Third North American Symposium
on Assessing the Environmental
Effects of Trade

Montreal / 30 November – 1 December **05**

R E S E A R C H P A P E R

Business Environmental Decisions in the Context of the Free Trade Agreement

Authors: Lilia Domínguez-Villalobos* and
Flor Brown-Grossman*

Date: January 2006

* Professor, *Universidad Nacional Autónoma de México*

Third North American Symposium
on Assessing the Environmental Effects of Trade

Commission for Environmental Cooperation
393, rue St-Jacques Ouest, Bureau 200
Montréal (Quebec) H2Y 1N9
Tel: (514) 350-4300 ; Fax: (514) 350-4314
E-mail: info@cec.org
http://www.cec.org

1. Introduction

Most of the 1980s saw slow progress in environmental matters. The last three years of that decade saw an acceleration in the process of updating environmental rules. The General Law of Ecological Balance and Environmental Protection (*Ley General del Equilibrio Ecológico and la Protección al Ambiente*—LGEEPA) was passed in 1988, and one year later there were constitutional reforms to make the preservation and restoration of the ecological balance and environmental protection duties of the state. While there had already been environmental protection initiatives when LGEEPA was promulgated in 1988, in the 1990s the signature of the North American Free Trade Agreement (NAFTA) accelerated the development of the environmental regulatory framework and the institutional changes required to enforce environmental policy (ECLAC, 1998). This rules framework has evolved, adding voluntary instruments and greater simplification, although there is clearly room for improvement. An additional factor is that society has become more aware and demanding, and communities pressure on government to enforce nearby businesses' compliance.

In addition, by encouraging the modernization of Mexican industry, NAFTA has been a factor leading companies to endeavor to solve their environmental problems. Such modernization is part of a process of structural change of the economy, requiring profound changes at various levels. Changes in economic policy include the elimination of subsidies, a more flexible regulation of foreign direct investment and technology transfer, deregulation of certain services, the privatization of public enterprises, and very importantly the opening of the economy.1 For the Mexican manufacturing industry, such economic openness and the negotiation of several free trade agreements was the key step. NAFTA is without a doubt the most important of those agreements. The rules of the game changed, and in a notably short time industrial businesses found themselves in a radically different environment, leading to the need to update their technologies and invest in improving their technological capabilities.

The presence of export market incentives, along with regulation and behaviors more in line with learning and innovation, resulted in new patterns of business conduct to prevent environmental impacts of their businesses. Initially, when regulation became more strident, pollution abatement was associated with control technologies, such as treatment plants, filters and other control equipment. However, it was increasingly recognized that the solutions to industrial environmental problems were not confined to this kind of equipment, but rather were interrelated with investments enabling economic benefits to industry. In other words, companies could link their modernization goals with improved environmental performance. Thus, the number of companies with environmental investments tripled from 1994 to 2002.

However, the modernization process has been highly selective. The process is marked by a core of transnational enterprises and a sector of domestically owned industry that altered its competitive strategies to put itself directly or indirectly in the international market directly, predominantly comprising medium-size and large enterprises (Garrido, 1994; Dussel, 1997; Domínguez and Brown, 1998; Domínguez, 1999; Dutrenit, Vera-Cruz and Arias, 2003). In contrast, a larger number of smaller companies have been left behind.

In light of this fact, and the difficulties faced in compliance with the set of rules applicable to industry, environmental investment has not been as widespread as expected. There is a high degree of concentration in a group of companies pertaining to high-pollution sectors where requirements are stricter, companies that are already exporters and whose

1 Share of gross production in the manufacturing industry by public and state-owned enterprises declined from 16.3% in 1988 to 10% in 1993. INEGI Industry Census 1988, 1993.

images depend in part on environmental performance, multinational companies with environmentally demanding matrices, or financially solvent companies given the scarcity of industrial loans.

This work seeks to analyze the dynamics of environmental spending and changes in companies' profiles following NAFTA and factors that have negatively or positively affected their environmental behavior. We propose an econometric model to examine the determining factors in business environmental decisions over eight years, starting in 1994, when NAFTA began. Until now, there has not been any work analyzing the evolution and distribution of environmental spending over the long term, with a broad sampling. Of the factors affecting environmental behavior, we are interested in examining the evolution of environmental spending in light of the following business characteristics: scale, capital ownership, extent of international market penetration, technological capabilities, and economic performance.

This report consists of six sections, including this introduction. Section 2 below reviews the literature on determinants of business environmental behavior, proposing a model. Section 3 analyzes the structuring and trends in environmental investment over the eight years following Mexico's NAFTA entry. Section 4 analyzes the results of the econometric modeling, seeking to reflect on environmental behavior incentives and obstacles. Our conclusions and policy recommendations are presented in Section 5. Lastly, Section 6 contains the methodological and statistical exhibits.

2. Determinants of business environmental performance: Hypothesis for a proposed econometric model

Business behavior determinants are analyzed using two approaches. The first approach is through case studies. These studies examine the different environmental activities carried on by companies, the existence or nonexistence of an express policy, environmental management and training programs, and investment in environmental equipment and machinery, as well as the association of these aspects with the company's size, aging of technology, and whether it is a foreign or exporting enterprise.

The second approach involves the specification of econometric models to examine businesses' environmental stewardship actions and their determining factors. This has been done for several countries, including Thailand, Bangladesh, Malaysia and Indonesia (Hettige, Huq, Pargal and Wheeler, 1996), Mexico (Hettige, Huq, Pargal and Wheeler, 2000) and Korea (ECLAC, 1998; Aden, Kyu-hong and Rock, 1999). Differences in terms of model specifications, dependent and independent variables, and of course results, are seen. Given the lack of adequate information to develop this type of model, the dependent variables are not coincident. In most cases, authors have undertaken to elaborating *ad hoc* indices. For example, Dasgupta, Hettige and Wheeler (2000) built an index based on environmental management systems, such as ISO 14001, officers and employees exclusively dedicated to environmental stewardship, training and degree of compliance, while Hettige, Huq, Pargal and Wheeler (1996) developed an index of abatement efforts in Thailand, Bangladesh and Malaysia and water pollution intensity in Indonesia. As an example of estimates using other kinds of dependent variables, Aden, Kyu-Hong and Rock (1999) used the amount of environmental spending.

Environmental investment decisions depend on various factors. First are the factors arising from pressures outside the firm, the most obvious of which is the regulatory pressure. However as Hettige, Huq, Pargal and Wheeler (1996) say regulatory change can hardly explain on its own the reduced pollution in those countries, and therefore includes other

motives, such as companies' structural characteristics, to explain differences in environmental behavior. As is well known, changes in the environmental law framework in the aforementioned countries occurred nearly 20 years later than in developed countries. Also, these regulations do not always have the same degree of enforcement, or when they do, there is insufficient institutional capacity to enforce them with the same efficacy. This framework asserts that there are factors, such as image and community pressure, compelling companies to search for solutions to their environmental problems. These studies have documented companies that endeavor to abate pollution at the level of developed countries, which does not always correlate to the level of enforcement.

