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12

# The Mexican Maquila Industry and the Environment; An Overview of the Issues

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# Contents

## Tables



## Boxes



## Graphics

# Abstract

The maquiladora in-bond industry is a key factor for Mexico's economic development and dominates the economic activity in the region of its principal presence - the northern frontier states. For instance, in the 1993-98 period, the maquiladora exports accounted for 41.5% of the average Mexican export value (Dussel, 2000). As is the case for most industrial activity, the maquiladoras have received much negative attention in terms of their impact on the environment, which can be summarized in three factors: population, traffic and industrial activity (EPA, 2000). The complexity is accentuated by growth of population in the regions of Mexico bordering the United States: projected to double by 2020 from 10.6 million in 2000.

This report examines different aspects of the environmental performance of the maquiladora industry in northern Mexico. One of the greatest challenges faced was the scarcity of data. A special effort was made to gather scattered information to create a broad picture of the variables studied. A set of drivers of environmental performance is defined, and a set of environmental indicators is used to illustrate the maquiladoras' performance. Specifically, this report aims at filling the gap in existing studies, by considering environmental production-related externalities (e.g. atmospheric emissions), indirect social-economic externalities (e.g. traffic and population pressure), regional resource constraints (e.g. short-and long term water supply), and by studying different maquila sectors as well as spatial aspects.

According to the research carried out for the present document, the main fields of environmental concern regarding the maquiladoras are direct externalities in terms of hazardous waste generation, and

critically, indirect externalities in terms of water use. In this respect, the current transborder water crisis between Mexico and United States is a symptom of the problem in adequately addressing issues of natural resource management and industry policy on both sides of the border, for example the choice of location and high growth rate of the maquiladoras in northern Mexico and their impact on the region's explosive population growth. These variables cause maquiladora-specific indirect environmental externalities that put long-term regional sustainability under pressure, especially in terms of water supply, and high maquiladora-induced traffic with associated emissions.

Regarding hazardous waste generation, in the 1996-1999 period a scale effect in increasing economic activity resulted in an increase in the waste tonnage returned to the United States (a proxy for waste generation). However, an additional composition and/or improved reporting effect was present, as more waste was returned than should have been induced by the increased economic activity per se. Baja California alone contributed a large part of this aggregate increase. This state, in some aspects, also received a higher share of environmental sanctions than explained solely by its larger waste tonnage.

By maquiladora sectors, the "electronic & electric" maquiladoras in the Mexican border states are more intensive in environmental capital [1] than is the "autoparts" maquiladora-sector (together with "apparel", which is generally held to be relatively clean, these three make up the dominating maquiladora-sectors in terms of value added). In this respect, a previous study in Tijuana (Kopinak & García, 2000) suggests that part of Baja Californa's performance is derived from a negative composition effect in terms of a structural shift to more environmentally intensive small scale electronics firms. During the 1993-2000 period, the number of inspections did not keep pace with the increasing quantity of maquiladoras, a fact that resulted in a diminishing share of these firms being inspected. A change in the policy variable is partly attributable, as inspection efforts were concentrated to serious violators.

In spite of the sometimes-harsh environmental critics against the maquiladoras, the report suggests that in aggregate terms, the maquiladora industry performs better than the non-maquiladora industry with respect to direct environmental externalities. This is explained by the structure of sector-presence of the maquilas, with a bias towards industry sectors dedicated to transformation of intermediate goods, such as autoparts, rather than primary materials, such as metal foundries. Another determinant is the structure of industry-processes, with a bias towards natural resource extensive processes, such as assembling, rather than water- and pollution intensive processes, such as painting. Taken together, these technological characteristics are ultimately determined by, among others, international linkage and stakeholder pressure induced by location choice, technological vintage, as well as Mexico's competitive advantage in low-cost labor capital endowments.

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[1] The expression "environmentally intensive" refers to the set of production inputs used in an industry process. The firm determines the proportion of capital used in its processes, e.g. labor capital, man-made capital, and, natural capital. The latter incorporates direct inputs, e.g. water and minerals, and, in its wider definition, indirect environmental services such as absorption and assimilation of waste arising form production processes (Pearce, forthcoming). Although both are essential for the production process, direct inputs are normally prized, while indirect inputs often constitute negative environmental externalities, "In this sense, a factory that pollutes a body of water, destroying fish stocks, is no different from a fishery which over-exploits the species, rendering it extinct" (Johnstone, 1995).

# I. Introduction

The Mexico-United States border region comprises one of the most dynamic and complex industrial areas in the world. The region is characterized by high population growth and increasing urbanization and industrialization, all of which is taking place in a context of rapid political and economic change (Rincón, 2000). The Mexico-located maquila in-bond industry is a key player in this development. In the 1993-98 period, the maquilas accounted for 41.5% of the average Mexican export value (Dussel, 2000), and in the 1994-2000 period its share of foreign direct investment grew from 6% to 21.4%.

However, while industrial development is desirable as a generator of material wealth (e.g. provision of employment and tax base), it also causes negative effects such as depletion of natural capital (e.g. consumption of environmental goods like water, and services such as the assimilation of emissions). In particular, the location choice and the rapid growth of the maquila industry constitute true challenges for the policy maker. This is accentuated by the fragility imposed by climatic conditions in the Border States and topographical disadvantages as illustrated by the Tijuana region that is vulnerable to erosion, floods and landslides (Ojeda, 2000).

Furthermore, this choice of location emphasizes the transborder interdependence in the form of, for example, the many drainage basins which links Mexico and the United States (Johnstone, 1995). The aggregate environmental impact takes the form of augmented demand for space, water, and energy, increased traffic and congestion, hazardous waste generation and subsequent demand for waste management and disposal, atmospheric pollution, and risks for environmental accidents (EPA, 2000). Especially hazardous waste is perceived as one of Mexico's most alarming industry-environmental themes and PROFEPA (2000) states that this is especially true for maquilas.

Apart from strong industry growth and the choice of location, the maquilas are distinguished by their production-processes, namely; a) a bias towards labor-intensive (and consequently relatively less sophisticated) processes, [2] b) location in the production-chain, (i.e. spatial, and sometimes ownership-specific separation from the parent company), and c) less extensive production chains.

The purpose of this report is to explore the environmental performance of the maquiladoras in this vulnerable setting, taking into account the specific characteristics of this industry. The study will add to existing research in two ways. Firstly, it aims at bridging the gap between previous studies, by isolating and analyzing the key components that determine the maquila's environmental performance, and subsequently put them in their corresponding context. Specifically, it studies the maquiladora's environmental performance in terms of environmental production-related externalities (e.g. atmospheric emissions) as well as regional indirect social-economic externalities (e.g. demographic effects on water consumption). Furthermore, the framework is applied specifically to Mexico, and the United States comparisons are included only to the extent that they are perceived as essential in the Mexican context.[3]

Secondly, aiming at gathering scattered information so as to provide a broad picture of the variables at hand approaches the challenge posed by the scarcity of data. Previous attempts in the literature to cast light on the environmental performance of the maquiladoras reveals the serious shortage of quantitative as well as qualitative data in the field.

Chapter 2 provides definitions, limitations and sources applied in the study. Specifically, a classification of environmental indicators is introduced. Chapter 3 combines the findings of a literature survey with economic theory in order to introduce an analytical framework, which aims to specify the key drivers to the maquiladora industry's environmental performance. The empirically oriented chapter 4 presents indicators that aim to illustrate the drivers to environmental performance. Finally, chapter 5 presents some preliminary conclusions and policy implications.

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2 That is, any labor skill, including basic labor skill, is relatively cheaper in Mexico than in industrialized economies such as United States and Japan. Other drivers to this choice of location are, for example, firm-specific endogenous factors (Carrillo, 2002) and tax incentives.

3 In this respect, much literature in the field includes United States- Mexico comparisons that are not necessarily relevant for Mexican policymaking, but may distort domestic priorities. For overviews of the United States-Mexico environmental context, see, for example, Liverman et. al.(1999) and EPA (2000).

# II. Background and Sources

A literature survey as well as an extensive search for statistics was conducted in order to obtain a base of quantitative and qualitative secondary material, subsequently complemented with a number of key-interviews with related experts. The nature of maquiladoras [4] makes it impossible to apply many of the common methodologies used in Less Developed Countries (LDC) and it is problematic to define proper benchmarks for the maquilas. For example, the World Bank's IPPS [5] methodology is not applicable, as it does not take into account that maquilas incorporate only a smaller share of the entire production-chain, making it non-comparable with other industry sectors. Furthermore, the extreme internationalization of the maquilas complicates the application of "industry value-added" in the widely used pollution-intensity denominator. [6]

4 The term "maquila" is of Arabic origin and refers to the unit of grain destined for the mill. Thereby, it is linked to a productive process in which the owner of the input is distinguished from the operator of a specific production activity. Nowadays, the term is not necessarily used in the same context. Frequently, "maquila" is applied in a legislative context and refers to a tariff-classification for temporary imports of production-inputs (CEPAL, 1999).

5 The Industrial Pollution Projection System (IPPS) is a modeling system which combines data from industrial activity (e.g. production output or employment) with data on pollution emissions, in order to calculate pollution intensity factors. Estimates for industrializing countries with poor emissions data can be obtained by combining United States pollution estimations with data on industry activity for the country of interest for the study (World Bank, 2002). However, the IPPS industry classifications does not apply to the maquilas.

6 Pollution intensity is expressed as quantity of pollution divided by some indicator for industry activity, e.g. value-added.

The bulk of statistics [7] applied in this report are provided by the Mexican Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) and its semi-autonomous bodies: Instituto Nacional de Ecología (INE, which provides data on the aggregate returning of hazardous waste to the United States by the maquiladoras), Procuraduría Federal de Protección al Ambiente (PROFEPA, with data on enforcement of environmental regulations) and Comisión Nacional del Agua (CNA, which provides aggregate data on water supply and infrastructure). Specific attention is given to the topic of hazardous waste, and HAZTRAKS, [8] virtually the only available structured source on hazardous waste, provides statistics on the maquilas returned volumes of hazardous waste to the United States. As point-source emissions statistics on atmospheric emissions is legally protected, the air-emissions data used in this report centers on regional air-emissions. It is necessary to take on a similar spatial approach to the study of water management due to the difficulties in accessing water-consumption and residuals.

Box 1 details the framework of indicators applied to cast light on the environmental impact of the maquiladoras. Some trends are revealed by disclosing scale and composition effects in the data. [9]

**Box 1**

**ENVIRONMENTAL INDICATORS**

Indicators of environmental performance contribute to produce informed policy decisions by providing means to detect changes over time in industrial emissions, for example. OECD (2001a) has developed a useful taxonomy, which organizes environmental indicators in three categories: “pressure”, “state” and “response” variables. Pressure indicators reflect the direct or indirect pressure on the environmental capital. This pressure is caused by, for example, point source emissions and consumption of environmental products and services as well as social-economic factors. State-indicators refer to stock related issues such as air quality. Finally, response variables refer to the measures taken to mitigate the detrimental impact on the environment and can be illustrated by environmental policy in the form of legal framework and its enforcement as well as adoption of pollution abatement technology (PAT). [a]

[a] EPA/SEMARNAT (1998) develops a general framework of the environmental situation in the border area, based on the OECD taxonomy of environmental indicators.

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7 Availability and representativeness of official statistics is constrained by, among other factors, methodological (i.e. lack of consistency in data collection and presentation), organizational (i.e. lack of data due to poor coordination and systematization between the three levels of government, and between the Mexican states), legal (i.e. confidentiality) and, ultimately, financial and resource constraints. For example, Silva (2002) notes the large discrepancy in reporting priorities and routines among local PROFEPA delegates. Data-reliability may suffer from the lack of incorporating illicit use and in-bond recycling (ITAM, 2000). Furthermore, leakage and illicit use results in that only some 70% of national water generation is accounted for in offical data (Szekely, 2001); centrally available data on federal water does not take into account the significant portion of water consumption that originates in municipal water sources (Mendoza, 2001).

8 The HAZTRAKS database, managed jointly by INE and the United States EPA, contains statistics on Mexico-US transfers of hazardous waste (by the top ten firms in terms of quantities, and disclosed per Mexican northern border state). It was initiated in the mid-1990s as a means to track the large volumes of hazardous waste dumped on the United States side of the United States-Mexico border (Silva, 2002). The statistics are based on customs registers and the firm’s compulsory reporting of the volumes of hazardous waste returned.

9 Increased contamination can be caused by an increase in economic activity (scale effect) or by dirtier economic activity (composition effect). An increase in aggregate contamination caused by a corresponding increase in industry activity can be socially efficient if the decrease in natural capital is compensated by investments in socially important capital, such as education. For the sake of exposition, the scale expressions of “contamination” and “pollution” are used. However, a conceptually more appropriate term (but practically more demanding) is “damage”, as it encapsulates not only the “gross” scale effect, but the “net” detrimental effect on health or nature, including resiliance and carrying capacity considerations.

When not specifically pointed out, the text refers to the maquila industry in general. However, the empirical chapter 4 provides sector-specific analysis of the “autoparts” and “electronic & electric” maquilas. Due to time constraints, this report approaches the wide concept of “environment” by focusing on hazardous waste as well as water and atmospheric pollution. [10]

[10] For a recent view of the performance on the part of the maquila industry in terms of labor health, see, for example, Denman y Cedillo (2000).

# III. Conceptual Framework

This section aims to shortly introduce key drivers to the environmental performance of the maquiladoras. [11] The individual firm faces endogenous as well as exogenous constraints to its environmental conduct, exemplified by firm-specific financial factors and type of trade regime. In this context, theory predicts the firm to determine its environmental performance by weighing the cost and benefits of each alternative. Meanwhile, the authorities and other stakeholders influence the firm's expected cost of compliance through mechanisms such as environmental regulations. [12]

## 1. Institutional Framework, Policy Failure and the Firm's Expected Cost of Compliance

The environmental conduct of economic agents in Mexico, including maquiladora and non-maquiladora firms, is regulated in LGEEPA. [13] One example is its Art. 10 that requires special permits for the installation and operation of systems of storage, transport, and management of hazardous waste.[14] The La Paz Agreement establishes a particularly strict regulatory framework for maquilas, obliging them

[11] For a more detailed review, see for example Kolstad (1999).

[12] Expected cost of no-compliance is obtained by weighing the probability of getting caught, with the corresponding penalties and other costs of not complying with environmental regulation (Kolstad et.al, 1990).

[13] La Ley General del Equilibrio Ecológico y la Protección al Ambiente. In particular, the COA (Cédula de Operación Anual) requires that firms report their potentially hazardous substances to the authorities. COA contains a detailed subsection called Registro de Emisiones y Transporte de Contaminantes (RETC).

