709456*** (0.7020916)	5.813993*** (0.7111867)	4.228934*** (0.7809178)	4.669348*** (0.7053047)	5.781529*** (0.7140517)	0.7099013*** (0.1542468)
OWN	1.943273* (1.158929)	0.1647584 (0.7972425)	-1.141078 (0.8254019)	1.962883* (1.157666)	0.1738634 (0.7961687)	-1.10865 (0.8257932)	-0.0901975 (0.1735097)
PRES x OWN	-1.797001 (3.154628)	2.009136 (1.740581)	5.387238*** (1.710305)	-1.114852 (3.253047)	3.090219* (1.878869)	5.843972*** (1.852205)	-
PRES x HIGHAC	-	-	-	1.137762 (1.227768)	1.587879* (0.9453609)	0.8677544 (0.9895077)	-
PRES	1.79227 (1.538635)	1.289861 (1.069931)	-0.436229 (1.029561)	1.141222 (1.6906)	0.3283206 (1.246363)	-0.8945411 (1.214563)	-
Size	.2679508 (0.2064315)	0.3634014** (0.1445556)	0.7405123*** (0.1569473)	0.2396485 (0.2092)	0.3276677** (0.1473844)	0.7190326*** (0.1595262)	0.281477*** (0.0549843)
Skills	-.3918851 (0.8911441)	0.7024119 (0.5983354)	1.045656* (0.6107802)	-0.5119177 (0.9069434)	0.5382288 (0.6118562)	0.9500058 (0.6232974)	0.5069498** (0.235417)
R&D (RD)	29.39351 (36.90193)	37.6954 (32.95617)	38.88779 (33.09197)	27.92875 (35.99762)	36.33091 (31.86592)	37.48669 (31.9966)	92.42883*** (24.20069)
Technology Acquisition (TA)	5.772404 (5.741854)	9.264026** (3.649952)	8.205445** (4.097295)	5.298296 (5.765562)	8.803764** (3.658555)	7.765778* (4.106774)	19.57641*** (3.80043)
Exports	-3.479175** (1.593428)	-1.711717* (0.9638213)	-1.510082 (0.9781032)	-3.543994** (1.594912)	-1.805706* (0.9635433)	-1.586344 (0.9796051)	0.3003535 (0.3281457)

*, ** 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.

The effect of regulatory pressure on environmental management quality was to induce EOP through CP management (although this effect is statistically significant only for "simple" CP). Nevertheless, regulation pressure made complex CP a more likely outcome than simple CP. In turn, the other motivation for undertaking EMAs considered in this study—to improve the firm's environmental image—enhanced the quality of environmental management by increasing the relative likelihood of complex CP against simple CP and EOP management. These results were from 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 whether their difference is statistically significant.[15]

For our fourth research question, the effect of environmental regulatory-pressure on innovation in manufacturing firms was an increase of innovation by 20 per cent. This result is statistically significant at the one per cent level. In this way, our estimations show that innovative performance was stimulated in manufacturing firms whose EMAs were motivated by local environmental regulations. Comparatively, the effect of undertaking EMAs motivated to improve the firm's environmental image increased the probability of innovating by 22 per cent.

After comparing averages in Table 5, we have seen that foreign firms were more involved in EMAs, particularly in complex CP management, than domestic firms. These observations are driven in part by TNCs that are different than domestic firms in many aspects, such as larger firms with specific scale

15 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.

economies rich in intangible assets and technological opportunities. However, our analysis controls for these characteristics to isolate the effects of ownership status. The MNL model estimation suggests that foreign firms were more likely to undertake EMAs than domestic firms during 1998–2001. Nevertheless, foreign ownership also decreased quality of EMAs in comparison to domestic firms, as EOP and simple CP were more likely than complex CP management. This finding is significant at a 10 per cent confidence level.

For our last two research questions, the MNL estimation results in Table 7 show that the presence of foreign firms undertaking EMAs was a significant determinant for undertaking EMAs and of their quality, only when domestic firms were classified according to their absorption capabilities. In particular, the spill-over effect of foreign presence was to induce simple CP management in firms with high absorption capabilities, with a statistical significance of 10 per cent. On the contrary, there was no significant effect on environmental management spill-overs on domestic firms with low absorption capabilities.