Customers may be another external factor affecting environmental decision-making. A company's environmental compliance avoids fines, the risk of temporary or permanent closure, and the possibility of adverse publicity. Some customers have strict purchasing policies dictated by the home office and avoid business with suppliers who do not have acceptable environmental practices. In the case of customer pressure, it is reasonable to suppose that such pressure may be noted in the case of sales on the international market, where customers are more demanding. Thus, exporting enterprises may be compelled to comply with environmental rules and make the necessary investments. They know that otherwise they may be vulnerable to ecological dumping claims and have more compliance incentives than those operating exclusively in the domestic market. However, so far evidence does not clearly associate proactive environmental behavior with exports (Mercado, 2000; Brown, 2000; Domínguez, 2000; Montalvo, 2002; and Dalcomuni, 2000).

There are also internal compliance pressures, arising primarily from the company's shareholders since the occurrence of events can have adverse environmental effects that influence banks and businesses that base their decisions on risk assessment. Greater risk implies more expensive lending or business premiums, which may mean that that board of directors has an incentive to authorize environmental investments and their concomitant activities (Henriques and Sadorsky, 1996). As a measure of shareholder pressure, we chose foreign capital ownership. While shareholder pressure may be present in any company with publicly traded stock, we can obtain this information for foreign enterprises. However, this is not necessarily a limitation, as this kind of pressure may actually be higher in the case of multinational companies: a subsidiary's accident may further imply a fall in stock prices. Most studies point to a positive association between foreign ownership and environmental performance.

In addition to these pressure factors, the firm's facilitating or restricting characteristics should be considered. Key characteristics include size, financial strength and the firm's technological capabilities. The linkage between a firm's size and the intensity of its environmental programs shows various aspects, *e.g.*, a greater level of pollution and visibility and therefore a greater susceptibility to public scrutiny. There is also a scaling effect on abatement costs, which may facilitate the solving of environmental problems. Dasgupta, Hettige and Wheeler (2000); Aden, Kyu-Hong and Rock (1999); Hettige, Huq, Pargal and Wheeler (1996) obtained a positive result with the size variable.

Financial strength refers to the availability of cash flows or the ability to receive loans to make such investment. In Mexico, this variable has been particularly critical in the period under review, as bank credit was virtually nonexistent. Environmental public credits, with the exception of FIPREV2 have not been suited for the needs of small firms (Domínguez, 2002).

2 FIPREV is a fund established by FUNTEC (Fondo establecido por la Fundación Mexicana para la Innovación y Transferencia de Tecnología en la Pequeña y Mediana Empresa A. C.) and the Comimssion for Environmental Cooperation (CEC) to finance pollution prevention projects in small and medium firms.

Therefore, companies with internal funds or capable of obtaining loans from the international financial system are better able to make such investments. Previous evidence shows that companies with large margins of unutilized capacity do not have a good environmental performance and give the lack of resources as a reason.

In a world of imperfect competition and uncertainty, not all enterprises have access to environmentally friendly technologies, nor the necessary levels of skills to identify, prepare and obtain technology for new project design, building, equipping and staffing. Various authors (Finger, Haldimann and Bürgin, 1995; Dalcomuni, 1997; Montalvo, 2002; Domínguez, 2004) have proposed the accumulation of technological capabilities as a determinant of business environmental behavior. This variable is especially important in the Mexican case, since its industry is characterized by a great technological heterogeneity (Dutrenit and Capdevielle, 1993). Firms often lack documentation and management systems, and thus face difficulty in establishing environmental management methods and solving environmental problems, and more so in innovations. The idea that environmental compliance implies only the acquisition of a control technology made available to a business has proven to be very simplistic. Solving environmental problems involves a large degree of innovation (Dalcomuni, 1997), leading to the need to seek a variable among business innovation determinants that explains environmental innovation, beyond the mere investment in machinery. These capabilities are expressed in a progressive environmental learning process in which organizations transform their structures and culture to control and prevent the firm's pollution. This is the result of a combined effort of individual learning and organizational transformation. The initial outlook was possibly cost reduction, far from an environmental goal. However, the demands of environmental regulation and the firm's responsibility drive the interest in linking this goal with pollution prevention, given competitive pressures. Numerous case studies have shown that high levels of technological capability are behind the environmental innovations found in industry.

Before presenting the specification and results of the econometric model, the following section shows the trends and structuring of environmental investment in Mexican manufacturing.

3. Environmental investment in Mexican manufacturing: 1994–2002

The information source for this report is the Annual Industry Survey (*Encuesta Industrial Anual*—EIA). The advantage of this information source is that it features a sampling of 6000 establishments3, covering around 70% of industrial GDP from 1994 to 2002 and 205 industrial classes, which enables us to examine the environmental spending of a broad base.4 The survey also contains other economic variables, such as exports, gross production, added value, investment and employment, among others. Thus, the information may shed light on the association between the environmental spending of various establishments and their institutional and economic characteristics.

Ideally, environmental spending should include all expenditures made for such purpose, including machinery and equipment as well as the salaries of the staff who operate it and who carry out environmental management functions. The EIA does not include this last-

3 As is usual in industrial censuses, the information refers to an establishment, rather than a firm. Small firms usual have only one plant or establishment, but large firms may have more than one, so conceptually they are not the same thing.
4 Information for 2003 will not be available until mid-year.

mentioned item, as personnel compensation is reported without breaking down such functions. Therefore we are able to analyze equipment only, and thus our dependent variable focuses on investment spending and as a result our environmental spending variable is underestimated. Another reason for underestimation is that the updating of machinery and equipment may imply significant environmental improvements coming from higher energy or raw materials efficiency preventing pollution. But, available information does not include them as environmental investment, even if firms may be counting on these environmental effects when acquiring them. Notwithstanding this limitation, in our opinion the EIA variables may enable us to analyze trends and changes in spending structures.

Environmental investment spending is seen in a wide range of equipment, which includes, but is not limited to, control assets. Other assets are dedicated to research and development for solving the company's environmental problems. The EIA includes questions on annual purchases, building and retirement of pollution control assets, as well as questions on acquisitions of environmental research and development equipment and machinery. It is important to take care in making the distinction between these two kinds of investments, and not associate them strictly with a focus on control versus prevention. The terms are not mutually exclusive, control assets are often the vehicle to recover and recycle raw materials, *i.e.*, they complement a focus on prevention.

