Third North American Symposium on Assessing the Environmental Effects of Trade

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

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

The Maquiladora Electronics Industry and the Environment along Mexico's Northern Border

Authors: Claudia Schatan[1] and Liliana Castilleja[2]

Date: November 2005

[1] The opinions expressed in this paper are the authors' and do not reflect those of the institution where they are employed—the Economic Commission for Latin America and the Caribbean.

[2] We are grateful for Pablo Sauma's valuable technical advice in the analysis of the survey on maquiladoras and the support Cyrille Schwellnus provided on econometric issues during his time at ECLAC.

Third North American Symposium on Assessing the Environmental Effects of Trade

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

INTRODUCTION

This paper intends to draw attention on the importance of dealing with the environmental problems of the electronics assembly industry in Mexico. The reasons for this concern are motivated by the vulnerable environmental conditions in which these enterprises are set up, particularly those located in the northern Mexican border region, the potentially negative effects on maquiladora workers's health as a result of using toxic substances in the assembly process, as well as the missed opportunities of the industry as a consequence of lagging behind rapidly advancing international electronics environmental standards. Hence, although there has been a progress in terms of the environmental performance by the industrial sector in Mexico since the NAFTA negotiations started (around 1992), partly as a result of the environmental concerns of the United States civil society, this effort has fallen short of that required. Since the early nineties, the Mexican authorities have set up a better legal and institutional framework as well as a more efficient enforcement, but this effort has been insufficient. A wide survey on electronics maquiladoras industry in northern Mexico – region where there has been a specific surveillance effort, precisely for being next to the U.S. border - shows that around one half of them have no environmental policy within the firm. From this perspective, Mexican electronic assembly industry is unable to insert itself in the forefront of technologically more advanced and environmentally friendly electronics markets.

The electronics industry is one of the most important manufacturing sectors in the world. In 2002, with a GDP of 185.6 billion dollars, it was the third biggest manufacturing sector in the United States, after food industry (including beverages and tobacco) and chemicals (US Census Bureau, 2005). Through its horizontal incorporation into a large number of sectors—including telecommunications, televisions, production machinery of every kind, robotics, as well as a range of domestic appliances—the production of electronic components and computers has expanded dramatically in the last 15 years. In Mexico, the electronics production has had an extraordinary dynamism as it increased by threefold its contribution to total GDP between 1988 and 2004 (INEGI, 2005[3]). The foreign direct investment going to this sector, which was 256 million dollars in 1994, reached the level of 1.6 billion dollars in one single year (1999) and, in 2004 this figure was near 700 million dollars[4] Although between 2001 and 2003 the electronics maquiladora industry went through a critical period, it has tended to recover since then.

The electronics industry is often deemed relatively non-polluting, in terms of its production processes and the characteristics of its final products. As for the former, this sector is assessed in accordance with the pollutants generated during the manufacturing process. From this point of view, the industry is perceived as relatively non-polluting in the United States. In effect, according to the emissions data collected for the Toxics Release Inventory (TRI), it annually generates 1.6% of total hazardous wastes.[5] Nor is it considered a particularly polluting industry as regards the final product. Not in comparison with other industrial sectors that

[3] http://dgcnesyp.inegi.gob.mx/cgi-win/bdieintsi.exe/
[4] Secretaría de Economía, Dirección de Inversión Extranjera Directa.
[5] Indicator developed by the World Bank based on the risk that the toxicity of production processes represent for human health.

produce “environmentally sensitive” goods, such as the iron and steel industry, the chemical and petrochemical industries, and the pulp and paper industry, among others (Low and Yeats, 1992). This perception is due to the fact that neither the rapid expansion in the production of these goods, especially computers, nor the gigantic accumulation of solid wastes resulting from their rapid obsolescence is taken into account, not to mention the toxic substances that are released when proper disposal of such wastes is not ensured. Little attention is paid to the consequences on human health of the production process, which is labor intensive, particularly during the assembly phase. In short, the industry's environmental performance is assessed in a very incomplete fashion and the product's environmental characteristics over its entire life cycle are not taken into consideration.

The environmental aspects of this phenomenon have aroused considerable concern, especially in the industrialized countries. The rapidity with which equipment becomes obsolete, particularly computers, generates an enormous quantity of solid wastes, for which adequate mechanisms for recycling and disposal are still lacking. In addition, electronics products contain toxic and hazardous substances, which, if improperly disposed of, are released into the soil, water and air, where they become a threat to human health and the environment in general. As a consequence, a trend has emerged promoting "extended producer responsibility" (EPR) on the part of the manufacturer, such that the latter assumes financial and physical responsibility for the product it manufactures for the duration of the good's life cycle.