Finally, among the control variables included, firm size was an important determinant of the EMAs in the manufacturing industry, since larger firms had higher probabilities of undertaking EMAs during 1998–2001.[16] In addition, the types of environmental management stimulated by firm size were simple and complex CP activities. It is worth pointing out that, although not reported in Table 7, the sectoral dummies included in the regressions were, in general, significant explanatory variables of EMAs and their quality. Although our analysis cannot determine which sectoral characteristics explain these results it suggests there is substantial differences in environmental management across industrial sectors.

VII. Concluding remarks

In this paper, we have analyzed the determinants of whether firms undertake EMAs and the quality of environmental management in the Argentine manufacturing industry during 1998–2001. We have provided evidence on issues in the sustainable development process in Argentine industry.

We have found that firm size and technology acquisition increased both the probability of undertaking EMAs and the quality of environmental management. In addition, we have found that environmental regulatory pressure positively impacts innovative behaviour, although such regulatory pressure induced EOP at the expense of simple CP management. Finally, although foreign ownership decreased the quality of environmental management, foreign firms were more prone to undertake EMAs and generate positive environmental spill-overs by inducing simple CP management in domestic firms with high absorption capabilities.

In any case, it is vital to handle the results with caution. Although we have measured the explanatory variables at the beginning of the analysis period and included sector-fixed effects in our regressions to obtain better estimations, problems still remain. They may come from the impossibility, given the data available, of controlling for firm-fixed effects and other unobservables that may be correlated with both the regressors and the dependent variables. For these reasons, the results should be interpreted with caution. We prefer to view our findings as showing the relationships between variables, rather than proper causal relationships.

16 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 EMAs. This result requires further research.

It is still possible to suggest several policy implications from our findings. To begin with, the frequency and quality of EMAs decrease in smaller firms clearly suggests that environmental management policies should be an integral part of the public policies for SMEs. Unfortunately, this is not the case in Argentina.

That technology acquisition expenditures (composed mostly of imported inputs) but not local research and development outlays enhance EMAs and their quality, supports the view that developing countries should favour imports for accessing more worldwide technology and resources to enhance environmental management.

However, it is not possible to conclude that liberalization is the most effective innovation policy instrument for promoting environmental management in the manufacturing industry. More research is required to assess the importance of policy instruments for fostering innovation to complement technology acquisition.

Since many firms (especially SMEs) often make expenditures in innovation not considered research and development, it would be important to extend our proxy for in-house innovation beyond research and development measures, to include in-house management, design and engineering related to innovation. Further research is needed to investigate how much innovative research and development and/or management, design and engineering expenditures have complemented or substituted for technology acquisition.

It is important to note that although most Argentine environmental regulations are of the command and control type, our finding is that regulatory pressure induced EMAs and innovation does not necessarily support this type of regulation. As mentioned in the introduction, due to data constraints, we have not compared firms exposed to different regulatory schemes; instead, we tested the impact of perceived regulatory pressure. Therefore, our finding does support a particular regulatory scheme, but rather the importance of enforcement of regulations to promote EMAs.

It is promising to find a strong and positive relationship between regulatory pressure and innovation at the firm level. This finding suggests that regulatory pressure has the potential to encourage innovation and quality improvement necessary to offset a reduction in firm competitiveness from environmental regulations. However, deepening our understanding of the possible impacts of environmental regulation requires enhancing the quality of available data.

The contribution of TNCs to the diffusion of environmental practices in the manufacturing industry appears to have been positive. Although, our analysis suggests foreign ownership might induce lower quality environmental management, TNCs also differ from domestic firms in other respects that enhance EMAs. In fact, when compared to local firms, more foreign firms undertook EMAs, which were generally more concentrated around higher-quality environmental management. This overall effect is probably what policy-makers are interested in.