The manufacturing industry's overall value of assets with environmental purposes[5] grows on average at a 27.2% annual rate (Table 1). In 1994, 725 establishments had environmental investments, while in 2002 this number grew to 2,462. This means that after NAFTA 1,738 establishments—less than a third of the 6000 sampled establishments—made some investment in environmental compliance. Compared to the 200 000 establishments in the Industry Census, this is an insignificant proportion. However, these establishments contribute 65% of the EIA added value in 2002, suggesting major progress among the companies with the most added value. Annual growth rates show a strong initial drive followed by declining rates through 1998, when rates continue to grow, although slower than initially, and then falling in 2002. The high growth rate in the first and second years coincide with NAFTA's entry into force, but this may also be construed as a product of the institutional and regulatory environmental changes (see Graph 1).

Table 1
Value of environmental assets in sampled establishments, 1994–2002
(Thousands of 1993 pesos)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	GR %
Total asset value	984030	1581800	2619352	3474374	3904908	4471785	5191590	6322031	6735942	27.2
Number of establishments	725	1089	1574	1843	2140	2311	2351	2443	2462	16.5
R&D assets	426470	607882	748363	923019	1075488	1198330	1302899	1513309	1641226	18.3
Number of establishments	387	742	1266	1544	1854	2039	2086	2176	2206	24.1
Control assets	557560	973918	1870989	2551355	2829420	3273455	3888691	4808722	5094716	31.9
Number of establishments	455	568	645	717	774	804	831	851	859	8.3

GR = Annual mean growth rate.

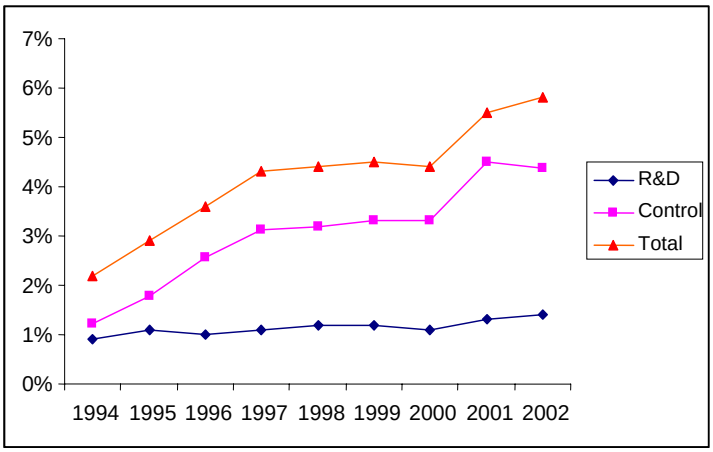
Source: Authors' estimates based on EIA, INEGI;

5 Hereinafter referred to as environmental assets.

The composition of gross environmental assets in the manufacturing industry has changed over the period. The value of environmental R&D assets constituted 43% of total spending in 1994, with 387 establishments, while in 2002 it represented 24% of overall spending, with 2,206 establishments. In comparison, control spending grew at a higher rate (32% versus 18.3%), increasing from 57% (455 establishments) to 76% of spending (859 establishments). That is, R&D investment tended to spread out more among establishments, but R&D spending per establishment decreases over the period. The mean per-establishment value of control investment is much higher (744,000 versus 5.931 million 1993 pesos).

A growing concern refers to the concentration of the value of capital environmental assets within a small number of establishments. Of the 2,206 establishments with positive R&D spending, 345 contribute 87% of all such spending. In the case of control assets, 112 establishments account for 90% of the overall asset value of all 859 establishments.

Graph 1
Share of environmental assets in added value, 1994–2002



Source: Data from Table 1.

The extent of companies' environmental efforts is noticeable in the increase of of establishments´ environmental spending in value added. In 1994, establishments' spending on environmental R&D assets represented less than 1% of the added value of all establishments with such spending. This increased slightly over the period, reaching 1.4% in 2002. There was a much greater change in control assets, rising from 1.2% to 4.3% (see Graph 1).

Insofar as industry sectors are distinguished by their particular technological characteristics, they require different energy and water intensities. These intensities are reflected in differentiated environmental investment spending. Table 2 shows the weighted growth rates in environmental spending with each sector's share in overall industry spending. The highest growth is seen in basic metals (8.81), metal products, machinery and equipment (6.17), chemicals, petroleum, rubber and plastic (4.38) and food, beverage and tobacco (5.89). In fact, these four industries accounted for 82% of overall industry spending in 2002, with the following distribution: basic metals (24%), food, beverage and tobacco (20%), metal products, machinery and equipment (20%), and chemicals (17%). See table 2 and Graph 2.

Table 2
Dynamic and structure of environmental assets per industry sector
(Thousands of 1993 pesos)

	Environmental assets per establishment (EAE)			TEA growth rate
	1994	1998	2002	(%)
Food, beverage and tobacco	1107	658	2645	5.89
Establishments	153	432	508	
Textiles, garments and leather	332	284	527	0.65
Establishments	54	231	278	
Wood and wood products	143	115	560	0.24
Establishments	13	55	65	
Paper, printing and publishing	2230	1479	1746	0.50
Establishments	46	132	152	
Chemicals, rubber and plastic	950	932	1948	4.38
Establishments	186	510	580	
Nonmetallic minerals, other than petroleum derivatives	3804	780	4476	2.06
Establishments	55	149	174	
Basic metals industries	5199	13502	20769	8.81
Establishments	30	74	82	
Metal products, machinery and equipment	819	711	2244	6.17
Establishments	179	525	587	
Other manufacturing industries	424	248	407	0.04
Establishments	9	32	37	
Total	1357	1179	2735	
Establishments	725	2140	2462	

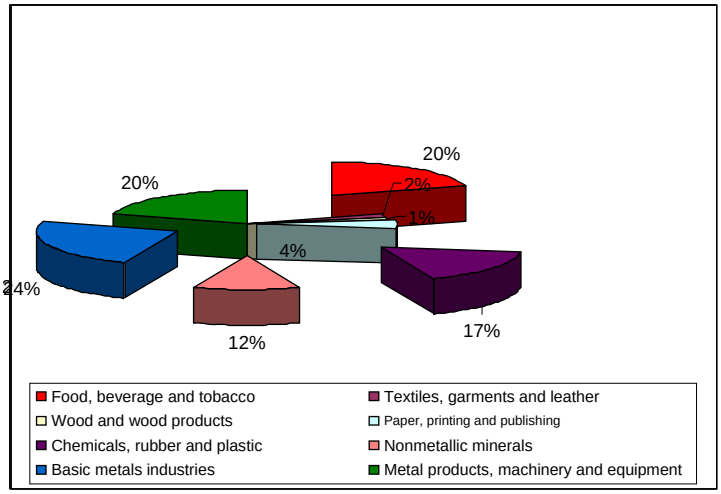
*Weighted by each sector's share of spending.