[14] CESPEDES (1999) provides a comprehensive overview of the legal environmental framework for the industry in general.

to return their hazardous waste to the country of origin (Hegmann, 1999). [15] Additionally, since the 1990s several mechanisms of voluntary compliance have been applied as a means of cost-efficient environmental policy.

Policy failures and institutional constraints figure among the key features that obstruct legal enforcement and subsequently determine the firm's expected cost of compliance. These constraints include resource constraints and disciplinary shortcomings, poor information systems and powerful interest groups. [16] One study (Dasgupta et. al., 1997) found that less stringent environmental policy in Mexico is indeed correlated with lower environmental performance on behalf of the industry. In this context, the expected cost of compliance may be structurally different for maquila vs. non-maquila due to stronger negotiation power with authorities for one than for the other. One factor is that the maquiladoras share a rather homogenous set of interests and a corresponding scope for policy-coordination. Some results from Kopinak & García (2000) [17] may reinforce such a hypothesis: they describe the success of maquilas in defending their industry-presence in residential areas in Tijuana in which industry is normally banned. Also, several maquilas which, on the grounds of environmental violations have been forced to close down, re-open without having corrected their shortcomings (Kopinak & García, 2000).

Additionally, the opportunity cost of complying rises in a context of uncertainty. This determinant is fostered by discontinuity as well as contradictions and gaps in the environmental regulation between the three levels of government; federal, state and municipality (CESPEDES, 1999). Moreover, at least previously, short-term permits for maquilas were commonly issued, particularly in the apparel sector. [18] This affects the firm's willingness to make commitments in environmental investment.

## 2. Financial Constraints, Scale, and Environmental Performance

There is a rich body of literature dealing with how financial constraints as well as scale of production affect environmental performance. The individual firm perceives its financial situation as a constraint to the possibilities to undertake "green" investments. In this respect, some empirical material based on Mexican firms have found a positive linkage between profits and environmental performance at the firm level (World Bank, 1998).

It has been argued that scale of production generally is a positive driver to environmental performance (Beckerman, 1995). One explanation is economies of scale. [19] Further, larger companies are more "visible" and consequently more likely to attract scrutiny by authorities and neighboring communities. Moreover, large companies may face lower barriers to get access to investment capital, both in terms of "green" investments and investments linked to technological vintage. [20] In this respect, empirical studies by Dasgupta (1997) [21] and the World Bank (1998) support a positive relationship between firm-size and environmental performance concerning Mexican firms in general, and García (1999) [22] and Mercado (2001) [23] with respect to Mexican

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[15] There exists some exceptions to this rule. For example, Reed (1998), in 1996, states that more than 5% of the total hazardous waste-volume of United States owned maquilas were disposed of legally in Mexico.

[16] For those "green" investments that are motivated by reasons of competitive advantage, see subsequent section on "Stakeholder Preferences".

[17] Their study is based on local environmental enforcement data, other environmental data such as HAZTRAKS, and interviews.

[18] Personal interview with Carlos Silva, General Director of Industrial Technology, Subprocuraduría de Verificación Industrial, PROFEPA, April 3, 2002.

[19] Illustrated by EOS in environmental technology.

[20] See section on Technological Vintage.

[21] Dasgupta defined large companies as "large plants in multi-plant firms".

[22] In-depth interviews with 12 maquiladoras in the electronics sector in Tijuana, Mexico.

[23] Survey of 43 maquiladoras in the north and south of Mexico.

maquilas in particular. However, many factors intervene, and larger firms may use their more substantive resources to avoid enforcement measures (Silva, 2002). [24]

Regarding financial constraints and the maquilas, Lichaa (2001), for example, notes that environmental considerations on the part of maquiladoras are often constrained by the cost-constraints imposed by foreign parent companies. In this respect, to the extent that labor intensive processes (i.e. maquiladora assembly) compete predominantly on a low cost-basis, they may have little maneuvering room for additional expenditures in environmental technology. However, as demonstrated in other sections of this chapter there are also forces that work in the opposite direction, favoring the maquiladoras in terms of environmental performance.

## 3. Stakeholder Preferences and Competitive Advantage by "Green" Investments [25]

Apart from interventions on the part of authorities, private stakeholders affect the firm's willingness to undertake voluntary measures to improve environmental performance. On the demand side, investments in environmental performance may constitute a de facto competitive advantage on the international trade scene, by facilitating access to profitable "green" product niches. [26] Furthermore, innovators of "green" technology may gain privileges from authorities and influence the type of industry-standards to be established. However, also seemingly indirect stakeholders can have substantial impact on the firm's environmental performance. This can include protest actions by communities exposed to production externalities, or, investors and authorities sensitive to put their stock values or mandate at risk by negative publicity. Wheeler (2000), based on empirical material from Latin America and the OECD countries, demonstrates that such stakeholders in several occasions have forced firms to enhance their environmental performance.

Maquila stakeholders, it can be argued, suffer from greater information failure than others, and subsequently have a relatively minor scope of influence. This can be explained by spatial and process-specific reasons. For example, maquila stakeholders who are geographically distanced from the manufacturing sites share neither the incentive structure nor the information of local stakeholders. In particular, while national information fora and mass media provide the firm's stakeholders with sufficient information to judge the associated production processes, in the case of foreign owned maquilas, end-consumers and investors face difficulties in tracking the maquiladora-firm's contribution to the entire production chain.

## 4. Internationalization; Comparative Advantage and the "Race to the Bottom" Approach

A striking feature of the maquiladora industry in Mexico is its extreme degree of internationalization (98% of its input is imported, 100% of its output exported). Accordingly, the vast literature on the environmental impact of trade liberalization provides a basis for this section.

24 See also section "Institutional Framework".

25 For the purpose of this report, "Stakeholders" refers to all private agents, including NGOs, which influences, or are influenced by, industry activity. Thereby, it includes agents such as neighboring communities, populations and, investors, among others.

26 In this respect, Jenkins (1998) argues that trade liberalization may direct firms towards more environmental friendly production due to the influence of international consumer preferences. See for example CESPEDES, 1999, for an application to Mexico, and Porter & van der Linde, 1995, in general.

To this end, Box 2 contains a short discussion about the rationale and non-rationale of international diffusion of environmentally intensive industrial activity. [27]

**Box 2**

**ARGUMENTS AND COUNTER-ARGUMENTS FOR THE RATIONALE OF INTERNATIONAL DIFFUSION OF ENVIRONMENTALLY INTENSIVE INDUSTRIAL ACTIVITIES**

Firstly, under the general assumption of exponentially increasing Marginal Abatement Costs (MAC) of industry pollution, [a] countries with relatively low degree of adoption of abatement technologies would be expected to face lower MAC. Consequently, as the adoption of abatement technology is generally correlated with the degree of industrialization, Mexico would face lower MAC than, for example, the United States. Another, though highly controversial, argument is that less industrialized countries face lower marginal damage cost (MDC) of pollution. One reason would be that lower wages translates into lower opportunity cost of hospitalized workers. [b] Another argument would be that the factor-endowments of natural capital assets is larger in many non-industrialized countries (e.g. nature's capacity of pollution reception). This argument clearly does not apply to the maquiladora-intensive Mexican border-states, which face severe capacity constraints in the provision of such goods.

Further, the stock dependence of marginal utility (MU) means that on the average a given unit of income is worth more in a country with lower average income level. In this context, international transfers of, for example, waste management technology would be effective (assuming that wastes are managed properly). The Nash Cooperative Bargaining Problem [c] constitutes an analytical tool for the illustration of efficient levels of transfer. Especially for these recycling processes of hazardous waste which are intensive in labor-capital, such transfers would be motivated from an efficiency point of view . [d] Notice that the above pro-arguments assume well-functioning markets and absence of information failures (Swanson & Johnston, 1999), both of which are often problematic in a typical developing country context.

[a] Marginal abatement cost refers to the cost, in marginal terms, that the firm incurs in order to abate emissions. The "mining problem" serves as an illustration of the generally assumed condition that the first unit of abated pollution is less costly to achieve than is the last: The per unit cost of extracted ore increases. This is attributed to, among other factors, that the purest ore is extracted first.
[b] A multitude of factors interacts, apart from the obvious moral problem. For example, poorer countries face stricter capacity- and quality constraints in their public services. The subsequent under-supply of rehabilitating services and social protection would therefore translate in high opportunity cost for the family members of hospitalized workers, as measured in purchasing power parity.
[c] Simplified, the concept consists in that cooperation and joint transfers can result in optimal solutions thanks to the optimal distribution of wealth (Gravelle & Rees, 1992).
[d] Comparative advantage in labor costs is a driver to international trade flows waste that require labor intensive recycling. One example is China's imports of "electronic" waste and plastic containers (Stromberg, 2001). In this respect, the labor shortage in the Mexican Border States may constitute a reduced comparative advantage.

One pessimistic vein of thinking suggests the presence of a Race to the Bottom phenomena, by which trade liberalization serves as a determinant and a vehicle of specialization in environmentally intensive production-processes (e.g. pollution- intensive manufacturing). The argument is that poorer countries compete with their environment as a stake (Daly & Goodland, 1994). The core issue is that, irrespective of the underlying reason, multinational firms will invest only where the institutional context imposes low pressure on the firms to undertake environmental investments. In the case of the maquilas, Méndez (1995) argues that less stringent environmental policy may figure among the drivers to the maquila's choice of location.

[27] The box is based on Summers' (1992) discussion on North-South allocation of industrial residuals. It serves to theoretically define associated arguments about international distribution of environmentally intensive production processes.

However, there is substantial empirical material that contradicts the above Race to the Bottom argument. Firstly, direct cost analysis suggests that the potential benefits from lax environmental regulations are simply too low to influence location decisions. OECD (2001b), for example, indicates that the direct cost-savings only amounts to some 2-3 percent on average of total production costs. However, in this respect it is important to incorporate indirect non-regulatory environment related production costs (e.g. user charges associated with the use of environment-related public infrastructure as well as ex-post liability costs). Those costs differ substantially across the Mexico-United States border and prohibits any single conclusion on this matter (Johnstone, 1995). Secondly, Schatan (2000), Wheeler (2000) and Gallagher (2000) use industry-wide analysis on Mexican international trade to conclude that trade liberalization in the 1990s did not cause a negative composition effect on environmental performance. [28] In fact, Schatan linked the surge of the NAFTA treaty to export-intensification in relatively less-polluting industries, not the contrary. [29]

However, Jenkins (1998) studied the Mexican case and broke down the analysis to individual contaminants. He found that export-oriented industries in general tend to be cleaner only concerning a small number of contaminants (total suspended solids, particles and carbon monoxide). [30] Another issue with respect to international re-location is that many of the most pollution-intensive industries in Mexico posses structural characteristics which render them less subject to relocation patterns derived from changes in trade policies. [31] Moreover, the mere international re-location of production-processes may not be sufficient to gain lower environmental policy pressure: Johnstone (1995) highlights the policy impact of transfrontier movements of environmental externalities, for example, the substantial quantities of maquiladora transborder emissions that affect the United States (e.g. transborder flows of air and water emissions). In this respect, the concentration of maquilas along the United States border may expose them to considerable attention from policy makers in both countries. [32]

Another factor, which has been showed to be common in OECD countries, is the presence of a “regulatory chill” by which the host country restricts its environmental enforcement in order to attract or maintain investments (OECD, 2001b). As discussed in the section on Institutional Framework and Policy Failure, this is a theme repeatedly observed in the application of environmental policy among maquilas.

## 5. Technological Vintage in Natural-Resource Efficient Technology

Theory predicts that technology may enhance an otherwise unsustainable development path by diminishing the use of inputs per unit of output of production processes. Specifically, application of newly fabricated units of a given technology may enhance resource efficiency (e.g. by phasing out hazardous waste leaking obsolete machinery), as may environmental-enhancing technological vintage by the adoption of new innovations. [33] In this respect, the adoption of technologies

[28] On the contrary, a negative composition effect would indicate that relatively dirtier industries compete more successfully, and shift the country’s production stock towards more environmentally intensive activities.

[29] An additional export driver at the time when the NAFTA treaty coming into force, especially in the autoparts industry, is the Mexican economic crisis which occurred in 1994. A collapsing domestic market and devaluated peso contributed to a redirection of Mexican-produced goods to the export markets (Stromberg, 1999).

[30] Jenkins (1998) discuss the role of government imposed trade barriers *per se*. Jenkins found that relatively more pollution-intensive industries were not structurally more favored by pre-trade liberalization protective measures than other industries. Consequently, those “dirty” industries would not be expected to be less favored by reduced trade barriers than others. However, this argument ignores many determinants, among others, changes in stakeholder pressure.

[31] Factors such as demand and supply elasticities, input-output linkages etc. discourage territorial restructuring of production in traditional non-maquila sectors such as metal foundries and the cellulose industry (Johnstone, 1995). Johnstone argues that these variables are often ignored.

[32] See also section on Internationalization and Information Failure.

[33] A, ilustrative example is the continously enhanced resource-efficiency of combustion-engines.

motivated by other than environmental concern may serve the same purpose as recycling, or the use of pollution abatement technology. Accordingly, countries situated at a relatively lower industrialization stage can “leap-frog” into more environmentally friendly technology by acquiring technology already developed by industrialized countries. In this respect, Gallagher (2000) found that the Mexican steel industry, on the average, is cleaner than its US counterpart. This is explained by the fact that the relatively later development of the Mexican industry allowed it to adopt more recent and cleaner mini mill technology. In this respect, internationalization intervenes by facilitating technology and know-how transfer.

However, the scope for technological vintage is determined by the characteristics of the firm’s production technology. The same study distinguishes between sectors where plant vintage determines pollution levels and sectors which pollution is a function of end of pipe technology (e.g. the Mexican paper industry). In the latter, the level of emissions will be relatively more determined by other factors than the adoption of vintage technology. [34]

PROFEPA (2000) argues that the maquila industry, due to its relatively late date of establishment, [35] enjoys more environmental benefits from generally more upgraded technology as compared to non-maquilas. [36] However, the relative labor intensity in maquila processes in general (Dussel, 2001) may also imply that the scope for technological vintage is less pronounced. On the other hand, the generally less extensive production chains of the maquilas means that some of the environmentally intensive production steps excluded. For example, the vehicle-manufacturing maquila is not characterized by incorporating processes related to painting (Carrillo, 2002), and it is a comparatively small direct user of water (Silva, 2002). [37] Furthermore, Silva (2002) notes that the relatively low sophistication of maquila technology may make the option of imported second-hand technology (which is often more polluting than new technology) a less attractive alternative than is the case for many non-maquilas with greater degree of production complexity.

However, the maquiladoras are becoming a highly heterogeneous group in terms of sector presence and production technology. For instance, Carrillo & Hualde (1997) provide examples of maquilas that have integrated more into the Mexican economy by using a larger amount of Mexican inputs and more extensive and sophisticated production processes. [38] Those maquilas can be expected to approach the non-maquila industry-regime in terms of several determinants to environmental performance, with a corresponding differentiated effect on the environment (e.g. the inclusion of longer production chains and associated polluting processes).