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

It is important to extend our analysis of spill-overs to include inter-industry (backward) spill-overs. On one hand, it is not surprising to find limited evidence of horizontal spill-overs (TNC presence stimulates 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 suppliers of TNCs and explains a greater potential for finding backward spill-overs to domestic firms.

References

Alpay, S. "Can environmental regulations be compatible with higher international competitiveness? Some new theoretical insights." Bilkent University, Department of Economics, 2001.

Anton, W., G. Deltas and M. Khanna. "Incentives for environmental self-regulation and implications for environmental performance." *Journal of Environmental Economics and Management*, Vol. 48, Issue 1, pp. 632–654, 2004.

Arora, S., and T. N. Cason. "An Experiment in Voluntary Environmental Regulation: Participation in EPA's 33/50 Program." *Journal of Environmental Economics and Management* 28 (3), pp. 271–286, 1995.

Barton, J. "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, 2002.

Bartzokas, A. "Environmental Regulation and Industrial Restructuring: The Case of the Fertilizer Industry." In Jenkins, Barton, Bartzokas, Hesselberg and Knutsen, *op cit*, 2002.

Bhattacharya, A. "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; University of Innsbruck; Innsbruck, Austria, November 20–22, 2002.

Bohm, P. and C. Russell. "Comparative analysis of alternative policy instruments." In *Handbook of Natural Resource and Energy Economics*, edited by A. Kneese and J. Sweeney. North-Holland, Amsterdam, 1985.

Borger, G. and I. Kruglianskas. "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*, 2004.

Borregaard, N. and A. Dufey. "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, Paris, France, February 7–8, 2002.

Cadot, O. and B. Sinclair-Desgagné. "Innovation under the threat of stricter environmental standards," CIRANO, Scientific Series, No. 95s-11, Montreal, February 1995.

Cetrángolo, O. *et al*. "Policy and environmental management in Argentina: cost and financing." Cepal, Environment and Development Series, No. 90 LC/L.2190-P, octubre 2004.

Chidiak, M. and V. Beláustegui. "Revision of the policies to environmental and technological subjects in Argentina." Report of the Project "National Strategy of Clean Production." UNDESA-SAyDS, Buenos Aires, 2002.

Chidiak, M. and V. Gutman. "Characteristics, motivations and obstacles to environmental management in the Argentine industry: results of the Second Survey of Innovation and Technological Conduct," mimeo, CEPAL, 2004.

Chudnovsky, D. and M. Chidiak. "Competitiveness and Environment. Clarity and darkness in the industries of Argentina," CENIT, DT 17, Abril, 1995.

Chudnovsky, D. and A. López. " Environmental management and innovative capabilities in Argentine industry," second draft, June 2004, mimeo, CENIT, 2004.

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

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

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

Conte Grand, M. "Federalism and regulation of the hazardous waste: the case of Argentina," mimeo, 1998.

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

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

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

Di Paola, M. "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. "Do corporate global environmental standards create or destroy market value?" *Management Science* 46 (8), pp. 1059–1074, 2000.

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

Esty, Daniel C. and Bradford S. Gentry. "Foreign Investment, Globalization, and the Environment." Organisation for Economic Co-operation and Development Working paper, OECD 1997.

Ferraz, C. *et al*. "How do firms make environmental investment decisions? Evidence from Brazil." Center for International Development at Harvard University Publications, 2002.

Garrod, B. "Business Strategies, Globalisation and the Environment," paper prepared for a Workshop on Economic Globalisation and Environment, OECD, Vienna, January, 1997.

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

Glazer A. and I. Macmillan. "Pricing by the firm under regulatory threat." *Quarterly Journal of Economics* 107, 1089–1099, 1992.

Hansen, M. "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, 1999.

Helfand, G. "Standards versus taxes in pollution control." In *Handbook of Environmental and Resource Economics*, edited by J. van den Bergh, Edward Elgar, 1999.

Hemmelskamp, J. "The influence of environmental policy on innovative behaviour: an econometric study." IPTS, Seville, Spain, 1999.

Henriques, I., and P. Sadorsky. "The Determinants of an Environmentally Responsive Firm: An Empirical Approach." *Journal of Environmental Economics and Management* 30 (3), pp. 381–395, 1996.