Source: Authors' estimates based on Tables 1a, 2a, 3a and 4a of the Statistical Exhibit.

The basic metals industry has the highest mean value per establishment, with a notable growth from 5.1 to 20.7 million pesos between 1994 and 2002,6 followed by nonmetallic minerals (3.8 to 4.5) and food, beverage and tobacco (from 1.1 to 2.6). Paper, printing and publishing decreased its high spending between 1994 and 2002, from 2.2 to 1.7 million pesos (Table 2).

6 At constant prices, base 1993.
*TEA = Total environmental assets

Graph 2
Distribution of value of environmental assets per sector in 2002



Source: Data from Table 2

Analyzing the distribution of environmental assets by size, we observe a correlation between size and spending throughout the period. In 2002, giant establishments account for 65% of spending, followed by large enterprises with 18%, medium-size establishments with 13%, and micro and small businesses with 2%, respectively. As seen in table 3, there is a gap in the growth rate between giant establishments and all others. While giant enterprises had an 18.7% annual growth rate, large establishments had only 4%, medium-size establishments had 3.7%, micro-enterprises had 1% and small establishments had a 0.21% annual growth (Table 3).

Table 3
Dynamic and structure of environmental assets per size
(Thousands of 1993 pesos)

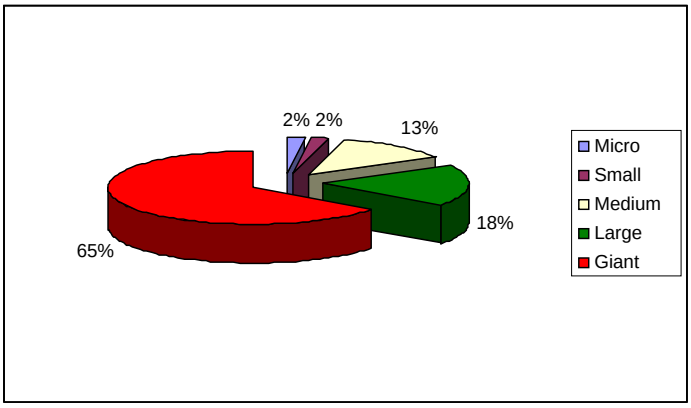
	Environmental assets per establishment (EAE)			TEA growth rate
	1994	1998	2002	(%)
Micro	80	61	274	1.06
Small	443	345	287	0.21
Medium	522	725	1279	3.71
Large	1662	2005	2727	4.07
Giant	3067	5999	9980	18.76
Total	1370	1816	2739	

Source: Authors' estimates based on Tables 5a, 6a and 7a of the Exhibit.

A noteworthy positive aspect is the fast-growing per-establishment mean value for micro enterprises, closing the gap with giant establishments. The difference between the value of environmental assets between giant and micro establishments was 72 times higher on average in the first three years of the period, decreasing to 56 in the last three years. This

was not the case for small, medium and large businesses. Lastly, the analysis of the distribution of the number of establishments per size shows that while there has been considerable progress in the number of establishments with environmental spending (from 53 to 484 micro-businesses and from 93 to 379 small businesses), these numbers are clearly insufficient given the number of small enterprises in the Mexican manufacturing industry.

Graph 3
Distribution of the value of environmental assets per establishment size, 2002



Source: Data from Table 3.

The behavior of environmental assets among foreign enterprises is more dynamic than industry growth rates (35% versus 27%). Likewise, foreign companies' share of overall industry increases from 21% to 35% between 1994 and 2002. However, notwithstanding the above, not all results are positive. From an EIA sample total of 1385 companies, 577 report environmental investments. Companies reporting no such investment might be because their processes do not so require or the company has personnel and operating expenses to address its environmental problems, which was not covered in our information. However, it would be important to analyze in greater depth the reasons why this high proportion of foreign establishments has no environmental assets for R&D or control.

Table 4
Dynamic and structure of environmental assets per ownership and exports (Thousands of 1993 pesos)

	Environmental assets per establishment (EAE)			TEA growth rate
	1994	1998	2002	(%)
Foreign	1111	2598	3934	35
	(180)	(523)	(577)	
Exporters	1417	2701	4432	34
	(339)	(1082)	(1142)	
High capabilities	2547	3211	4924	25
Low capabilities	1107	1215	1308	22
Industry	1357	1825	2735	27.2
	725	2140	2462	

Source: Authors' estimates based on Tables 8a and 9a of the Exhibit. Numbers in parenthesis denote the number of establishments.

As in the case of foreign enterprises, exporting enterprises are highly dynamic, with 34% growth in the value of total environmental assets, as compared to 27% for the manufacturing industry. The number of establishments with some environmental investment represented less than 50% of all establishments, but accounted for 75% of overall value. That is, there were more nonexporting establishments following NAFTA, but exporters had an intensive increase in environmental spending. Spending per establishment also increased considerably.

As expected, technological business capabilities are correlated with environmental investment. Firms with high capabilities represent 12% of all establishments and 50% of overall environmental spending, seven times greater than those of lower capability.

In sum, a large number of enterprises have added environmental investments. However, a more detailed analysis shows that environmental investment spending is extremely unstable over time, and may often occur only once. Thus, we were interested in locating a group of companies with consistent investment over the period, using 1994, 1998 and 2002 as reference years. Table 5 shows that only 322 establishments meet this condition, and the value of their environmental assets represents 45% of the sample total. Of these establishments, 84 are foreign, with a 31% share of environmental assets of total foreign establishments, and 188 are exporting enterprises, with 47% of total environmental assets of export establishments.7

Table 5 shows that these establishments raised the mean value of their environmental assets. It is possible that not all industry sectors justify the need for ongoing spending, but there is no doubt that environmental investments must be renewed and updated to have an effect on the environment. Furthermore, our information on investment is in gross terms, which implies a need for all sectors to at least recapture equipment wear and tear. Therefore, notwithstanding the progress seen in the addition of companies in compliance, we cannot be too optimistic.

Table 5
Group of proactive enterprises: Environmental investment in 1994, 1998 and 2002 (Thousands of 1993 pesos)

	Sample	Foreign	Exporters
Number of establishments	322	84	188
Environmental assets per establishment, 1994	1738	1005	1969
Environmental assets per establishment, 1998	5350	3888	7212
Environmental assets per establishment, 2002	9348	8468	12602
Mean growth rate, 1994–2002 (%)	23	31	26
% environmental capital	45	31	46

Source: Authors' estimates based on EIA, INEGI

7 It is possible that some establishments do not appear in this group because they did not invest in the starting year. However, the underestimation does not appear to be important, given these establishments' percentage of environmental assets.