[34] In the latter, e.g. cellulose production, the Mexican industry had not benefitted from a vintage effect. In this case, the end-pipe pollution abatement technology is expected to enhance environmental performance more than would the application of more recently acquired units of a given, or recently innovated, technology.

[35] And, due to the maquilas industry composition.

[36] Dasgupta et. al. (1997) did not find a linkage between the application of modern technology and enhanced environmental performance in Mexican firms. However, the study is highly simplified in the sense that it only differs between technology investments made “before” and “after” the year 1990.

[37] Especially painting processes constitute an environmental problem for the non-maquila “autoparts” sector (Carrillo, 2001).

[38] Those are so called second and third-generation maquilas: first-generation maquilas typically have the following features: high labor intensiveness, foreign ownership in terms of United States investment capital, and are disassociated from the domestic industry. Second-generation maquilas incorporate more automatized production processes and a higher education profile on its employees. They are also characterized by a more flexible scope of production tasks and, just-in-time production. The origin of its investment capital is more heterogeneous, including Asian FDI. Third-generation maquilas are characterized by knowledge-based competition with an important share of R&D. Those firms are still highly internationalized in terms of input, but they are also dependent on domestic firm-clusters and national direct and indirect providers of engineering services and other (CEPAL, 1999). Delphi constitutes an example of the latter type. The firm is linked to the General Motors and incorporates sophisticated production processes and R&D (Carrillo & Hualde, 1997).

## 6. The Impact of Internationalization and Information Failure on the Diffusion of Pollution Abatement Technology

Among the variables affecting the diffusion of pollution abatement technologies are international linkages, information failure, and policy (e.g. legislation and enforcement). However, as previously described, the likelihood that firms apply those technologies is determined by the associated costs and benefits. In this respect, the determinants to the firms pollution abatement cost (PAC) are, firstly, the degree of environmental regulation and enforcement and secondly, time, as a proxy for technological progress and deflated prices on a given technology. Further, as environmental technology is subject to EOS and Learning Curves, PAC is expected to diminish with increased production and industry maturity. The relative weights of those and other forces determine absolute PAC.

In this respect, international linkages may serve as a means of reducing information failure, enhance transfers of “green” technology, as well as “transferring” multinational corporations’ (MNC) strict environmental standards. Regarding the latter, it has been found that MNCs commonly apply standardized environmental measures in order to gain economies of scale in technologies that have been developed in order to cope with strict standards in the home-country (OECD, 2001b). For example, García (1999) found that the application of environmental technology was correlated with the degree of international linkages and higher degree of technological sophistication in production processes. [39] Mercado (2001) came to similar conclusions. Wheeler (2000) and others state that MNCs commonly apply the home country’s technology standards in their overseas manufacturing-activities, however Dasgupta et. al. (1997), in an econometric study of 236 interviewed Mexican firms, did not find that international linkage enhanced environmental performance of the firms.

CESPEDES (1999) adds to the World Bank’s [40] experience concerning information-failure in micro and middle-sized firms, and describes the common feature of information failures in the availability of “green” production processes. While, on the one hand, the reduction of information barriers may pay off in terms of avoided penalties or gained access to green markets, they may also reduce production costs (PROFEPA, 2000). This insight has motivated efforts such as the Texas Border Council programs, which provides free waste management consulting for maquilas (Lichaa, 2001). [41] The program has also discovered that maquiladoras often lack knowledge of environmental and cost-effective substitutes (one example is machinery oils). Another example is bulky waste wood that contains hazardous paint on its surface and therefore was subject to returning to United States. However, by simply separating the hazardous surface-paint from the wood the volumes that needed to be returned were substantially reduced. Simultaneously, as this lowered the cost of compliance, the incentive to cope with regulations increased (Lichaa, 2001).

## 7. Location Choice, Industry Growth-Rate and Indirect Environmental Externalities

The society incurs social costs from indirect externalities which are generated by the combined force of strong industry growth rate, and the fact that many maquiladoras choose to locate in cities, in order to exploit advantages such as favorable conditions for micro-firm clusters (e.g. in Tijuana, Cd. Juarez and Matamoros). Secondly, facing labor shortage and high turn-over

[39] This factor is likely to apply equally to those non-maquila sectors that in a similar way enjoy the benefits from internationalization (e.g. the Mexican “autoparts” and “electronics/electronic” products firms in general).

[40] For example, the World Bank’s experience from a partnership project in Guadalajara (World Bank, 1998) and an econometric estimation of data gathered together by interviews of Mexican firms (Dasgupta, 1998).

[41] This is also congruent with the rational of exploiting the potential for lower MAC in Mexico than in the United States

rates of labor, as well as local infrastructure shortages, maquiladoras often locate in residential areas in order to minimize transaction costs (Kopinak & García, 2000). The consequent rapid growth in localities with highly concentrated population puts infrastructure supply under additional pressure. Also, environmental externalities such as emissions and environmental accidents expose both nature and human populations to risks.

Moreover, the maquiladora´s induce urbanization to historically new areas when workers families and associated supporting services establish in the border region. [42] Issues related to negotiation power and policy enforcement have a stake in this outcome (Kopinak & García, 2000). Another societal cost is the subsidized and insufficiently controlled water usage (consumption and disposal).

Box 3 details some of the context and drivers to the maquilas location choices.

**Box 3**

**THE MAQUILADORA INDUSTRY IN THE BORDER REGION**

The maquilas are extremely internationalized, with both their production input and output being independent from the country of establishment. By locating in the northern states some of the joint transaction costs of the relocation of production are minimized. Among the costs are transport costs [a] as well as sunk costs in manmade- and social capital (i.e. fixed investments in, for example, capital assets, firm networks and firm infrastructure). The location choice has been influenced by, to varying degree, politically imposed restrictions that forced maquilas to establish in the border region.

However, this choice of location brings a broad set of disadvantages, largely related to the regions severe constraint on long-term water supply and nature's reception, assimilation and storage of sewage water. Shortage in investment capital restrict the potential short-term impact of technology, i.e. in the form of water infrastructure investments and water imports from the United States. Furthermore, the location-choice, combined with high population growth-rate in maquila centers, emphasize the need for public investments in order to ensure adequate infrastructure service levels for the industry and its workers. Moreover, the labor-intensive maquilas in the border region face a labor-market that is unable to provide the required quantities and qualities of labor. This, in turn, is reflected in increased labor-costs (e.g. search cost due to high labor rotation).

[a] The transport costs are a function of, among other factors, distance and the quality of roads. Transport costs in Mexico are high due to Mexican road-infrastructure shortages (Mattsson, 1998; Körte, 1998).

Expansion of road-infrastructure, which is motivated by the maquila's transport demands, constitutes an indirect externality derived from the maquiladoras' choice of location. In this respect, and with a reference to the environment-trade variables described previously in this report, Gallagher (2000) highlights the real scale effect of internationalization, e.g., concerning manufacturing-induced growth in traffic and associated emissions (EPA, 2000, OECD, 2001b). The corresponding environment impact is composed by the modification of the habitat for land and aquatic flora and fauna, of superficial water flows, as well as changes in land use (PROFEPA, 2000).

Also, the past 20 years' sharp increase in industry activity and population growth in many maquila centers have put institutional planning efforts under pressure, including environmental enforcement efforts (EPA, 2000).

[42] See for example Garcia y Lara (2000), who describe the substantial micro-firm clusters required to sustaining the population of maquila workers and their corresponding families.

## 8. Section Summary

The conceptual framework suggests that location choice, industry growth and subsequent population growth constitute indirect drivers to environmental pressure. Further, financial constraints may affect the maquiladoras in several ways. On one hand, the maquiladoras still constitute, to a large extent, separate units in the production chain operating under a low-cost rationale. The margins for "green" investments may appear restricted. On the other hand, factors such as internationalization, stakeholder pressure and MNC-wide environmental standards lower barriers to accessing resource efficient and environmentally motivated technology options. Furthermore, the institutional framework is a key variable in the firm's expected cost of compliance and subsequent conduct.

# IV. Empirical Study

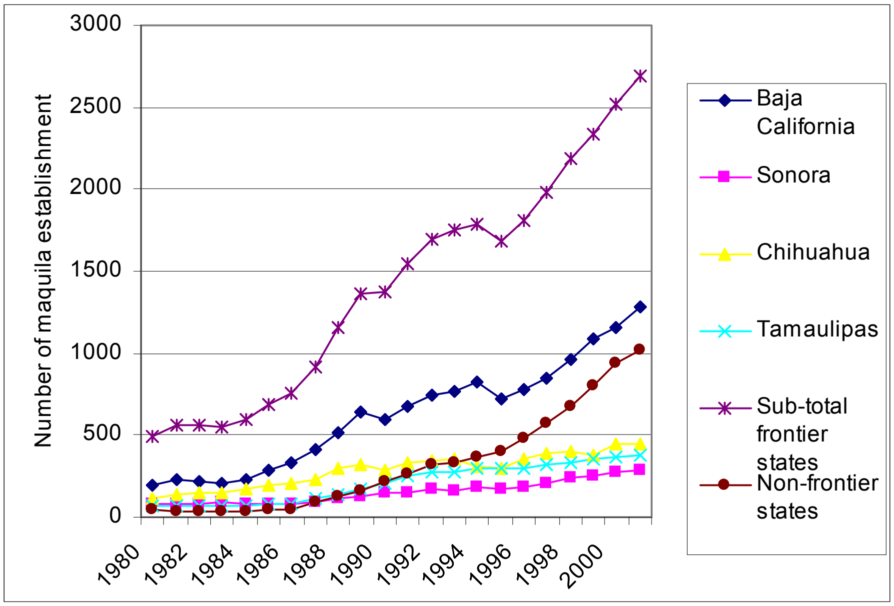
The framework in chapter three lays out a basis for the analysis of the maquila's environmental performance. The current chapter serves to complement with empirical evidence in the form of indicators, which contribute to illustrate the impact of the individual drivers of environmental performance.

## 1. Maquila Industry Activity

In the year 2000, Mexican maquiladoras attracted US$ 2,983 million in foreign direct investment (FDI), or, 21.4% of all Mexican FDI. This meant a substantial increase in absolute numbers from 1994, and an increasing share of total Mexican FDI (from 6% to 21.4% in the 1994-2000 period, see Table 3A). A sector comparison shows that, in 1996, the maquila accounted for 73% of total "electronic & electric" equipment exports, and had a 65% share of the transport industry's exports (Schatan, 2000). The present section describes more closely how this development was reflected in the border region.

Graph 1 depicts the development in the number of maquila establishments in the Border States, in the 1980-2001 period. Thereby, it links to the environmental performance driver which is "Location Choice and Industry Growth Rate" (chapter 2).

**Graph 1**
**NUMBER OF MAQUILADORA ESTABLISHMENTS, PER BORDER STATE, 1980- 2001**




**Source:** Own elaboration, INEGI (2001).

As seen, the Border States dominate at the national level, and their maquila presence grew rapidly during the past two decades. However, during the latter half of the 1990s, the number of establishments grew faster in non-Border States. Baja California dominates in the Border States in terms of number of maquiladora establishments and growth rate. The other maquila-dense states are Chihuahua and Tamaulipas.

Although for reasons of data availability it is convenient to handle statistics at the state level, it should be clear to the reader that the maquiladoras in the Border States are extremely concentrated to urban centers. For example, the Baja California statistics are dominated by Tijuana (particularly intensive in "electronic/electric" maquiladoras) and, to a much lesser extent, Mexicali. Equivalently, the maquiladora production in Chihuahua is concentrated to Cd. Juarez (espically "autoparts" maquiladoras). Lastly, Matamoros is the maquiladora center in Tamaulipas (SECOFI, 2000).

Table 1 provides data on value added, employment [43] and number of establishments of the maquiladoras in the border municipalities. [44] For example, in 1999, preliminary data (P), the maquilas' value added in the frontier municipals made up 80,8 million pesos, and they employed more than 700,000 persons. The same year, "autoparts" maquilas represented 23.3% and "electric & electronic" maquilas 43.1% of total maquila value added in the frontier municipalities.

Employment numbers are of particular interest for this study. Namely, employment is a pressure indicator and an indirect estimator of maquila-related population pressure in the border

[43] In determining a proper deflator of maquiladora industry activity, it is preferable to use number of working hours instead of some monetary index (because of the characteristics of the maquiladora industry, e.g. obstacles to choose between Mexican or foreign inflation indexes). However, employment is used due to the lack of statistics on man-hours. I argue that employment is an acceptable deflator, because the maquiladora industry, and especially the sectors "autoparts" and "electronic & electric" products, were characterized by a strong increase in production during the 1990s (as measured in number of establishments and value added). In particular, because the major drawback of the employment deflator is its low negative, not positive, production output elasticity.

[44] This is a somewhat more narrow set than is data at the state level. However, statistical analysis suggest that the two sets of data do not substantially differ from each other (see table 11A for more updated employment statewise anual data).

region. In this respect, in the 1994-1999P period, maquila employment increased with 69.2%. This was explained by scale- and composition effects because, in the period, the number of maquiladora establishments increased from 1,489 to 2,001, while the average number of employees per establishment increased from 284 to 357.

An inter-sector comparison reveals that employment in "autoparts" and "electronic & electric" maquilas expanded by approximately the same rate (69.5% and 63.5%, respectively, both explained by a positive composition effect).

**Table 1**
**MAQUILA INDUSTRY DATA, FRONTIER MUNICIPALITIES (MONTHLY AVERAGES), 1994-1999P [a]**

| Sectors | Years | No. of establishments | Value added (1 000 mexican pesos, nom.) | Employment |
|---|---|---|---|---|
| All sectors | 1999P | 2 001 | 80 844 685 | 714 715 |
| | 1998 | 1 857 | 63 499 425 | 661 273 |
| | 1997 | 1 735 | 47 850 550 | 607 642 |
| | 1996 | 1 579 | 33 935 391 | 522 508 |
| | 1995 | 1 446 | 23 661 931 | 465 071 |
| | 1994 | 1 489 | 14 890 350 | 422 996 |
| Auto parts [b] | 1999P | 161 | 18 845 576 | 157 307 |
| | 1998 | 150 | 14 687 742 | 148 287 |
| | 1997 | 140 | 11 424 066 | 135 456 |
| | 1996 | 129 | 8 223 506 | 116 705 |
| | 1995 | 118 | 5 968 928 | 105 453 |
| | 1994 | 118 | 3 954 821 | 96 281 |
| Electronic & electric products [c] | 1999P | 518 | 34 884 942 | 295 583 |
| | 1998 | 486 | 27 787 843 | 270 848 |
| | 1997 | 465 | 20 146 833 | 252 163 |
| | 1996 | 434 | 14 347 812 | 217 837 |
| | 1995 | 420 | 9 825 684 | 196 913 |
| | 1994 | 429 | 6 003 726 | 174 957 |

**Source:** INEGI (2000) "Estadística de la industria maquiladora de exportación, 1994-1999".

[a] Preliminary data.
[b] "Construction, reconstruction and assembling of transport equipment and their accessories". This excludes "Assembling and reparation of accessories and equipment and their parts excluding electrical products".
[c] "Assembling of "electronic" and electric machinery, equipment and articles" and "Electronic and electric materials and accessories". This excludes "Assembling and reparation of accessories and equipment and their parts excluding electrical products".