Although in Mexico environmental damage from the electronics industry—over entire product life cycles—is less than in developed countries, due to the much smaller number of computers per capita in this country and to their less rapid obsolescence, this problem will tend to become increasingly important. Presently, there are far more serious environmental problems to be resolved in Mexico than those generated by the industry under study in this paper. In fact, the problems generated by the sugar industry, to mention just one example, are far more acute. In general, many of the industries that entail combustion in their production processes have a more serious effect on the environment than the electronics industry. That said, this latter (including its maquiladora component) has been one of the most dynamic sectors in Mexico over the last two decades, therefore there is a “scale effect” of production on the environment. Furthermore, in view of the sector's export activities, Mexico's industrial and environmental policies should take into consideration the environmental agendas of final destination countries.

Environmental policy, particularly in Europe and Japan, has adopted a "life cycle"-based vision regarding the electronics industry. This requires firms to consider the environmental impact of these products from their design process, through the production process, until the final stage in which they are disposed of. In fact, the importance acquired by environmental policy in the technological development of computers deserves careful consideration on Mexico's part, especially with regards to the materials used in their manufacture and the substances employed during the production process.

In this paper, reliable information is analyzed regarding three border cities, Juárez, Mexicali and Tijuana, which account for over 36% of the maquiladora export industry's total nominal value added.[6] Both the international dimension and issues of a more local nature will be considered, so as to discern the evolution of environmental awareness and of the measures taken

[6] According to official INEGI data (http://www.inegi.gob.mx/) and our own estimates.

to defend the environment on the part of the enterprises. As for the international dimension, this paper discusses the development of environmental standards in the industrialized world and the responses by transnational electronics corporations to these. Furthermore, this paper surveys the regional and international conventions that have been signed to reduce pollution and the utilization of hazardous substances, some of which are used in the manufacturing process, while others are contained in finished electronics products. Finally, the international dimension also includes the market segmentation brought by the rise of "eco-labeled" electronics products, among other factors.

As for the local dimension, this paper is based on an extensive survey of maquiladora electronics and auto industry plants (including their suppliers) that examined technological learning and industrial scaling-up on Mexico's northern border.[7] In this survey, interviews were conducted with 289 establishments in the cities of Tijuana, Juarez and Mexicali. The present paper shall only be concerned with maquiladora electronics firms and their suppliers, i.e., 200 plants from the original survey. It employs econometrics methodologies to identify the factors influencing these firms' environmental behavior.

This paper is organized as follows: Section I surveys the recent evolution of environmental policy in developed countries and regions, as well as the response of transnational corporations to these new measures; Section II describes the status of the maquiladora electronics industry in Mexico and presents an analysis of the afore-mentioned survey's findings by applying a LOGIT model to identify the factors contributing to the adoption of an active environmental policy, on the part of maquiladora plants; Section III contains this paper's final conclusions.

[7] CONACYT Project Nº 36947-s "Aprendizaje tecnológico y escalamiento industrial. Perspectivas para la formación de capacidades de innovación en las maquiladoras en México," COLEF/FLACSO/UAM.

I. DEVELOPED COUNTRIES'
ENVIRONMENTAL STANDARDS FOR THE ELECTRONICS
INDUSTRY

In several developed countries, strict measures have been adopted to resolve the environmental problems caused by the electronics industry with respect to both production processes and the final product, including its final disposal. Standing out among such measures are the ones implemented by the European Union (EU) in January 2005 through two directives published in its Official Gazette: the *Waste Electrical and Electronic Equipment Directive* (WEEE) and the *Restriction on Hazardous Substances Directive* (RoHS), which limits the use of certain toxic substances in electrical and electronic equipment. The provisions stipulated in these directives were to be incorporated into the legislation of UE member states by mid August 2004.[8]

In August 2005, a WEEE measure will enter into effect making it mandatory for producers to recover electronic products (either individually or jointly), without cost to the consumer, and to consign them for recycling or proper disposal. By December 2006, EU members shall be required to collect an annual average of four kgs. of waste equipment per capita.

As of 1 July 2006, compliance with the second directive (RoHS), which prohibits the use of toxic substances in the manufacturing of computers—lead, mercury, cadmium and hexavalent chromium (flame retardant)—, must be achieved for all products for sale. Processes for which substitutes do not as yet exist are exempted.