4. Environmental behavior incentives and obstacles: Estimation and results of the econometric model

Attending the discussion around the determinants of business environmental performance we proposed the following specification:

$$\text{TOTAL ENVIRONMENTAL ASSETS}_{it} = \alpha + \beta_2 \text{TOTAL ENVIRONMENTAL ASSETS}_{it-1} \beta_3 \text{TECHNOLOGICAL CAPABILITIES}_{it} + \beta_5 \text{SALES}_{it} + \beta_6 \text{SIZE}_{it} + \beta_7 \text{EXPORTS}_{it} + \beta_8 \text{FOREIGN ASSETS}_{it} + \lambda_t + \eta_i + \upsilon_{it}$$ [8]

The dependent variable is the value of capital invested or capital assets for environmental purposes (see the Methodology section). As applicable to any model involving an official information source, we must build our variables relying on the assumption that they are good approximations of the reported aspects. This variable is not measuring the quality of application of these expenditures, only the magnitudes. The survey does not provide any information regarding it. Thus, our variable can only be considered as a proxy to the effort made by firms to improve their environmental performance.

Without a direct measurement of regulatory enforcement, we used on previous estimations energy intensity as an approximation of pollution levels, supposing that greater pollution requires greater compliance oversight. In fact, the handling of large volumes of fuel is one of the criteria applied under the stricter federal environmental enforcement in Mexico. However, following the comments of an anonymous referee and given that it was not statistically significant, we decided not to include it in the final estimation.

Size is a multinomial variable with five levels, in which 1 is for micro firms, 2 for the small sized ones, 3 to the medium firms, 4 to large and 5 to gigantic. Foreign ownership is a dummy variable where 1 denotes a proportion of 25 percent foreign ownership or more. We selected growth net sales as a proxy to financial capacity[9].

Lastly, technological capability is an eminently qualitative and complex concept. It is possible to measure it indirectly, *i.e.*, by growth in labor productivity. However, we believe there are many circumstances that give rise to increased labor productivity without involving an improvement in technological capabilities. Therefore, in this report we refer to another variable[10] based on the linear combination of four variables: research and development (R&D)[11] spending, technological spending, (patents, trademarks and technical assistance), and investment in machinery and wage and salary payments. R&D and technological spending express the software aspect of technology; the hardware side expressed in investment in equipment and machinery. The skill aspect of technology is approximated by wages and salaries, given the lack of a variable measuring degrees of skill, formal education or training. We took the firm's mean compensation as a proxy: greater skills are associated with a higher wage or salary. The method of principal components allowed us to identify one factor out of the four mentioned variables and factorial scores for each observation. These

8 where the i and t sub-indices indicate the firm and time, respectively

9 While performance may bring endogeneity problems in the estimation, the dynamic panel model using endogenous variables can be an instrument to solve them.

10 Although previous work proposed to measure technological capabilities based on my than 25 indicators (Domínguez, 2004), the EIA does not provide the required variables, and we therefore chose the linear combination as mentioned.

11 R&D spending refers to those activities focused on the production process and product design and not in environmental aspects.

were used as an index. This linear combination provides us with an index to distinguish different levels of capabilities among firms. We would expect the presence of greater technological capabilities to be associated with increased environmental investments.

Estimates of the environmental assets were made with a dynamic panel model using the GMM method in one step. A non balanced panel of 243812 industrial establishments was used for the 1994-2002 period. Thus our sample has 19 504 observations. The dynamic panel techniques allow us to introduce lags in the endogenous variable as instruments and assume the strict exogeneity of the explanatory variables.13 The specification controls for the heterogeneity of expenditure among industrial divisions and changes through time. The advantage is to reduce the effects of omitted variables having some impacts in time or individuals (Hsiao, 1999).

Table 6 shows our results. The highest elasticity corresponds to lagged environmental spending (1.012). This suggests the significance of entrepreneurial environmental culture expressing a steady increase spending over time. Next comes the size dummy with an elasticity of 0.83. Large firms are more visible and thus subject to a greater extent to public scrutiny. Besides, they can take advantage of a scale effect in pollution abatement. This is consistent with the evidence presented in the last section relating to the environmental expenditure of large local firms. Business sales growth has also a relatively high elasticity (0.085), which suggests the importance of an appropriate economic performance as an incentive for environmental spending.

The result of technological capabilities confirms our claim that companies' technological efforts and skills and abilities are needed to access environmentally friendly technologies and undertake environmental investment projects. Exports were significant, although with the lowest elasticity (0.027). This result denotes that the assumption that international customers are stricter may not always rule, and hence, we would need to identify those products in which a green tag has a value for the customer.

The negative result on foreign assets was a bit surprising. It means that foreign firms' decisions on environmental investment are influenced by size, the stringency of customers and technological capabilities and not by the shareholders pressure.

12 Three establishments were eliminated because of poor information, thus the sample was reduced en 24 observations, corresponding to the eight years.

13 It must be noted that GMM estimators that use lag variables as instruments are consistent if there is no serial autocorrelation of errors.

Table 6
Results of econometric model in panel form
Dependent variable: Environmental assets logarithm

Variable	Coefficient	"t"	Probability	Elasticity
Environmental assets (-1)	1.012	138.0	0.00	1.012
Technological capability	0.164	6.58	0.00	0.03
Size	0.270	5.94	0.00	0.83
(dummy)				
L Exports	0.027	4.52	0.00	0.027
Foreign ownership (dummy)	0.087	0.69	0.48	
L sales	0.085	3.39	0.00	0.085
Constant	-1.886	-6.03	0.00	

Wald (joint): [0.000] ; Wald (dummy): [0.000] ; Wald (time): [0.000]

AR(1) (0.007) AR(2) test: [0.38]

In summary, environmental investment decisions depend on size, businesses' technological capabilities, business sales performance, and the need to comply with the standards required by customers in the international market.

It is worth emphasizing that the model has some limitations. Our model does not address the possible influence of communities on business environmental decisions. We were unable to obtain information on the regional location of establishments, which would have enabled us to relate such effect with education levels and demographic concentrations. Other limitations may be attributed to the fact that our variables are approximations. For example, in the case of regulation, it would have been much better to have information on environmental inspections. Furthermore, to measure the effect of NAFTA, it would have been desirable to have a longer period, particularly before the agreement's entry into force. The EIA did not provide information on investment in environmental assets before 1994.

We believe that despite these limitations, the fact that we have a broad sampling over a considerable number of years opens the possibility of obtaining a more in-depth understanding of the determining factors of environmental decision-making, which is needed to establish environmental policy lines.