The increase in maquiladora establishments and their associated workforce highlight that resource-constraints in Northern Mexico is placed under high pressure, especially considering the multiplicative indirect maquiladora related population. Furthermore, this pressure has increased during the past decades.

The current Mexican economic crisis strikes the maquiladora industry particularly hard. For example, the total Mexican maquiladora workforce diminished by approximately 228,000 employees during 2001 (INEGI, 2002), and seven "autoparts" maquiladoras ceased operations. This means that the industry is subject to its largest relative employee layoffs since the early 1980s (SIEM, 2001). Table 11A indicates that the 5 most maquila intensive Border States are generally less affected in terms of percentage decrease in the labor force than is the national average. Nevertheless, the scale effect is substantive in the above average layoff percentage in maquila intensive northern states such as Baja California and Sonora (-23% and –29%, compared to the national average of –18%). The precise environmental impact of the layoffs remains to be evaluated. For example, if a structural shift occurs towards more environmentally intensive sectors. Further, it may be the cases that the crisis adjusts the firm’s financial capacity and willingness to undertake green investments (Silva, 2002).

## 2. Hazardous Waste Management [45]

Hazardous waste generation and adequate management constitute considerable challenges in Mexico, for maquila as well as non-maquila industry. Some basic statistics provide an idea of the scale of the issue; in 1996, the estimated quantity of hazardous waste generated by the manufacturing subsector of “Metallic products, machinery and equipment” was 152,286 tons, or approximately 15 percent of the Mexican industry’s total generation that year (INE, 1999). In relative spatial terms, CESPEDES (1998) reported that approximately 33,765 tons of hazardous waste is generated in the Mexico-US border region, annually (defined as the area within 100 km from the US border), compared with 5,114,507 tons for the area comprising the central Mexican states.

As regards the maquiladoras, at the beginning of the 1990s, it was estimated that 65 percent of the maquiladoras in the northern frontier states did not return their hazardous waste (Cámara de Diputados, 1993). However, a radical improvement has occurred ever since. The founding of PROFEPA in 1992 gave rise to a more stringent institutional framework, and, in 1994, the first Mexican hazardous waste inventory was created (Kopinak & García, 2000). Nevertheless, in 1996, INE still lacked records on approximately 26 percent of hazardous waste generated by the maquila (Reed, 1998).

Reflected in the statistics in Table 2 are the explicit obligation to return hazardous waste to the country of origin. The data on hazardous waste is the only available indicator of hazardous waste-generation and provides at least a lower benchmark for the real volumes. During the first eight months of 1999, the maquilas returned 97,301 tons of hazardous waste. Furthermore, between 1996 and September 1999, the tonnage returned increased by 35 percent. A comparison with the corresponding years’ economic activity, i.e. employment, reveals that, until 1999, the increase in hazardous waste tonnage approximated the increase in employment. However, in 1999, a strong composition effect almost doubled the tonnage per employee, which suggests that the increase in tonnage was not explained by an increase in economic activity alone.

A spatial comparison shows that the states which dominate in terms of number of maquiladoras, i.e. Baja California, Chihuahua and Tamaulipas (and increase their domination, as seen in the previous graph 1) also returned the largest quantities of hazardous waste to the United States. In particular, two thirds of the increase in returned tonnage from Baja California and Chihuahua was caused by a composition effect with respect to the economic activity, and this effect was stronger in Baja California than in Chihuahua. (The effect was strong enough to explain 35% of the increase of hazardous waste from all five northern states).

[45] Hazardous waste refers to those residuals which, due to their characteristics of being corrosive, reactive, explosive, toxic, inflammable or biologic-infectious, represent a danger for the ecological equilibrium (LGEEPA, Art. 3, Fracc. XXXII, in INE, 1999). The nature of hazardous waste can be further defined according to their form (isolated, mixed or solution) and state (solid, liquid or clay) as well as in the way they have been generated (e.g. production-process sub-products, or as a result of cleaning of machinery and installations). Depending on their physical-chemical and toxicological characteristics, hazardous waste may represent a threat to human life, health, ecosystems and property. In particular, hazardous waste in the form of liquids, and clay, constitute a more distinguished risk of contaminating superficial as well as subterrain water (Méndez, 1995). This may occur voluntarily or accidentally.

This composition effect in the data may be explained by a shift to more polluting industrial activity. Such a change would cause a real increase in waste generation, and a subsequent increase in the data reported. Alternatively, the compliance rate may have increased, so that waste that was earlier deposed illegally to a higher degree got returned to the United States. This "waste management effect" would be congruent with the increase in regulatory enforcement efforts that occurred during the period. Furthermore, in 1996, the initial year of the period, Baja California showed a relatively low estimated rate of reporting, as compared to the other northern states (data from INE, in Reed, 1998). [46] Consequently, a shift to more stringent regulatory efforts may have paid off relatively well in this state compared to other states.

**Table 2**

**RETURNING TO COUNTRY OF ORIGIN OF HAZARDOUS WASTE FROM THE MAQUILA INDUSTRY, NORTHERN FRONTIER STATES, 1996-SEPTEMBER 1999**

*(Tons)*

| Federal entity | 1996 | 1997 | 1998 | January-September 1999 | % change 1996-September 1999 |
|---|---|---|---|---|---|
| Baja California | 19 032 | 21 322 | 24 979 | 35 886 | 89 |
| Chihuahua | 26 502 | 22 551 | 23 679 | 34 019 | 28 |
| Coahuila | 883 | 1 425 | 1 174 | 735 | -17 |
| Sonora | 3 569 | 4 983 | 4 983 | 731 | -80 |
| Tamaulipas | 22 127 | 26 527 | 27 120 | 25 930 | 17 |
| Sub-total | 72 113 | 76 808 | 81 935 | 97 301 | 35 |
| Employment northern frontier municipalities [a] | 522 508 | 607 642 | 661 273 | 476 476 | -16 |
| Ratio (Returning/employment) [b] | 0.14 | 0.13 | 0.12 | 0.20 | |
| INE [c] | 869 | 884 | 1 534 | 754 | -13 |

**Source:** Own elaboration of INE (in INEGI, 2000).

[a] 1999 is adjusted for 8 months. Note that the employment data refers to the more narrow "Frontier municipalities" than "Northern frontier states", the definition for the waste tonnage data. Nevertheless, statistical analysis estimated that the two data sets are not substantially different.
[b] The author find no particular reason to believe that potential seasonal bias would drastically disrupt the ratio.
[c] Number of notice on returning of hazardous waste, which is the basis for the statistics, by INE.

Changes in industry structure may also contribute to this situation. For example, the number of relatively small-sized "electronic" firms increased in Tijuana during the latter half of the 1990s. This group of firms have been found to generate proportionally more hazardous waste than many other maquila sectors (Kopinak & García, 2000). The same study determined that firm size and riskiness [47] of waste was positively related for maquilas in the "electronics" sector in Tijuana, thereby challenging the idea of a positive firm scale vs. environment relationship in the region. It remains to be seen if these results are applicable to other sectors, such as the firm concentration among "autoparts" maquiladoras in Cd. Juarez (fewer and larger firms during the recent years).

Graph 2 provides data on hazardous waste, divided along sector and spatial lines. Specifically, it details the tonnage of reported returned waste, statewise and per "autoparts", "electronic" and total maquila, respectively. As seen, the "electronic" maquila represents a significant portion in terms of tonnage returned, but both maquila sectors have a higher waste-intensity than the aggregate maquila average in the cities subject to the study (106

[46] As an example of the internationalization of waste flows, Kopinak & García's (2000) comment that in the 1996-97 period, approximately 70.000 tons of maquiladora hazardous waste was exported to Europe. The number is likely to refer to re-export from United States because this tonnage corresponds to half of the total maquiladora exports of such waste in the period.

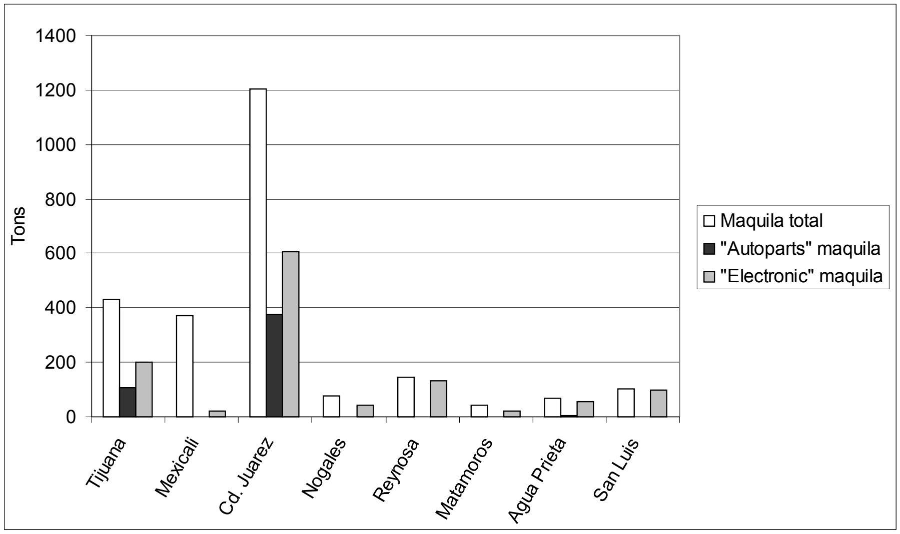
[47] INE (1999) sometimes defines risk as the probability that an event occurs. Nevertheless, "Risk should not, however be confused with probability since it is an amalgam of both this probability and the size of the event" (Pearce, 1992).

ton/establishment). However, the waste-intensity [48] is not significantly different between the sectors. An analysis of the data in Graph 2 and Graph 3A reveals that the tonnage returned is 121 and 134 ton/establishment for "autoparts" and "electronic" maquila, respectively.

**Graph 2**

**RETURNING OF HAZARDOUS WASTE BY THE MAQUILADORAS BY MAQUILA CENTER, FROM MEXICO TO UNITED STATES, TOTAL AND SEPARATED BY AUTOMOTIVE ELECTRONICS/ELECTRIC PRODUCTS, 1997**

*(Ton.)* [a]




**Source:** Own elaboration based on HAZTRAKS (1998) and SECOFI (2000).

[a] The graph is obtained by cross-relating HAZTRAK data on the 10 firms in each location with the largest hazardous waste tonnage returned (i.e. volume of hazardous waste from the maquila returned to US, per named firm) and SECOFI's Electronic Directory of the Maquiladora industry (which enables to determine the maquila-status of individual firms). Note that the SECOFI data refers to the year 2000 while the HAZTRAK data refers to the year 1997, which implies that maquilas which changed name or seased operations are excluded from the data.

Kopinak & García (2000), in their empirical study on Tijuana, highlighted the importance of taking into account the content of the hazardous waste. In this respect, the chemical input in the "electronics" maquilas is particularly demanding in terms of treatment; while, on the one hand they found that non-maquilas were representing a relatively higher number of establishments that generate hazardous waste, they also determined that the composition of maquila-waste was substantially more hazardous (Table 7A and 8A). The most contaminating maquilas are those which incorporate chemical processes. [49] Textile maquilas include chemicals in the form of pigments, which are highly pollutant. However, among the three largest maquila sectors in the northern Mexican states (measured by the number of establishments and value added), the "electronic & electric" maquilas are more environmentally intensive in terms of pollution tonnage and content than "autoparts" and "apparel" (Valle, 2002). This applies irrespective of industry-regime: PROFEPA (2000) characterizes the aggregate "autoparts" industry (maquilas and non-maquilas) as a good performer in terms of environmental management, and better than for example the "electronics" industry (based on statistics on ICNA and environmental auditing).

48 Tonnage of waste per establishment and sector.
49 Together with a number of firms, which are technically to be defined as maquilas, dedicated to recycling activities (Silva, 2002).

According to the statistics on composition of hazardous substances generated by the maquilas (Table 6A), in 1998, maquila-dense Tijuana generated 4,517 tons of solids (235 maquilas), 718 tons of liquid waste (131 maquilas), 141 tons of solvents (31 maquilas) and 199 tons of heavy metal slag (30 maquilas). Méndez (1995) determines that the principal hazardous waste generated by the metal mechanic maquiladoras (e.g. "autoparts") is acids, solvents and paint. Solvents count among the three most detrimental residuals in the north of Mexico, and if taking an aqueous form, they may solve heavy metals in the ground and subsequently contaminate water, agriculture and organisms. Among the principal hazardous waste substances generated by the "electronic" maquiladoras are cleaning solvents, metals for welding and acids/basis for treatment of metals, whose degree of toxicity depends on the form (Méndez, 1995).

The above-reported growth in hazardous waste generation is not reflected in data on the number of environmental accidents, or, abandoned sites of the maquilas. In fact, of the twenty-six principal environmental accidents in the 1996-2000 period, only one took place in a maquiladora. The accident consisted in leaked steam of ethilic alcohol and silicon by Daewoo Orion Mexicana in Baja California, which produces electric products and accessories (PROFEPA, 2000). [50] However, this statistic does not take into account accidents that occurred during transport. [51]

In terms of abandoned hazardous waste sites, the maquiladora industry is represented by only one serious incident. PROFEPA (2000a) lists 15 cases of abandoned sites with substantial quantities of hazardous waste involved in the 1990-s. Of these, the Baja California based maquiladora Metales y Derivados de México, S.A. (SECOFI, 2000) was found responsible for having abandoned at least 4,729 tons of lead, cadmium and arsenic contaminated soil. However, the obstacles in linking specific firms to the abandoned sites obstruct general conclusions.

A future issue with respect to Mexican management of hazardous waste is the expressed intention that Mexico, in order to comply with NAFTA, will eliminate the obligation for United States owned maquiladoras to return their hazardous waste to the United States (Reed, 1998). However, since both the United States and Mexico have signed the Basle Convention on hazardous waste, any such change would require previous increase in the Mexican capacity for domestic waste management. [52] INE (in Kopinak & García, 2000) estimated that by 2000, Mexico would have installed capacity to manage 66% of its hazardous waste. This insufficiency in capacity has resulted in a delay in introducing required regulation.