Hesselberg, J. and H. Knutsen. "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, 2002.

INDEC. "Survey on the technological conduct of the Argentine industrial companies, Series Studies," No. 31, Buenos Aires, 1998.

INDEC-SECYT-CEPAL. "Second National Survey of Innovation and Technological Conduct of the Argentine Companies, Series Studies," No. 38, Buenos Aires, 2003.

International Organization for Standardization. ISO. <http://www.iso.org>.

International Organization for Standardization. *Environmental Management: the ISO 14000 Family of International Standards*, ISO Publications, 2002.

Jaffe, A. *et al*. "Environmental regulation and the competitiveness of U.S manufacturing: What does evidence tell us?" *Journal of Economic Literature*, Vol. 33, pp. 132–163, 1995.

Jaffe A. and K. Palmer. "Environmental regulation and innovation: a panel data study." *Review of Economic and Statistics*, Vol. 79, pp. 610–619, 1997.

Jenkins, R. "Environmental regulation and international competitiveness: a review of literature and some European evidence," revised version of a paper prepared for the Workshop meeting of the research project on Environmental Regulation, Globalization of production and Technological Change, UNU/INTECH, Maastrich, March 14–15, 1997.

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

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

Khanna, M. and R. Anton. "Corporate environmental management: regulatory and market-based incentives." *Land Economics, University of Wisconsin Press Journals*, November, Vol. 78, No. 4, pp. 539–558, 2002.

Khanna, M., and L. Damon. "EPA's Voluntary 33/50 Program: Impact on Toxic Releases and Economic Performance of Firms." *Journal of Environmental Economics and Management* 37 (1), pp. 1–25, 1999.

Lanjouw, J. O. and A. Mody. "Innovation and the international diffusion of environmentally responsive technology." *Research Policy*, Vol. 25, pp. 549–571, 1996.

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

McGuire, M. C. "Regulation, factor rewards and international trade." *Journal of Economic Perspectives*, 17 (3), pp. 335–354, 1982.

Meyer, K. "FDI Spill-overs in Emerging Markets: A Literature Review and New Perspectives." Center for new and emerging markets, London Business School, DRC Working Paper No. 15, 2003.

Nakamura, M., Takahashi and I. Vertinsky. "Why Japanese Firms Choose to Certify: A Study of Managerial Responses to Environmental Issues." *Journal of Environmental Economics and Management*, Vol. 42, Issue 1, pp. 23–52, 2001.

O´Connor, D. and D. Turnham. "Managing the Environment in Developing Countries." OECD Development Centre, Policy Brief No. 2, 1992.

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

Palmer K., W. Oates and O. Portney. "Tightening environmental standards: the benefit-cost or the no-cost paradigm?" *Journal of Economic Perspectives* 9, 4, pp. 119–132, 1995.

Pethig, R. "Pollution, welfare and environmental policy in the Theory of Comparative Advantage." *Journal of Environmental Economics and Management*, 2, pp. 160–169, 1976.

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

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

Porter, M. and C. van der Linde. "Green and competitive: ending the stalemate." In R. Weldford and R. Starkey (eds.), *The Earthscan Reader in Business an the Environment*. London: Earthscan, 1996.

Rappaport, A. *et al*. "Multinationals and the Environment: A Survey of Global Practices." MA, The Center for Environmental Management, 1991.

Roediger-Schluga T. "The stringency of environmental regulation and the 'Porter Hypothesis'." Maastricht University, Maastricht, The Netherlands, March 2001.

Roediger-Schluga T. "Some micro-evidence on the 'Porter Hypothesis' from Austrian VOC emission standards," paper prepared for ERSA 2002, Dortmund, Germany, August 27–31, 2002.

Ruud, A. "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, 2001.

Siebert, H. "Environmental quality and gains from trade." *Kyklos*, 30 (4), pp. 657–673, 1977.

Simpson, R. D. and R. L. Bradford. "Taxing variable cost: Environmental regulation as industrial policy." *Journal of Environmental Economics and Management*, 30, pp. 282–300, 1996.