In conclusion, these results suggest that the predictions that NAFTA would be associated with lax environmental behavior have not come true. Insofar as the agreement's entry into force was associated with greater exports, it provided an incentive to increase environmental investment. Likewise, insofar as NAFTA's entry into force and the accompanying rise in competition encouraged companies to improve their technological capabilities, such improvement also resulted in greater environmental investment.

The obvious question is: What is happening with the environmental behavior of Mexican companies? Our evidence suggests that such businesses make environmental investments as they become large enterprises and exporters. Mexican companies in these groups contribute a good part of the gross value of their production, but this is doubtless a small part of all firms in the respective industry. This means that although a large part of manufacturing industry pollution (caused by larger companies) is being abated by their investments, most pollution widely caused by small and medium-size enterprises persists and is uncontrolled.

It is clear that overly optimistic predictions of a NAFTA effect of a massive modernization process did not occur, and small business' existing weaknesses not only did not decline but even grew. The evident problem is that smaller firms, which prefer to operate in the domestic market, have a very low cumulative average of technological capability. In other words, the factors that inhibit or impede environmental investment are the insufficiency of internal financial resources, sales stagnation and the lack of technological capabilities, as well as the lack of environmental investment incentives such as small business loans, tax credits, interaction with demanding customers, and the perceived lack of enforcement by the environmental authorities.

5. Conclusions and recommendations

This report shows, on an industrial scale, a cumulative growth of environmental assets and the inclusion of a greater number of establishments since the year NAFTA entered into force. Investment is relatively concentrated in four energy- or water-intensive sectors subject to considerable regulatory pressure under federal oversight.. With respect to size differences, we found that the number of small establishments with environmental spending increased, although the number is still insufficient. By far, giant establishments' contribution to total spending stands out, as does the per-establishment mean spending. Spending by exporters and foreign enterprises tends to be more dynamic than others.' Insofar as such companies contribute a good part of gross production value, this means that a good part of manufacturing industry pollution is being abated by such investments. However, there is a considerable percentage persistent, widespread pollution.

The results of the econometric model show that environmental investment is associated with size, the pressure of foreign shareholders, businesses' technological capabilities, business performance, regulation and the need to comply with the standards required by customers in the international market. It may thus be said that to the extent that NAFTA has been associated with a fuller regulation, with high growth among exporters and foreign enterprises and an industrial modernization process, it has positively affected pollution prevention and control efforts. However, the incentive of international competition and a predominantly market-based policy were insufficient to achieve industry-wide implementation of the modernization process.

Without a doubt, one of the most worrisome aspects of the statistical results is the extremely high concentration of environmental investment among a relatively small segment of the manufacturing industry, in terms of both sector and size. This has already been identified by a range of studies conducted for Mexico and other Latin American countries14. The scarcity of public funding had led monitoring efforts to focus on larger, more notorious polluters. Regulatory pressure is nearly nonexistent for micro and small business polluters. The powers that drive demand in the environmental services market do not work properly, and therefore the market has no incentive to grow.

Also, the availability of small business loans has been limited. The first and foremost problem is that environmental programs offer little funding. In addition, with few exceptions, loans depend on the banking system, which imposes requirements that micro and small businesses cannot meet; *i.e.*, environmental loan programs generally do not contemplate the needs of small and medium-size businesses.

14 These studies were undertaken by a joint project of the Economic Commission for Latin America and the Caribbean and the German Society for Technical Cooperation for the following countries: Argentina, Chile, Colombia and Mexico.

Of course, the suggested tracking of small businesses can be very inefficient. The most important thing is to create incentives to promote a more active environmental behavior by such companies, *i.e.*, self-regulation. This could take advantage of information on pollution foci in industrial classes and geographical regions alike, to coordinate a "high-impact" inspection program among federal, state and municipal authorities. These inspections would help to awaken the need for change within small companies. It is also necessary to create economic instruments to offset the cost of short-term environmental investments and promote self-regulation. The key factor would be competitive, accessible small business loans. .Programs such as the Pollution Prevention Fund (*Fondo de Prevención de la Contaminación*—FIPREV) should have more extensive coverage and funding.

As regards tax provisions, at the federal level only two have been conceived to date, which are of little use to small business. An interesting example is the payroll tax and real estate tax reductions for individuals or entities that carry on a recycling business, or for companies or insitutitons that support environmental improvement programs in the Federal district. This incentive is new, and has barely been publicized.

There is abundant evidence on innovative measures that companies could take to prevent pollution wihle saving input costs. However, companies do not always take this evidence into account in the short term. Small businesses believe, wrongly to a large extent, that environmental stewardship is only a cost. In addition, they do not have technology search routines allowing them to identify efficient solutions, nor do they have innovative skills—many of which do not require major investment. As is the case for any innovation, one ingredient of environmental innovation is the presence of technological capabilities. This takes us back to the problem of the influence of the unequal accumulation of technological business capability on environmental investment. Support approaches, by rewarding businesses' environmental behaviors, would solve part of the problem because insufficient technological capabilities cannot be resolved without a policy in such regard. In our opinion, the broad area of coincidence between technological development policy and environmental policy geared toward small and medium-size enterprisees, promoting the generation of clean technologies, has not been addressed.

The business objective of competitiveness should be incorporated into the social goal of sustainability. The results as to the importance of having technological business capabilities to achieve environmental innovation on the path to ecoefficiency indicate that there is a window of opportunity for technology policy, whereby the National Science and Technology Council (*Consejo Nacional de Ciencia y Tecnología*—Conacyt) could act by making the environment a clear national priority and creating incentives for environmental innovation. Incentives could be linked to technological innovation, requiring pollution reduction or prevention regardless of whether it offers economic benefits.

Another area of opportunity lies in supplier development programs, which could include an environmental compliance requirement supporting small businesses' entry into such programs.

Information should also be publicized to allow businesses to see the benefits of cleaner technologies, in the form of lower waste, energy and material costs. The use of environmental management systems and environmental stewardship guidelines may be one way. The efforts of institutions such as the Center for Cleaner Production (*Centro de Producción más Limpia*), with its small business self-assessment guidelines, are praiseworthy but have had limited release. It is important to convince different groups of society of the need to undertake awareness campaigns that are not just government campaigns.

In conclusion, the spreading of environmental investment among smaller, domestically oriented, low-profile enterprises requires the comprehensive focusing of environmental and business development policies on small business, with the promotion of technology programs and cleaner production, including such economic instruments as tax incentives and preferential loans. To date, financing continues to be a problem for small business. Greater coordination is needed among institutions forming part of the innovation system oriented towards the environment.