Pollution abatement cost (PAC) constitutes a key element in the "adoption of pollution abatement technology"-driver. It also influences the "Expected cost of compliance"-driver, and is subsequently an indirect pressure indicator (or response indicator, depending on the case). Molina (1993) studied the development of pollution abatement costs among different Mexican maquila sectors. Table 8A details the development for the aggregate maquiladora industry as well as its inter-sector development in pollution abatement costs, and is based on statistics on investments in

50 Information from PROFEPA (2000) combined with "Directorio Electrónico de la Industria Maquila" (SECOFI, 2000). Note that the statistics on accidents (PROFEPA) correspond to the 1996-2000 period, while the SECOFI statistics on enterprise identity and maquiladora status refers to 2000 data.

51 Those made up 72 percent (2.258 incidents) of the total number of environmental emergencies in Mexico in the 1995-2000 period (PROFEPA, 2000).

52 In the case of a conflict in the application of the NAFTA and Basel Convention (the Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal), respectively, the latter prevails.

pollution abatement technology. [53] The data allows for the construction of a ratio for "PAC/value added", which provide the tentative conclusion that the maquila's PAC diminishes in time. [54] This would be congruent with the general idea that resource efficiency, economies of scale (as international technology achieved critical masses) and learning curves in pollution abatement technology are related to time.

At the sector level, it is striking that the two sectors mentioned above showed lower than average decrease in relative PAC during the period. Furthermore, during the eight-year period proceeding the year 1990, the "electronic & electric" maquiladoras diminished that ratio more slowly than both "transportation equipment" maquilas and the maquilas on average. The "PAC/value added" indicates that in 1990, the "transportation equipment"-maquila incurred higher costs on investments in PAC than did the "electronic & electric" maquila-sector. This can be compared to the previous findings in this article, namely that the "autoparts" maquila (comparable to "transportation equipment"), in general, is less intensive in environmental capital than is the "electronic & electric" maquila. The "transportation equipment" maquila also spent more on PAC than did the average maquiladora (relative to their respective value-added). Furthermore, data on pollution abatement cost from the 1980s suggests increasing such expenditures among maquilas. Changes toward a stricter institutional framework in the 1990s may indicate that this trend continued during the last 10 years.

## 3. Compliance with Environmental Regulations

In the 1994-2000 period more than 3,383 resolutions against the maquiladora industry were realized, resulting in penalties that amounted to 17.8 million of pesos (PROFEPA, 2000). The subsequent section aims to present some of the underlying features and trends behind these numbers.

In general terms, the development of stakeholder pressure can be followed by, for example, studying a response variable constituted by number of environmental non-governmental organizations (NGO). In the 1990s a substantial increase was registered in the number of Mexican environmental NGOs, both at the national level and in the northern states. Another indicator of stakeholder pressure is the evolution of number of environmental lawsuits. In this respect, PROFEPA (2000) shows that the number of legal demands was lower in the 1998-2000-period as compared to the 1995-1997 period. Among the possible explanations are that a real improvement in environmental performance occurred, or the presence of a "start-up"- phenomena in initially high public consciousness. It may also reflect the impact of an historical "debt" in the sense of an initially large stock of unsolved cases.

In more specific terms, the Graph 3 contrasts the environmental performance of the aggregate maquiladora, versus the non-maquiladora industry, as measured by the outcome of environmental auditing in the 1992-2000 period. This pressure indicator suggests that maquiladoras are relatively "cleaner" than non-maquiladoras, reflected in a lower occurrence of both "serious violations" and "non-serious violations".

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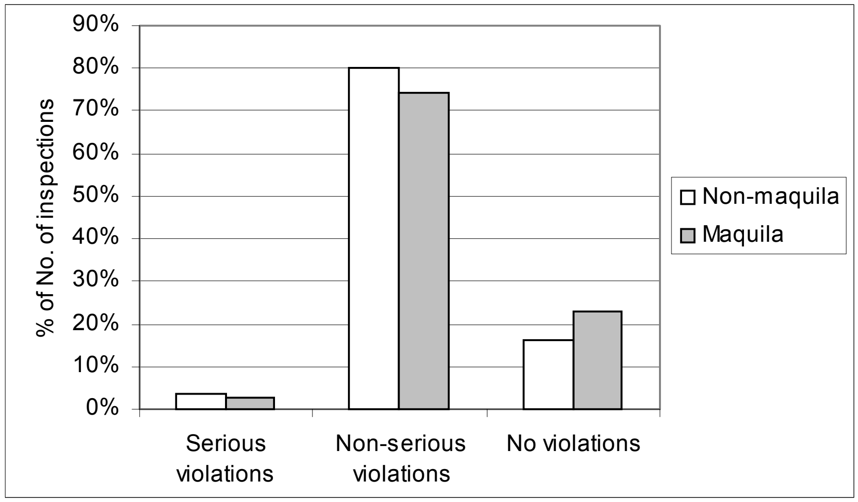
[53] Note that "ratio PAC/value added" is not comparable to external data from other sources, as both value added and PAC are expressed in nominal terms. A note on the deflator applied to value added and PAC in Molina (1993), discusses the obstacle in choosing a proper deflator index matching the characteristics of the maquila industry (US or Mexican, producer or consumer price index for the data on Value added, expressed in Mexican monetary units, and PAC, which is expressed in US monetary units). As Molina is more interested in relative changes, he uses the non-adjusted numbers. Abaonza (2001) comments that INEGI due to these problems uses "number of working hours" as a deflator for the maquiladora industry. Based on the same argument, I apply the unadjusted numbers.

[54] Although the result is congruent with the theory of decreasing technology costs over time, I have not had access to the specific data characteristics of Value Added and PAC, respectively. A factor of uncertainty is whether the value added is relatively more affected by the Mexican or the United States inflation.

The respective industry-composition in the maquila vs. non-maquila category is likely to explain a large part of this heterogeneity. Namely, the "non-maquila"-group includes a broader range of sectors, among which some are highly contaminating (e.g. metal foundries and cellulose sectors). For example, among the most contaminating industry processes, in general, are those that manipulate primary materials, an activity not incorporated by the maquilas (Valle, 2002). Another factor is technological vintage gained by maquiladoras in terms of the application of relatively more modern production-processes (PROFEPA, 2000).

**Graph 3**
**RESULTS OF INDUSTRIAL ENVIRONMENTAL INSPECTION, MAQUILA VS. NON-MAQUILA IN MEXICO, IN THE 1992-2000 PERIOD [a]**




**Source**: Own elaboration based on PROFEPA (2000).

[a] Note the different time periods: Maquila incorporates the Dec. 1994-Nov. 2000 period, non-maquila incorporates the Aug. 1992-Nov. 2000 period.

Graph 4 depicts the development in time of the structure of outcomes from industrial environmental inspection. Notably, the weight of "non-serious violations" experienced a decrease, from approximately 80% in 1993, to approximately 70% in 2001 compared to the total number of inspections. [55]

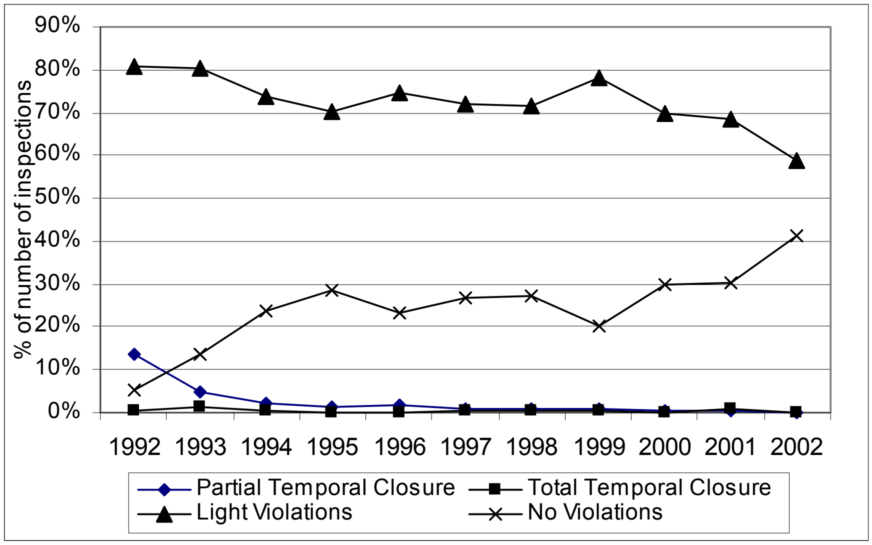
However, this data needs to be related to the basis of inspections, i.e. the aggregate number of maquilas. This is because an increased workload in terms of number of maquilas may have affected the scope and quality of the average industry inspection during the period. In fact, in the 1993-2001 period, the number of maquila establishments increased 54%, from 1749 to 2690 establishments. Simultaneously, the number of inspections decreased by 41%, from 1053 to 620 inspections (see Table 4A).

Graph 5 presents the data from a somewhat different point of view, by depicting how the types of outcomes of inspections relates to changes in the total number of maquilas. Specifically, between 1993 and 2001, the share of maquilas subject to inspections decreased by approximately 60%, from 60% in 1993 to 23% in 2001. Apart from the above described substantive augment in number of maquilas, Silva (2002) attributes part of the change to alterations in the institutional framework. Those changes contributed to intensifying the effort per inspection; the average personnel per inspection increased from 2 to 3, with the explicit aim to better address serious

[55] The years 1992 and 2002 are likely to be subject to start-up and seasonal bias and are excluded from the analysis. However, 1992 is included in the graph in order to illustrate the start-up characteristics of the first year of operations for PROFEPA, and January and February of 2002 are included in order to maximize the data coverage of the new Mexican administration.

hazardous waste violations. This brought with it a necessary decrease of total number of inspections, at a time when, additionally, the number of maquiladoras increased.

**Graph 4**
**OUTCOME OF MAQUILA INSPECTIONS AS A RATIO OF THE TOTAL NUMBER OF MAQUILA INSPECTIONS IN YEAR, IN 5 MEXICAN BORDER STATES, 1992-2002** [a b]




**Source**: Own elaboration of statistics obtained by PROFEPA (Valle, 2002).

[a] The year 1992 is represented by only the second half of the year, August-December, and 2002 by January-February. Consequently, they are not representative for the period.
[b] The states are: Baja California, Chihuahua, Tamaulipas, Sonora and Coahuila.

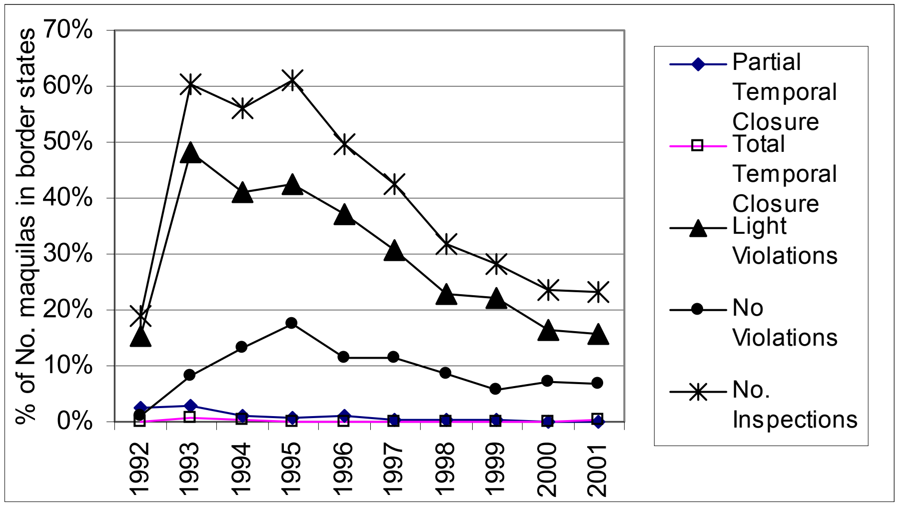
Concerning the structure of the outcome of environmental inspection, and congruent with the policy change, a declining share of the aggregate number of maquilas were found to commit "light violations" (see Table 5A). However, in spite of, or thanks to, the intensified auditing efforts of “serious” violators, the portion of maquilas that committed serious environmental violations was rather constant during the period (approximated by the number of firms caught with “serious violations”). In fact, only in the initial years, 1992 and 1993, it surpassed 1% (3% in 1992 and 1993).

In 2001, the 6 out of 9 maquilas in the Border States that were caught with "serious violations" were charged with "Total temporal closure". In 1992, only 2% of the firms with “serious violations” received this penalty (1 of 43, see Table 5A). This data is similar to the development in Baja California, which can be explained by the fact that this state received a large share (31%) of the total number of inspections in the 5 dominating Border States in terms of the number of maquiladoras in the 1992-2001 period (Table 2A and 4A).

Further information can be obtained by addressing the spatial differences at the state level. This approach give at hand that Baja California presents the highest frequency of environmental violations detected by PROFEPA, followed by Chihuahua, Tamaulipas and Coahuila. In fact, Méndez (1995) maintains that Baja California, together with the northeast frontier zone, is subject to the most serious industry induced environmental degradation in the entire Mexico. Furthermore, at least in the 1995-1997 period, the number of violations followed suit with the increase in maquila activity in the northern states.

**Graph 5**

**OUTCOME OF MAQUILA INSPECTIONS AS A RATIO OF THE TOTAL NUMBER OF MAQUILA ESTABLISHMENTS IN EACH TIME PERIOD, IN 5 MEXICAN BORDER STATES, 1992-2002** [a b]




**Source**: Own elaboration of statistics obtained by PROFEPA (Valle, 2002) and INEGI (2001).

[a] The year 1992 is represented by June - December, and 2002 by January - February. Consequently, they are not representative for the period.

[b] The states are: Baja California, Chihuahua, Tamaulipas, Sonora and Coahuila.

Baja California stands out also in terms of a higher frequency of serious degree violations. This is partially attributable to the dominance of this state in terms of hazardous waste generation (approximated by the statistics on tonnage of hazardous waste returned to the United States, see previous table 2). However, this serves as an explanation only for the last years of the 1990s. For example, in 1997, both Chihuahua and Tamaulipas returned larger volumes of hazardous waste than did Baja California. That same year, however, Baja California produced 6 "Temporal partial closures" of the total of 7 in Mexico. Furthermore, this state generated the only "Temporal total closure" in Mexico that year. To sum up: Baja California's rather average level of hazardous waste generation in 1997 attracted a high number of sanctions that year, possibly indicating that this state provided a less adequate management of the environment than the other Border States. Furthermore, the following years, until 1999, faced a substantial increase in tonnage that was largely explained by an increase in the state of Baja California.