Stewart R. B. "Environmental regulation and international competitiveness." *Yale Law Journal*, Vol. 102/8, pp. 2039–2106, 1993.

UNCTAD "Environmental Management in Transnational Corporations." Program on Transnational Corporations, Environment Series No 4, New York, 1993.

United Nations. "Plan of Implementation of the World Summit on Sustainable Development." 2002. <http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pd>.

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

Videras, J. and A. Alberini. "The appeal of voluntary environmental programs: which firms participate and why?" *Contemporary Economic Policy*, Vol. 18, Issue 4, pp. 449–461, 2000.

Walley, N. and B. Whitehead. "It's not easy being green." In R. Welford and R. Starkey (eds.), *The Earthscan reader in business and the environment*. London: Earthscan, 1996.

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

World Bank. "Argentina. Managing Environmental Pollution: Issues and Options." Environmental and Urban Development Division, Washington D.C., 1995.

Xepapadeas, A. and A. Zeeuw. "Environmental policy and competitiveness: the Porter Hypothesis and the composition of capital." *Journal or Environmental Economics and Management* 37, pp. 165–182, 1996.

Xu, X. "International trade and environmental regulation: time series evidence and cross section test." *Environmental and Resource Economics* 17 (3), pp. 233–257, 2000.

Yohe, G. W. "The backward incidence of pollution control: some comparative advantage statistics in general equilibrium." *Journal of Environmental Economics and Management*, 6 (3), pp. 187–198, 1979.

Zarsky, L. "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, January 28–29, 1999.

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 for emission, technology, products, inputs, etc.) with which polluters must comply. The most common ones are environmental quality standards and emission regulations, which are usually combined with incompliance sanctions (e.g., fines).[17] Nevertheless, the latter have been rarely implemented due to the scarce dissuasion power during the high inflation period (fines lost real value) and to the multiple administrative procedures required for implementation (e.g., for verifying polluter's incompliance) (Cetrángolo *et al*. 2004; Chidiak and Beláustegui 2002).

In turn, the use of economic incentives in Argentina is scarce. 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 compressed natural gas and a levy that hazardous wastes generators and operators must pay. This is the clearest case of implementation of an economic instrument in Argentina (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 and Beláustegui 2002).

Finally, neither "dissemination systems of negative information" nor tradable permits systems exist in our country.[18]

With regards to "sectoral" environmental legislation, unlike developed countries, Argentina has almost no specific considerations affecting each productive sector. On the contrary, environmental regulation is defined, according to the types of effluent emanated from productive processes in general (liquid, solid, gaseous, hazardous[19] wastes) and the media affected by the discharges (air, water, soil).

Historically, Argentine environmental regulatory framework has been limited to requiring EOP treatment of emissions, therefore imposing few stimulus for firms' adopting "clean production" strategies. However, in 2002, four Minimum Standards[20] laws for environment protection were sanctioned,[21] introducing the "prevention" principle into legislation and the possibility of applying

17 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.

18 Nevertheless, these systems are not massively implemented worldwide, with some exceptions, such as U.S.A.

19 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.

20 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.

21 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).

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 and 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 threaten 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 and Chidiak 1995; Chudnovsky, López and Freylejer 2000).

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 EMAs were motivated by coping with local environmental regulations
Image	Dummy equal for firms whose EMAs 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 EMAs 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 labour 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.,

$$\log\left[\frac{p_j(I,\beta)}{p_h(I,\beta)}\right] = I\left(\beta^j - \beta^h\right) \quad ,$$

where I is the variables of interest and P and β are, respectively, the probabilities and coefficients for the environmental management outcomes j and h[22] (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).

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

Appendix III: The Indices of Absorption Capabilities and Technological Behaviour

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, for each variable a ranking was constructed with values ranging between 1 and 5, and then the index was calculated weighting those values (Yoguel and Rabetino 2002).[23] 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):

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

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

23 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.

Table A2: Quantitative and Qualitative Aspects

1) Quantitative Aspects

	Weight	Level 1	Level 2	Level 3	Level 4	Level 5
Research and development of 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 research and development 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%