6. Statistical methodology exhibit

6.1 Environmental assets

Environmental spending was constructed as follows. Using information on spending on pollution control machinery and equipment, we determined the respective gross assets, referred to as environmental spending (control). We decided to analyze these assets because they reflect the company's pollution control or prevention efforts better than annual investment; equipment carries out its function during several years, and therefore the company does not need to invest in all years in order to be in full compliance.

Using the perpetual inventory method (Mexico, 1993), we first estimated annual gross capital, equal to equipment acquisitions plus construction, less the value of disposed equipment. This initial value was increased by investment in subsequent years. Environmental control assets are thus: $\mathbf{asset_{t-1} + gross\ investment_t}$.

Spending on research and development geared toward solving environmental problems includes annual investments in machinery and equipment. As it does not include personnel compensation, and as this type of equipment is not acquired every year, the information is subject to fluctuation. To avoid this, and following Maerasse and Sassenau (1991), we built a series of gross capital assets for research and development, with a procedure similar to that noted above: $\mathbf{R\&D\ assets_t = R\&D_{t-1} + R\&D_t}$. The variable considered in the econometric model is the sum of asset values.

Company size was classified by headcount: less than 50 employees is defined as micro-business; from 51 to 100 employees, small business; from 101 to 250 employees, medium-size business; from 250 to 500 employees, large business; and a company with more than 500 employees is a giant business.

The variables considered for companies' economic performance are profit margin and net sales growth, using added value as an approximation thereof. Profit margin is the difference between gross production value and spending on inputs and compensation, divided by the gross production value.

6.2. Statistical exhibits.

Table 1a
Value of environmental assets per sector
(Thousands of 1993 pesos)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	RI* %
Food, beverage and tobacco	169397	264794	183500	200699	284311	693916	787782	1237908	1343457	3.26
Textiles, garments and leather	17932	24350	17760	37221	65704	78071	83619	134605	146610	0.36
Wood and wood products	1862	4444	4833	3013	6313	29617	34035	34272	36394	0.24
Paper, printing and publishing	102571	128004	103234	142863	195204	200317	198170	258297	265416	0.27
Chemicals, petroleum, rubber and plastic	176624	263280	158494	379500	475206	673091	803604	1053468	1129964	3.44
Nonmetallic minerals, other than petroleum derivatives	209235	257449	68302	264483	116254	403237	480122	720486	778899	1.48
Basic metals	155957	274271	779012	874851	999113	1186241	1311038	1597987	1703019	7.89
Metals products, machinery and equipment	146639	262516	106186	452222	373365	908012	963258	1270515	1317127	4.27
Other manufacturing industries	3814	6360	4898	7193	7932	12051	13520	14492	15057	0.05
Total	984030	1485467	1426218	2362045	2523402	4184551	4675147	6322031	6735942	

Source: Authors' estimates based on EIA, INEGI; *rate of increase (%)

Table 2a
Number of establishments with environmental assets during the period

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Food, beverage and tobacco	153	206	289	379	432	475	482	503	508
Textiles, garments and leather	54	73	133	178	231	251	261	277	278
Wood and wood products	13	23	39	46	55	60	62	63	65
Paper, printing and publishing	46	73	93	106	132	145	148	151	152
Chemicals, petroleum, rubber and plastic	186	253	368	447	510	546	560	575	580
Nonmetallic minerals, other than petroleum derivatives	55	88	117	139	149	158	162	167	174
Basic metals	30	39	60	67	74	76	76	80	82
Metals products, machinery and equipment	179	261	372	456	525	568	565	589	587
Other manufacturing industries	9	13	21	25	32	32	35	38	37
Total	725	1029	1492	1843	2140	2311	2351	2443	2462

Source: Authors' estimates based on EIA, INEGI

Table 3a
Value of environmental assets per establishment
(Thousands of 1993 pesos)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	GR %
Food, beverage and tobacco	1107	1285	635	530	658	1461	1634	2461	2645	11
Textiles, garments and leather	332	334	134	209	284	311	320	486	527	6
Wood and wood products	143	193	124	65	115	494	549	544	560	19
Paper, printing and publishing	2230	1753	1110	1348	1479	1381	1339	1711	1746	-3
Chemicals, petroleum, rubber and plastic	950	1041	431	849	932	1233	1435	1832	1948	9
Nonmetallic minerals, other than petroleum derivatives	3804	2926	584	1903	780	2552	2964	4314	4476	2
Basic metals	5199	7033	12984	13057	13502	15608	17250	19975	20769	19
Metals products, machinery and equipment	819	1006	285	992	711	1599	1705	2157	2244	13
Other manufacturing industries	424	489	233	288	248	377	386	381	407	-1
Total	1357	1444	956	1282	1179	1811	1989	2588	2735	9

Source: Authors' estimates based on EIA, INEGI
*rate of increase (%)

Table 4a
Structure of environmental assets per sector
(Percentages)

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Food, beverage and tobacco	17	18	13	8	11	17	17	20	20
Textiles, garments and leather	2	2	1	2	3	2	2	2	2
Wood and wood products	0	0	0	0	0	1	1	1	1
Paper, printing and publishing	10	9	7	6	8	5	4	4	4
Chemicals, petroleum, rubber and plastic	18	18	11	16	19	16	17	17	17
Nonmetallic minerals, other than petroleum derivatives	21	17	5	11	5	10	10	11	12
Basic metals	16	18	55	37	40	28	28	25	25
Metals products, machinery and equipment	15	18	7	19	15	22	21	20	20
Other manufacturing industries	0	0	0	0	0	0	0	0	0
Total	100	100	100	100	100	100	100	100	100

Source: Authors' estimates based on EIA, INEGI

Table 5a
Changes in environmental assets per size
(Thousands of 1993 pesos)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	[GR
Micro	4227	5815	9360	15824	18289	22046	41873	36772	132530	1.06
Small	41207	63192	70801	110085	122791	150289	148438	216419	108584	0.21
Medium	124316	176816	334683	444988	460949	549274	593496	701274	890471	3.71
Large	250982	400950	577272	729588	882259	957171	1075270	1271184	1235511	4.07
Giant	564292	936065	1623283	2166160	2387593	2756175	3235570	4065848	4331339	18.76
Total	985024	1582838	2615398	3466644	3871880	4434955	5094647	6291497	6698434	

Source: Authors' estimates based on EIA, INEGI

Table 6a
Number of establishments with environmental assets per size

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Micro	53	112	204	251	302	337	370	436	484
Small	93	184	262	297	356	369	362	368	379
Medium	238	336	499	565	636	677	662	698	696
Large	151	219	305	377	440	472	485	478	453
Giant	184	228	288	340	398	429	451	445	434
Total	719	1079	1558	1830	2132	2284	2330	2425	2446