Some information can also be deducted from the budget that PROFEPA assigns for environmental auditing. These financial resources serve as a response indicator of the effort to enhance the firm's expected cost of no-compliance. PROFEPA's budget has shown an overall decline since the date of its founding, in the early 1990s. However, the maquilas constitute a somewhat prioritized area of environmental policy, even in times of a diminishing budget. For example, in 1998, due to severe budget constraints, PROFEPA limited its inspection efforts to two high priority areas, high-risk metropolitan activities, and maquiladoras (CEPAL, 2001). [56]

However, the decline in the beginning of the period may also be attributed to stock-effects. In this respect, it is expected that the initial auditing efforts target the most obvious targets, e.g. the historical debt from the non-regulated period before the 1990s. Also, part of the period's budget decline is explained by initially high start-up costs, e.g., the creation of a large firm register. The financial burden of environmental auditing also shifted from PROFEPA to the firms themselves.

[56] A matter of point is that, as have been argued in chapter 2, these areas often tend to coincide.

Among the other potential explanatory variables to any changes in auditing results during the period are the voluntary compliance schemes that were introduced during the second half of the period (PROFEPA, 2000). [57]

# 4. Water Management and Atmospheric Emissions

This section makes the case that the maquiladoras are rather low intensive in direct water use and atmospheric emissions. For example, neither autoparts, nor apparel, maquilas are particularly water-intensive, while electronics and chemical manufacturing are more intensive (Silva, 2002, and Quezada, 2002). However, in the context of the regional resource constraints on long-term water supply, the aggregate scale of the maquiladora industry imposes a serious threat to sustainable development. In this respect, the current transborder water crisis between Mexico and United States is a symptom of the problems in properly addressing issues of natural resource management and industry policy on both sides of the border. This is only the latest friction in the historical regional bilateral water conflict (EPA, 2000), formalized by difficulties in complying with the bilateral treaty of 1944 that regulates transborder exchange of water.

Graph 6 includes data estimations on population growth, changes in water coverage and changes in water drainage coverage, for the 1995-1999 period. It thereby encapsulates a large part of the contextual framework; “population growth” is a pressure indicator and reflects part of the pressure that is imposed by the maquilas; the two water infrastructure indicators constitute response indicators on the measures taken by society to intervene with technology in order to enhance water supply. Expressed in terms of environmental performance drivers, this set of variables reflect “Choice of location and industry growth rate”.

As can be seen, all the northern frontier states show higher than average population growth rates in the period. This would be expected to impact negatively on the water infrastructure indicators. However, contrary to the expectations, several of the states appear to generate more positive water indicators in the sense that they show a larger growth rate in water infrastructure indicators than the national average. [58]

More recent data from the Mexican border region [59] reflect a rather positive scenario in that the population served by wastewater collection has increased from 34 percent, in 1995, to 75 percent, in 2000. In the same period, the wastewater service coverage increased from 60 to 75 percent in the region (EPA, 2000). However, based on the data set in the graph 6, the statistics show strong spatial heterogeneity in the Border States. Choahuila and Tamaulipas enjoy a positive relationship between population growth, on the one hand, and development of the water infrastructure indicators, on the other. On the contrary, Baja California is the state with the most negative relation between these variables. Baja California may be a particularly illustrative example of the fact that urban growth tightens the margins of long-term water supply. However, the picture is somewhat mixed. Baja California, together with Chihuahua and Nuveo Leon, has the highest expected water coverage in 1999 among the Border States (95 percent, compared to the national average of 87 percent). However, it has the second lowest expected drainage coverage, after Tamaulipas (72 and 75 percent, respectively, compared to the national average of 73 percent).

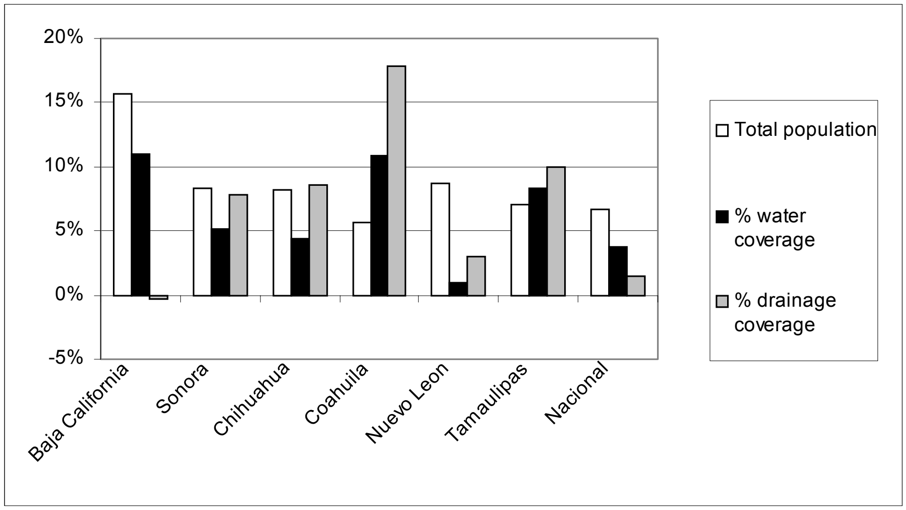
57 Personal interview with Antonio Azuela, PROFEPA’s former chief-prosecutor, November 28, 2001.

58 Demographic factors such as short-term employment and cross-border migration flows may cause systematic underreporting in the population data.

59 The Mexican border region, defined as the area within 100 km. south of the border, is a narrower data set than data at the state level.

**Graph 6**

**PERCENTAGE CHANGES IN POPULATION, WATER COVERAGE AND WATER DRAINAGE COVERAGE, STATE-WISE, 1995-1999 (PROJECTION ON THE BASE YEAR 1995)** [a b]




**Source**: Own elaboration based on CNA (1996).

[a] The data includes only water sources that are under federal responsibility. Water that is handled by the municipalities is not included.
[b] Water coverage and water drainage is expressed as percentage of the total state population.

On the water supply side, the technology factor provides an explanation to the relatively positive water indicators in the Border States. This variable has augmented the productivity in short-term supply extracted from national sources. Regional water supply shortages have also been compensated by water imports. For example, Tijuana and Tecate started to import water in the mid-1990s, and in 2000, the imports made up 55.9% of water consumption (Kopinak & García, 2000). The regions' relative wealth and the relatively small scale of the northern maquila-centers favor the scope of the technology variable. Also, the fact that much of the water in the region is a transboundary good makes it a major concern for both Mexico and the United States. Mexico depends on water imports from the United States, and simultaneously Rio Grande supports six million people with drinking and irrigation water and two million acres of agricultural land. The lower Rio Grande Valley of Texas is dependent on rainfalls in northern Mexico (GNEV, 2002).

This interdependency have given rise to such bilateral environmental institutions as the Commission for Environmental Cooperation (CEC), and the North American Development Bank (NADBank) which, together with the United States. Environmental Protection Agency has favored Mexico in terms of an augmented flows of investment capital for water infrastructure, among other categories. This capital, partly co-financed by Mexico, is aimed at enhancing the Mexican water infrastructure, as this also enhances the quality of the water flowing to the United States (BECC, 2002). This development is congruent with the logic of lower marginal cost of water cleaning on the Mexican side. Furthermore, cost-efficiency gains are reached by cleaning water at the point source in Mexico rather than at the dispersed water flows reaching the United States side (EPA, 2000).

On an annual basis, in the 1997-2000 period, Mexico destined on average US$ 34 million to water development, regulation, enforcement and state transfers in the Mexican border region. The United States assigned an annual US$ 50 to 100 million to water treatment facilities on both sides of the border. One example is the water treatment plants in Cd. Juárez, that, with a US$ 11 million grant from the United States. EPA has increased the water treatment in the city, from zero to 90 percent. Another example is the project to modernize the residual water treatment facility in Tijuana in order to meet increased pressure from this fast growing urban and industrial center (EPA/CNA, 2001). Such investments are highly needed, given that, as late as 1997, Tijuana lacked pre-treatment of any residuals, which caused chronically high levels of toxicity, above norms, affecting the Valle Rio Tijuana as well as the United States side of the border. The stock of NADB and BECC environmental investments in the border region amounts to US$ 958 million (EPA, 2000).

Another determinant of investment constraint is that decentralizing efforts have implied that municipalities that previously relied on federal transfers now must derive the funds for water infrastructure investments from their own taxbase. Incomes increased when, in the mid-1990s, the public institutions gained constitutional right to cut off water supply for those households that failed to pay the water bill. However, failure to pay water bills constitutes a major constraint on the sources for infrastructure investments (Carter, 2000). [60]

Nevertheless, data on long-term absolute water resource constraints suggests that technology alone may not be sufficient to maintain regional sustainability. For example, SEMARNAT (2002) classifies Tijuana, Mexicali, Cd. Juárez, and most other northern maquila centers, of being at risk to have their economic and social dynamic interrupted by shortcomings in water quality and quantity. For example, the first (Baja California), second and fourth least sustainable aquatic administrative regions in Mexico are these that incorporate the Border States (except for the Mexico City Metropolitan Zone). The problem filters down to the imbalance of demand between, on one hand, industry, agriculture and human settlements, and on the other side, capacity constraint of surface and sub-terran water (Mendoza, 2001). In the mid-term, the scenario is even more problematic, as the current 10.6 million population in the Mexico-United States border region is expected to double in 2020 (GNEB, 2002). Maquiladoras play an important role in the border regions rapid industrialization, and it tends to stimulate migration within Mexico, and subsequent urbanization (EPA, 2000). [61]

In this respect, the region's high population growth (Graph 5A) constitutes a major obstacle. Moreover, this pattern is accentuated in CONAPO's 2010 population estimates, where particularly Baja California stands out with an expected population growth of 32.9% between 2000-2010. In fact, of the Border States, by 2010, only Coahuila is situated below the national average expected population (12.6%) growth. Table 9A details the corresponding increases in maquila employment per region.

The shortage of water, both in quantitative and qualitative terms, has already forced the industry to start to purchase water rights, temporarily or permanently, from surrounding agricultural water shareholders. These water rights are traded with high market prices. One example is Nissan's automotive plant in Aguascalientes that purchased water rights required for its painting processes. The scale of this phenomena is currently transforming the economic landscape of the northern states and may potentially eliminate the future agricultural presence in this part of Mexico (Mendoza, 2001). The electronics industry has also raised concern about high prices of water and inferior water quality (given its particularly high industry-specific requirements). For example, the maquiladora Samsung Display (in 1997, the largest generator of hazardous waste returned to United States) claims that water costs figure among its highest production costs, as water costs are 20 times higher than in South Korea.

[60] "One rule of thumb commonly used by international development banks is that households can afford to pay up to 5% of their income for water and sewer services". In Mexico, the average tariff is 2.3%, based on a single, minimum wage earner (Wright, 1997, in Carter, 2000).

[61] Other sources of border urbanization are emigration and non-maquila economy activity.

In this respect, prices are differentiated according to consumption. For example, domestic, as well as agricultural consumption is more heavily subsidized than industrial consumption and does not reflect the true cost of consumption, in particular, regional infrastructure investments and scarcity rent. [62] The price issue is perhaps even more relevant with respect to private consumption (César, 2001). Thereby, the water price problem constitute an additional variable behind the maquilas' influence on overall water consumption in the frontier states.

Namely, the effects of subsidized water enter the firms decision model, with respect to location, in at least the two ways of subsidized industrial water and subsidized residential water. [63] In this respect, and within the framework of regional rapid urbanization, private consumption of water is the potentially greater problem than industrial use.

Regarding atmospheric emissions, the recent years have seen a worsening in air-quality in the border region (EPA, 2000). Graph 7 depicts atmospheric contamination, i.e. a state variable, in Mexican industrial centers. It thereby links to the environmental performance drivers "location choice and industry growth".

Some information can be derived from the graph by comparing maquila dense industrial centers with cities with low maquila intensity. A general impression seems to be that the traditional maquila intensive centers, Cd. Juarez, and Tijuana, do not seem to be particularly worse off than other cities, rather to the contrary. Mexicali, another maquila intensive urban center in the north, stands out in the sense that it suffers relatively more from air contamination than both the other maquila intensive urban centers. It is also worse off than non-maquiladora intensive areas (ZMG - metropolitan zones of Guadalajara; ZMM - Monterrey, and, ZMVT - Valle de Toluca); This is showed by that, firstly, Mexicali has a higher, and rising, percentage of days of the year above the established emissions thresholds. [64] Secondly, Mexicali is an outlyer in terms of high PM10 [65] values of seven urban centers compared [66] (see Graph 2A).

As seen, the other northern maquila centers, which are Cd. Juárez and Tijuana, seem to be less struck by air-pollution than, for example, the non-maquila center Toluca. However, not only Mexicali, but all three maquila intensive centers appear to face relatively high levels of contamination when compared to their industry-value added. [67] The determinants to this negative situation are related to the maquilas' choice of location and high urban growth rates: Climatic conditions, i.e. the northern cities' dry climate, stimulate the creation of dust and particulate matter in the air. Further, in the case of Mexicali, infrastructure shortages in terms of unpaved roads increase the generation of particles from heavy traffic. The latter is likely to be related to the city's fast industry and urban growth, that obstacles the scope to keeping pace with infrastructure investments. The maquilas have a considerable impact on both these factors, as well as on the increased cross-border flows of private and commercial traffic (EPA, 2000).

[62] Theory predicts that subsidies and non-market prices give rise to a vicious circle of consumption externalities. This takes the form of over-consumption and subsequent resource depletion, as individual consumers of a natural resource such as water bear the average rather than the marginal cost of their consumption (i.e. the individual consumer have less incentive to restrict its consumption today as tomorrows scarcity rent will be evenly distributed over tomorrows consumers, not individually distributed).

[63] The point here is not to reject the principle that water is seen as a common right. Rather, it is aimed to broaden the policy- makers decision-base in that subsidized water implicitly contributes to facilitate labor supply, and therefore constitutes an indirect transaction of public resources to the maquila industry (as well as to other sectors, such as agriculture). Further, attempts have been made to approach market prices, for example by adjusting the prices to regional supply characteristics. For example, the water price in some northern parts of Mexico is 4.47MN/$m^2$ as compared to the national average of 1.45 MN/$m^2$ (Medina, 2001).