Source: Authors' estimates based on EIA, INEGI

Table 7a
Mean value of environmental assets per establishment

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Micro	80	52	46	63	61	65	113	84	274
Small	443	343	270	371	345	407	410	588	287
Medium	522	526	671	788	725	811	897	1005	1279
Large	1662	1831	1893	1935	2005	2028	2217	2659	2727
Giant	3067	4106	5636	6371	5999	6425	7174	9137	9980
Total	1370	1467	1679	1894	1816	1942	2187	2594	2739

Source: Authors' estimates based on EIA, INEGI

Table 8a
Value of environmental assets of foreign enterprises

	1994	1995	1996	1997	1998	1999	2000	2001	2002	RI* %
1. R&D assets	89802	144853	193989	281163	344857	395838	429560	513496	560278	26
2. Number of establishments*	96	196	309	382	453	506	482	514	520	24
3. Control assets	110203	205988	421813	843648	1013931	1126106	1342564	1674821	1709680	41
4. Number of establishments**	112	141	159	178	194	202	200	205	207	8
5. Total assets	200005	350841	615802	1124811	1358788	1521944	1772124	2188317	2269958	35
6. Number of establishments	180	279	381	450	523	568	538	572	577	16
5 / Total industry assets		0.22	0.24	0.32	0.35	0.34	0.34	0.35	0.34	
6 / Total industry establishments		0.26	0.24	0.24	0.24	0.25	0.23	0.23	0.23	

Source: Authors' estimates based on EIA, INEGI
*rate of increase (%)

Table 9a
Value of environmental assets of export enterprises

	1994	1995	1996	1997	1998	1999	2000	2001	2002	RI* %
R&D assets	246094	382918	463161	593287	691771	813112	896480	1073520	1136508	21
Number of establishments*	190	375	648	831	940	1056	1056	1075	1035	24
Control assets	234247	611512	1468279	1946384	2230304	2518248	3017651	3774050	3924988	42
Number of establishments**	209	263	327	375	409	430	436	432	410	9
Total assets	480341	994430	1931440	2539671	2922075	3331360	3914131	4847570	5061496	
Number of establishments	339	534	808	988	1082	1180	1181	1199	1142	

Source: Authors' estimates based on EIA, INEGI
*rate of increase (%)

Bibliography

Aden, J., Kyu-hong, A., and Michael T. Rock (1999), "What is Driving the Pollution Abatement Expenditure Behavior of Manufacturing Plants in Korea?", *World Development* 27(7): 1203-1214.

Brown, F. (2000), "Environmental Performance and Trade Liberalization in the Mexican Textile Industry", R. Jenkins, *Globalisation, Trade Liberalisation and Industrial Pollution in Latin America*, London, Routledge.

Brown, F., and L. Domínguez (1998), "Productivity in large and small establishments with different input use intensities" (*Productividad en grandes and pequeños establecimientos con distintas intensidades en la utilización de insumos*), *Economía Mexicana* VII(1).

ECLAC (1998), "Industry and Environment: A Challenge of Survival" (*Industria and medio ambiente: un reto de supervivencia*), L. M. R.671. Mexico, ECLAC.

Dalcomuni, S. M. (1997), *Dynamic Capabilities for Cleaner Production Innovation: the case of the market pulp industry in Brazil*, PhD. Thesis, SPRU, Sussex.

Dasgupta, S., Hettige, H. and D. Wheeler, (2000), "What Improves Environmental Compliance," Journal of Environmental Economics and Management 39.

Domínguez, L. "Environmentally Favorable Business Behavior: The Case of the Manufacturing Industry in the Mexico City Metropolitan Area" (*Comportamiento empresarial favorable al medio ambiente: el caso de la industria manufacturera de ZMCM*), in Mercado, A. (comp.), *Instrumentos económicos para un comportamiento empresarial favorable al ambiente en México*, FCE - El Colegio de México, 1999.

Domínguez, L. (2000), "Environmental Performance in the Mexican Chemical Firms in the Context of an Open Market", R. Jenkins, *Globalisation, Trade Liberalisation and Industrial Pollution in Latin America*, London, Routledge.

Domínguez, L.(2002), "Necesidades de bienes y servicios ambientales en las micro y pequeñas empresas: el caso mexicano", *Serie medio ambiente y desarrollo* , Santiago de Chile, CEPAL/Sociedad Alemana de Cooperación Técnica GER/01/038 "Identificación de áreas de oportunidad en el sector ambiental de América Latina y el Caribe.

Domínguez, L. (2004),"Structural Change and Environmental Innovation in Mexican Industry" (*Cambio estructural e innovación ambiental en la industria mexicana*). Doctoral Thesis in Economic Sciences, Universidad Autónoma Metropolitana.

Domínguez, L., and F. Brown (1998), "Transition to flexible technologies and international competitiveness in Mexican industry" (*Transición hacia tecnologías flexibles and competitividad internacional en la industria mexicana*), Mexico, Miguel Ángel Porrúa.

Dussel, E. Piore, M. and C. Ruiz, "Think Globally, Act Regionally" (*Pensar globalmente and actuar regionalmente*), Ed. Jus, Mexico, 1997.

Dutrenit, G. and M. Capdevielle, (1993) “Technological profile of Mexican industry and its innovative dynamic in the 1980s” (*El perfil tecnológico de la industria mexicana and su dinámica innovativa en la década de los ochenta*), *El Trimestre Económico* 239.

Dutrenit, G., Vera-Cruz, A.O. and A. Arias (2003), “Differences in technological capability profiles in three Mexican companies” (*Diferencias en los perfiles de acumulación de technological capabilities en tres empresas mexicanas*), *El Trimestre Económico* (277).

Finger, M., Haldimann, U. and S. Bürgin (1995), “Organizational and inter-organizational learning towards sustainability”, *Mimeo*.

Garrido, C. (1994), “National Private Groups in Mexico” (*Grupos privados nacionales en México*), *Revista de la CEPAL* (53).

Henriques, I. and P. Sadorsky, (1996), "The Determinants of an Environmental Responsive Firm: an empirical research," *Journal of Environmental and Economic Management* 30.

Hettige, H., Huq, M., Pargal, S. and D. Wheeler (1996), "Determinants of Pollution Abatement in Developing Countries: Evidence from South and Southeast Asia" ,*World development* 24(12).

Hsiao, C. (2003), *Analysis of Panel Data*, London, Cambridge University Press.

Maerasse, J. and M. Sassenau, (1991), “R&D and Productivity: a survey of econometric studies at the firm level”, *W. P.* 3666, Cambridge.

Banco de México, (1993). “Survey of capital and capital assets” (*Encuesta de la formación de capital and acervos de capital*), Mexico.

Montalvo, C. (2002), *Environmental Policy and Technological Innovation*, Cheltenham, Edward Elgar.