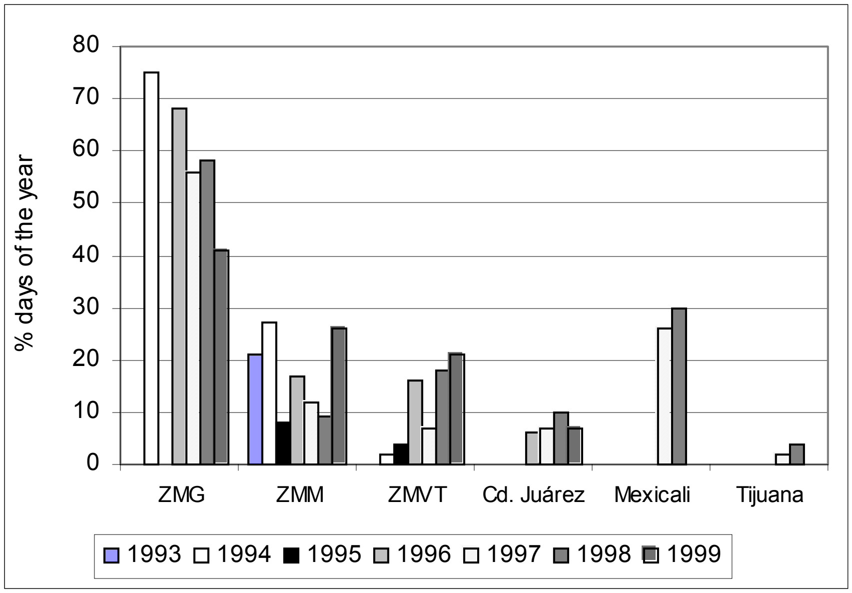
[64] No information was available for Mexicali and Tijuana for the year 1999.

[65] The fact that the concentration of particulate is measured in PM10 and not, as in many countries, PM2.5, is not a big problem as both measures tend to be highly correlated, (Wheeler, 2000).

[66] Zona metropolitana de Valle de México, Guadalajara y Monterrey, Toluca, Cd. Juárez, Tijuana, and, Mexicali.

[67] In particular, the application of value added as a denominator of pollution intensity raises the impression of high contamination in the northern cities. The characteristics of the maquilas implies that export value is a less adequate denominator.

**Graph 7**
**PERCENTAGE OF DAYS ABOVE THE NORMS IN TERMS OF AIR CONTAMINATION, SIX CITIES, 1993-1999 [a]**




**Source**: Gutiérrez (2001)

[a] ZMG, metropolitan zones of Guadalajara; ZMM, Monterrey; ZMVT, Valle de Toluca).

Due to Mexicali's location at the border it is particularly exposed to the emissions from cross-border traffic flows. Statistics from another border crossing, Laredo-Nuevo Laredo may serve as an indicator: [68] In 1999, 1.3 million trucks passed this border point. Data from two years earlier, 1997, reveals that 246,000 goods train wagons (equivalent to 1 million trucks) and 856 tons by air crossed the border, and, an additional 14.3 million of cars and buses. The associated atmospheric emissions from the road traffic alone consist of byproducts from combustion engines, in particular, volatile organic compounds (VOC) and nitrogen oxide. Together, these substances interact to create ozone, which is the principal component in smog (Poynter & Holbrook-White, 2002).

In terms of inter-sector performance for the industry in general, PROFEPA (2000) constructs an indicator in order to compare inter-sector performance. Namely, they combine ICNA (index of environmental compliance) and the result of environmental auditing (i.e. without distinguishing between maquila and non-maquila). The resulting indicator qualifies the "automotive" sector as "very good" and the "electronics/electric products" sector as "good". Table 1A shows a pressure indicator in the form of atmospheric point source emissions. In particular, it specifies the quantities of air emissions, among them particles, generated by "autoparts" manufacturing in general.

[68] Laredo-Nuevo Laredo is a typical non-maquila crossing. However, having in mind that 60 percent of Mexican exports to the United States is transferred at this border point (Poynter & Holbrook-White, 2000), it may give an indication of the traffic induced by the maquiladoras (which by definition are 100% export oriented).

# V. Conclusions and Policy Implications

This report examines different approaches to the environmental performance of the maquiladora industry taking into account its specific characteristics. In this respect, rather than aiming at a single conclusion concerning the maquila's environmental performance, a set of variables and corresponding conclusions are looked into.

The failure to properly address environmental problems, in the form of coordinating industry and natural resource policies, is putting at risk long-term sustainability in the border region. In this respect, two drivers to environmental performance stand out as being crucial for regional sustainability; choice of location, as well as industry-, population- and traffic growth-rate. Structural factors encourage the maquilas to locate in the arid northern part of Mexico, and often close to residential areas. In this perspective, the single most critical environmental issue is the maquila induced population growth and subsequent pressure on long run water supply. All the frontier states (except for Coahuila) experience higher population growth than the national average, and the maquila intensive state of Baja California is expected to increase its population with 32.9% in the 2000-2010 period, the highest in the country. Response indicators on water infrastructure and pollution abatement-cost suggest that technology play a crucial role in the maquiladoras' sustainable development-path. However, the applications vary in success; in Baja California, the expected population water coverage rate in 1999 was 95%, the highest among the frontier states and above the national average (87%).

However, at the output-side, this state reported the second lowest drainage rate among the border states and below the national average.

The data at hand indicates that the maquila industry performs better in environmental terms than the non-maquila industry. Drivers such as sector-composition and technological vintage contribute to this situation. For example, the composition of industry sectors is generally more "clean", as the maquilas do not incorporate sectors such as metal foundries or cellulose. Furthermore, international linkages intervene in several aspects. On one hand, the cross-border characteristics of hazardous waste, atmospheric pollution and water (the latter is presently actualized by a political bilateral crisis) exposes the maquiladoras to stakeholder pressure and policy attention from the United States side of the border. On the other hand, it has been argued that maquilas enjoy the benefits from globally-applied environmental standards by their mother companies. A counterweighing factor is the low-cost rationale of the maquilas (e.g. low labor-costs), which may leave little room for environmental investments. This is further emphasized by the recent economic crisis among maquiladoras.

Furthermore, it is generally held that, during the past decade, the maquilas have improved their environmental performance (Silva, 2002). This is congruent with the increased attention that the industry in general has received during this period, e.g. in terms of increased policy pressure and stakeholder pressure, [69] as well as factors related to technological progress. That is, although the literature point at cases of a "regulatory chill" by which enforcement measures are dampened by consideration of the investment climate, the institutional framework sets the maquilas under particular pressure in terms of the obligation to return hazardous waste to the United States. This indicator of waste generation suggests an increase in tonnage returned during recent years, due to either a true increase in waste generation, or a compliance effect. Nevertheless, as pointed out in this report, the number of inspections per maquila decreased during the 1993-2001 period, with a subsequent decrease in sanctions. Nevertheless, the number of serious sanctions (total temporal closure) remained constant.

A spatial comparison reveals that the maquiladoras in the states of Baja California and Chihuahua generate proportionally large volumes of hazardous waste, and that they increased their share of returned waste (calculated as the ratio of returned hazardous waste to the United States divided by employment, annually). In fact, these two states explained a substantial part of the aggregate increase in hazardous waste tonnage returned to the United States by maquilas in the frontier states in the 1996-1999 period. Specifically, this development was marked by a strong composition effect in 1999. Baja California also received a larger share of sanctions from environmental auditing than can be explained by its larger waste volume or number of maquiladoras alone.

A previous study on Tijuana (Kopinak & García, 2000) may suggest that part of the Baja California performance is derived from a composition effect in terms of a structural shift to more environmental intensive small scale electronics firms. Several studies indicate that "electronic & electric" maquila sector is more intensive in environmental capital than for example the "autoparts" maquila-sector (together with "apparel", which is generally held to be relatively clean, they make up the three dominating maquila-sectors in terms of value added). The present study supports, with empirical evidence, that "electronic" maquila generates more waste in aggregate terms, but finds that the generation per firm is not substantially higher than in the "autoparts" maquila. However, previous reports reveal a more hazardous composition of "electronic" maquila waste. Taken together, a cost-benefit approach to policy making would suggest that special attention should be paid to the "electronic" maquila sector.

[69] Facilitated by increased receptiveness to public opinion among new institutions, such as PROFEPA and INE.

This critical context emphasizes the merits of an effective cost-benefit approach that can determine the optimal fields of intervention, taking into account institutional and other constraints. In this respect, the conceptual framework as well as the pressure indicators provide some guidelines. Furthermore, it is necessary to provide policy coherence between trade and investment agreements, along with social and environmental agreements, in order to minimize uncertainty and areas of potential conflict (OECD, 2001b). Also it is needed to provide a solid set of indicators in order to give follow up to related sustainable development issues.

It appears that barriers to the influence of stakeholder preferences, such as information failure and lack of environmental consciousness, constitute a field with large potential as this is generally considered as a relatively cost-efficient entry to the firm's expected cost of compliance. Policy efforts should aim to diminish the transaction costs among stakeholders in obtaining information, including technical training at the firm level. In this respect, the present legal and resource constraint in the field of data-generation and diffusion deserves particular attention. [70] If Mexico follows the international trend, stakeholder preferences will be an increasingly relevant driver of responsible corporate-behavior.

A scope for future studies may be to analyze updated statistics on pollution abatement costs in order to confirm the tentative conclusions made in this report.

70 Recent efforts includes the firm level emissions register RETC that became compulsory during the spring of 2002.

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# Appendix

Table 1-A

**ATMOSPHERIC EMISSIONS BY PRINCIPAL CONTAMINANTS, MEXICAN "AUTO-PARTS" INDUSTRY, 1999 [a]**

| Contaminant | Emissions (Ton/year) | No. of establishments |
|---|---|---|
| Sulphor bioxide | 173.25 | 46 |
| Nitrogen oxide | 1 701.92 | 52 |
| Particulates | 3 672.43 | 122 |
| Non-combustion hidrocarbons | 201.70 | 30 |
| Carbon monoxide | 4 686.46 | 92 |
| Carbon bioxide | 138 793.48 | 73 |
| COVs | 1 911.00 | 65 |

**Source:** INE (2001).

[a] Based on RETC, which incorporates the "auto parts" industry sector but, not for example, electronics/electric products, or the apparel sector.

Table 2-A

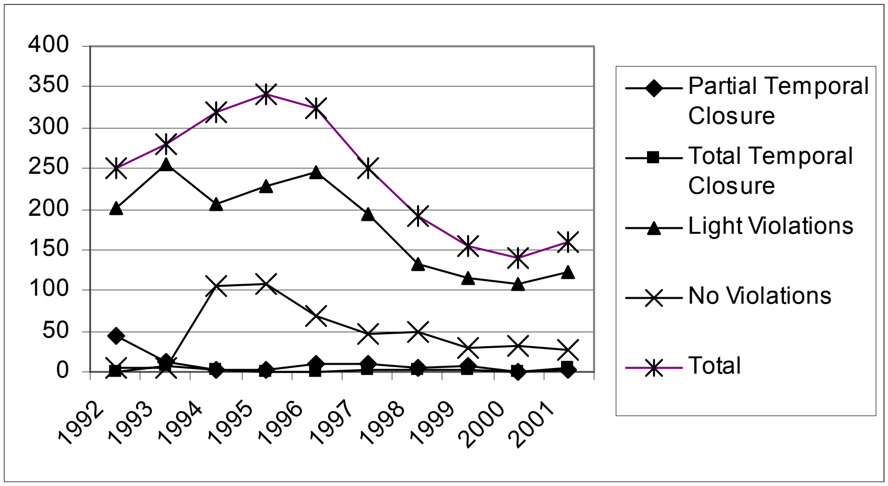
**OUTCOME OF MAQUILA INSPECTIONS IN BAJA CALIFORNIA, 1992-2002**

| Year | Partial temporal closure | Total temporal closure | Light violations | No violations | Total | No. maquila establishments |
|---|---|---|---|---|---|---|
| 1992 | 43 | 1 | 201 | 5 | 250 | 746 |
| 1993 | 12 | 8 | 254 | 6 | 280 | 772 |
| 1994 | 2 | 3 | 207 | 106 | 318 | 822 |
| 1995 | 3 | 0 | 229 | 109 | 341 | 727 |
| 1996 | 10 | 0 | 246 | 69 | 325 | 779 |
| 1997 | 9 | 2 | 193 | 46 | 250 | 847 |
| 1998 | 5 | 3 | 133 | 50 | 191 | 958 |
| 1999 | 7 | 3 | 115 | 30 | 155 | 1 090 |
| 2000 | 1 | 1 | 107 | 32 | 141 | 1 156 |
| 2001 | 3 | 6 | 123 | 27 | 159 | 1 280 |
| 2002 | 0 | 0 | 0 | 0 | 0 | |
| Total | 95 | 27 | 1 808 | 480 | 2 410 | |
| % of "5 Border States" | 56 | 77 | 32 | 26 | 31 | |

**Source:** Own elaboration of PROFEPA (Valle, 2002) and INEGI (2001).

**Graph 1A**

**OUTCOME OF MAQUILA INSPECTIONS IN BAJA CALIFORNIA, 1992-2002**




**Source**: Own elaboration of PROFEPA (Valle, 2002).

**Table 3-A**

**FOREIGN DIRECT INVESTMENT (FDI), MAQUILADORA VERSUS TOTAL, 1994-2000**

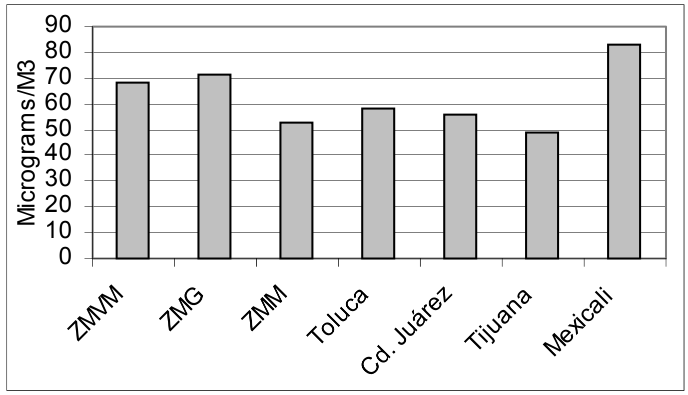
*(Millions of dollars)*

| Year | Total FDI | Maquiladora FDI | % maquila FDI of total FDI |
|---|---|---|---|
| 2000 | 13 950.9 | 2 983.0 | 21.4 |
| 1999 | 12 164.8 | 2 778.0 | 22.8 |
| 1998 | 11 826.2 | 2 110.5 | 17.8 |
| 1997 | 13 960.4 | 1 680.3 | 12.0 |
| 1996 | 9 928.5 | 1 416.5 | 14.3 |
| 1995 | 9 548.2 | 1 366.3 | 14.3 |
| 1994 | 15 036.9 | 894.8 | 6.0 |

**Source:** Secretaría de Economía (SE, 2001).

**Graph 2A**

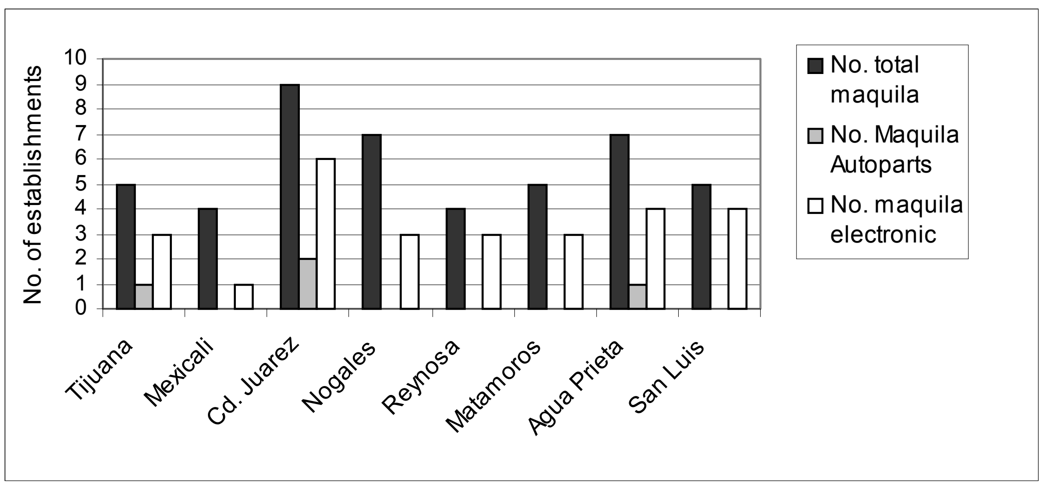
**ANNUAL AIR CONTAMINATION (PM10) IN SIX CITIES, 1998**




**Source**: Guttiérrez (2001)

**Graph 3A**

**NUMBER OF MAQUILADORA ESTABLISHMENTS RETURNING HAZARDOUS WASTE, TOTAL AND SEPARATED BY AUTOMOTIVE ELECTRONICS/ELECTRIC PRODUCTS, FROM MEXICO TO THE UNITED STATES, BY STATE AND SECTOR, 1997**




**Source**: Own elaboration based on HAZTRAKS (1998) and SECOFI (2000).

**Table 4-A**

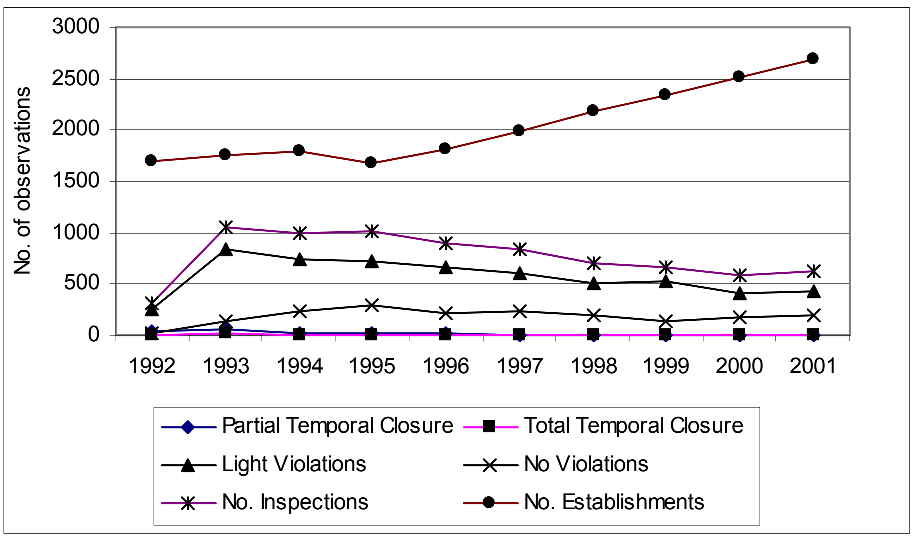
**OUTCOME OF MAQUILA INSPECTIONS IN 5 MEXICAN BORDER STATES, 1992-2002**

| Year | Partial temporal closure | Total temporal closure | Light violations | No violations | Total | No. establishments |
|---|---|---|---|---|---|---|
| 1992 | 43 | 1 | 259 | 17 | 320 | 1 695 |
| 1993 | 49 | 15 | 845 | 144 | 1053 | 1 749 |
| 1994 | 22 | 4 | 735 | 238 | 999 | 1 787 |
| 1995 | 13 | 0 | 716 | 293 | 1022 | 1 678 |
| 1996 | 17 | 0 | 668 | 208 | 893 | 1 805 |
| 1997 | 9 | 2 | 608 | 225 | 844 | 1 984 |
| 1998 | 6 | 3 | 498 | 188 | 695 | 2 190 |
| 1999 | 7 | 3 | 517 | 134 | 661 | 2 340 |
| 2000 | 2 | 1 | 412 | 177 | 592 | 2 521 |
| 2001 | 3 | 6 | 424 | 187 | 620 | 2 690 |
| 2002 | 0 | 0 | 20 | 14 | 34 | |
| Total | 171 | 35 | 5 702 | 1 825 | 7 733 | |

**Source:** Own elaboration of PROFEPA (Valle, 2002) and INEGI (2001).

**Graph 4A**

**OUTCOME OF MAQUILA INSPECTIONS IN 5 MEXICAN BORDER STATES, 1992-2002**




**Source**: Own elaboration of PROFEPA (Valle, 2002) and INEGI (2001).

Table 5-A

**OUTCOME OF MAQUILA INSPECTIONS IN 5 MEXICAN BORDER STATES, 1992-2001**

| | Serious violation | Partial temporal closure | % | Total temporal closure | % |
|---|---|---|---|---|---|
| 1992 | 44 | 43 | 98 | 1 | 2 |
| 1993 | 64 | 49 | 77 | 15 | 23 |
| 1994 | 26 | 22 | 85 | 4 | 15 |
| 1995 | 13 | 13 | 100 | 0 | 0 |
| 1996 | 17 | 17 | 100 | 0 | 0 |
| 1997 | 11 | 9 | 82 | 2 | 18 |
| 1998 | 9 | 6 | 67 | 3 | 33 |
| 1999 | 10 | 7 | 70 | 3 | 30 |
| 2000 | 3 | 2 | 67 | 1 | 33 |
| 2001 | 9 | 3 | 33 | 6 | 67 |

**Source:** Own elaboration of PROFEPA (Valle, 2002).

Table 6-A

**TIJUANA HAZARDOUS WASTE REPORTED IN 1998, BY TYPE OF WASTE AND INDUSTRIAL REGIME, IN TIJUANA**

*(Kilograms/plant)*

| Type of waste | Maquiladoras | | Non-maquiladoras | | Total | |
|---|---|---|---|---|---|---|
| | Kilos | Number of plants | Kilos | Number of plants | Kilos | Number of plants |
| Solids | 4 516 570 | 235 | 2 454 121 | 86 | 6 970 691 | 321 |
| Liquid waste | 717 524 | 131 | 256 723 | 67 | 974 247 | 198 |
| Sludge | 343 334 | 34 | 83 101 | 7 | 426 435 | 41 |
| Heavy metal slag | 199 203 | 30 | 222 304 | 3 | 421 507 | 33 |
| Spent oils | 176 059 | 54 | 145 096 | 40 | 321 155 | 94 |
| Solvents | 140 552 | 31 | 16 580 | 4 | 157 132 | 35 |
| Pitch/tar | 6 117 | 2 | 0 | 0 | 6 117 | 2 |
| Corrosives | 2 902 | 7 | 0 | 0 | 2 902 | 7 |
| Total | 6 102 261 | 524 | 3 177 925 | 207 | 9 280 186 | 731 |

**Source:** Kopinak & García (2000), based on SEMARNAT's data.

Table 7-A

**LEVEL OF RISK OF HAZARDOUS WASTE BY TYPE OF INDUSTRIAL REGIME, TIJUANA, 2001**

| | Maquiladora | | | Non-maquiladora | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| Risk level | Number of reports | Kg | kg/report | Number of reports | kg | kg/report | Number of reports | kg | kg/report |
| Minimal | 110 | 8 721 988 | 79 291 | 22 | 872 538 | 39 661 | 132 | 9 561 432 | 72 435 |
| Moderate | 157 | 11 499 321 | 73 244 | 2 | 52 381 | 26 191 | 159 | 11 551 702 | 72 652 |
| High | 36 | 1 128 513 | 31 348 | 4 | 21 581 | 5 395 | 40 | 1 150 094 | 28 752 |
| Very high | 17 | 1 326 991 | 78 058 | 0 | 0 | | 17 | 1 326 991 | 78 058 |
| Total | 320 | 22 676 813 | 70 865 | 28 | 946 500 | 33 804 | 348 | 23 590 219 | 67 788 |

**Source:** Own elaboration based on Kopinak (2002) based on SEMARNAT, Tijuana, B.C. and EPA. HAZTRAKS.

Table 8-A

**MAQUILADORA POLLUTION ABATEMENT COST (PAC) AND INDUSTRY DATA, AGGREGATE MAQUILA AND SECTOR VISE, 1982-1990**

*(Nominal value)*

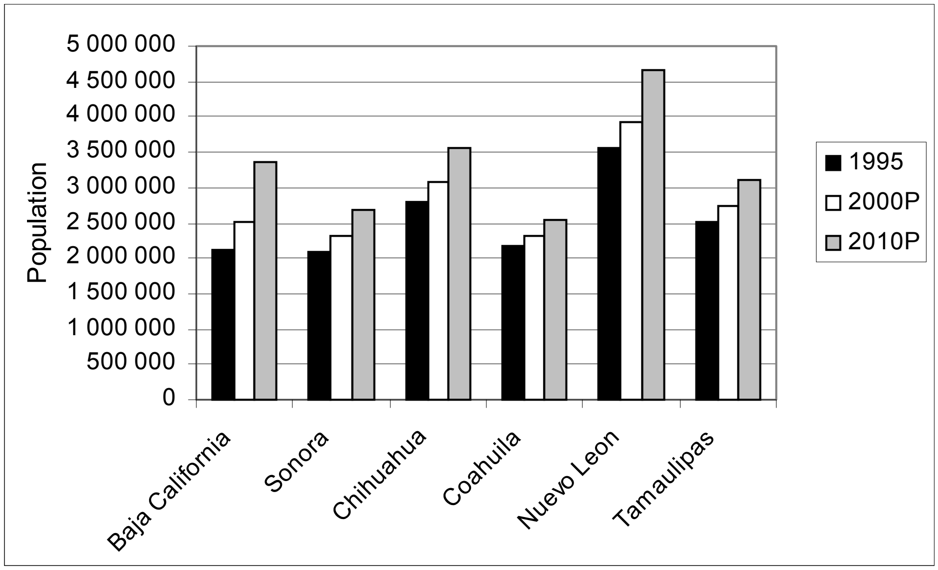
| | Number of firms | | Value added | | PAC | | Ratio PAC/value added 1990 | |
|---|---|---|---|---|---|---|---|---|
| Maquila sector | 1990 | % growth (1982-1990) | 1990 | % growth (1982-1990) | 1990 [a] | % growth (1982-1990) | 1990 | % change, 1982-1990 |
| Electric/electronic equipment [b] | 518 | 132.3 | 1 354.8 | 201.7 | 965.3 | 163.7 | 0.7 | -12 |
| Transportation equipment | 159 | 261.4 | 845.3 | 503.3 | 1 627.3 | 222.4 | 1.9 | -46 |
| All sectors | 1 852 | | 9 081.4 | | 11 079.6 | | 1.2 | -79 |

**Source:** Own elaboration based on Molina (1993).

[a] Based on the "Annual survey on manufacturers pollution abatement capital expenditures and operation costs", Census Bureau for the U.S. Department of Commerce.

[b] The exact title is "Assembling of machinery, equipment and electronic/electric equipment as well as electronic/electric material and accessories".

**Graph 5A**
**POPULATION, STATEVISE, 1995, AND ESTIMATIONS FOR THE YEARS 2000 AND 2010**




**Source**: Own elaboration on CNA (1996).

**Table 9-A**

**MAQUILA EMPLOYMENT, NATIONALLY AND STATE WISE FOR THE 5 MOST MAQUILA INTENSIVE BORDER STATES, 1990-2002**

| Period | Total National | Annual change | Baja California | Annual change | Coahuila de Zaragoza | Annual change | Chihua-hua | Annual change | Sonora | Annual change | Tamau-lipas | Annual change |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1990/01 | 424 652 | | 80 367 | | 26 964 | | 158 923 | | 39 827 | | 78 570 | |
| 1991/01 | 431 694 | 0.02 | 82 618 | 0.03 | 32 080 | 0.19 | 155 596 | -0.02 | 35 933 | -0.10 | 77 942 | -0.01 |
| 1992/01 | 485 205 | 0.12 | 90 719 | 0.10 | 38 406 | 0.20 | 169 971 | 0.09 | 37 708 | 0.05 | 90 381 | 0.16 |
| 1993/01 | 514 988 | 0.06 | 95 843 | 0.06 | 46 986 | 0.22 | 173 421 | 0.02 | 41 710 | 0.11 | 91 058 | 0.01 |
| 1994/01 | 546 433 | 0.06 | 111 728 | 0.17 | 47 830 | 0.02 | 166 134 | -0.04 | 43 670 | 0.05 | 100 027 | 0.10 |
| 1995/01 | 611 968 | 0.12 | 122 685 | 0.10 | 51 436 | 0.08 | 176 919 | 0.06 | 51 728 | 0.18 | 115 553 | 0.16 |
| 1996/01 | 687 326 | 0.12 | 142 823 | 0.16 | 57 175 | 0.11 | 199 709 | 0.13 | 55 581 | 0.07 | 119 012 | 0.03 |
| 1997/01 | 822 036 | 0.20 | 174 444 | 0.22 | 69 235 | 0.21 | 231 886 | 0.16 | 66 776 | 0.20 | 126 429 | 0.06 |
| 1998/01 | 958 124 | 0.17 | 204 338 | 0.17 | 85 555 | 0.24 | 252 370 | 0.09 | 85 615 | 0.28 | 142 290 | 0.13 |
| 1999/01 | 1 066 177 | 0.11 | 217 516 | 0.06 | 99 759 | 0.17 | 275 566 | 0.09 | 89 162 | 0.04 | 151 413 | 0.06 |
| 2000/01 | 1 214 541 | 0.14 | 255 052 | 0.17 | 110 696 | 0.11 | 294 946 | 0.07 | 104 416 | 0.17 | 171 578 | 0.13 |
| 2001/01 | 1 310 171 | 0.08 | 286 232 | 0.12 | 115 469 | 0.04 | 323 379 | 0.10 | 110 306 | 0.06 | 180 323 | 0.05 |
| 2001/02 | 1 289 799 | | 286 300 | | 110 576 | | 313 738 | | 110 290 | | 178 268 | |
| 2001/03 | 1 279 361 | | 282 313 | | 109 662 | | 309 538 | | 109 626 | | 178 858 | |
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| 2002/01 | 1 071 710 | -0.18 | 220 202 | -0.23 | 102 801 | -0.11 | 268 645 | -0.17 | 78 748 | -0.29 | 161 139 | -0.11 |
| 2002/02 | 1 060 481 | | 218 255 | | 105 358 | | 266 716 | | 77 291 | | 162 334 | |

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