It is hoped that these two directives will solve the rapidly developing environmental problem caused by this industry, at least within the EU. By 2008, both regulatory codes must be in full effect.

As other countries have not adopted measures as rigorous as those stipulated in the WEEE and the RoHS, the latter shall initially erect entry barriers to computers made in other parts of the world, thus resulting in market segmentation (Von Moltke and Kuik, 1998). Nevertheless, these codes will serve as models regarding the environmental norms applicable to these products in other countries.

The United States, for its part, has not evolved at the same pace as the EU in its electronics industry environmental policy, despite the worrisome environmental implications. According to National Security Council estimates, the obsolescence of between 315 and 680 million computers in the coming years will produce 4 billion lbs. of plastic, 1 billion lbs. of lead, 1.9 million lbs. of cadmium, 1.2 million lbs. of chromium and nearly 400,000 lbs. of mercury—of

---

[8] Some European countries adopted their own laws even before the WEEE was approved. For example, the Netherlands enacted the *Extended Producer Responsibility Act* (EPR) in January 1999. This legislation stipulates that all electronics products considered environmentally "brown" and "black" must be recovered, including small appliances beginning a year later. This legislation, which includes legacy wastes, prohibits the disposal of electrical and electronics products in waste disposal sites or via incineration. Municipalities are responsible for collecting all such waste, with said process to be financed via a special tax to be collected at the time of sale of such products (e.g. $12.50 dollars per television set).

which only 10% will be recycled if the present rate of recycling prevails.[9] One factor explaining why the United States is lagging behind is that it has not signed the Basel Convention, which prohibits exporting of hazardous wastes to other countries. Hence, instead of making a greater effort to cut down the dangerous substances in these products, the United States exports a major portion of its computer wastes to China, India and Pakistan, a practice not available to the EU. Furthermore, recycling in these and other developing countries is done through very primitive and dangerous methods for the persons participating in this process.[10] In response to findings on past imported toxic electronic wastes, China has recently prohibited such imports.

In other respects, the United States electronics industry itself has taken important steps to improve the environmental performance of such industry. One of the most important initiatives was undertaken by the Computer Systems Policy Project (CSPP)[11], in conjunction with the Microelectronics and Computer Technology Corporation (MCC)[12], and other research agencies and laboratories. They analyzed the challenges and opportunities of the electronics industry regarding environmental issues. These efforts enabled them to publish an "Electronics Industry Environmental Roadmap," under the coordination of the MCC. This document examines the environmental problems arising at every stage of the electronics products life cycle and proposes alternatives to resolve them (MCC, 1994). It also provides a guide on how to implement a cleaner production process and how to dispose of wastes in a manner that doesn't harm the environment (see Box 1). Among the major conclusions: information is insufficient on alternatives for producing environmentally friendly products (or is difficult to obtain); used electronics products represent a major potential business opportunity—i.e., if recycled, they can produce significant economic benefits; adequate infrastructure and technology are necessary if such opportunities are to come to fruition; in addition to seeking environmentally harmless substitutes for toxic and hazardous materials, greater attention must be focused on the more efficient use of inputs to produce fewer wastes and reduce costs; and, finally, voluntary programs for improving manufacturing processes in environmental terms produced better results than programs based on command and control measures.

In the United States, with regards to mandatory recycling of electronics products, state level legislation also exists in California and Massachusetts that prohibits the disposal of monitors and television sets in sanitary landfills, due to the lead content in screens. Furthermore, another 20 states in the United States have introduced legislation, albeit limited in scope, on wastes generated by electronics products (http://www.ncel.net/). Some of these states share a border with Mexico.

Moreover, in the United States, certain non government organizations (NGO) with considerable lobbying, negotiation and mobilization capacities, have been putting pressure on governments and the electronics industry to improve their environmental standards. The Silicon Valley Toxics Coalition, the Electronics Industry Good Neighbor Campaign (EIGNC) and the Computer TakeBack Campaign are among them.

---

[9] EPA (2001).
[10] See the Silicon Valley Toxics Coalition, "Exporting Harm" (http://www.svtc.org/cleancc/pubs/harm.htm.).
[11] CSPP is the information technology industry`s leading advocacy organization.
[12] One of the largest US computer industry research and development consortia.

Box 1

ENVIRONMENTAL GUIDELINE FOR THE ELECTRONICS INDUSTRY

This study was carried out in response to growing concerns in government, civil society and the business community regarding the increasing environmental problems generated by the electronics industry and the desire to resolve them, taking into account the product life cycles. This guide includes an analysis of the technical issues requiring the attention of the computer and electronics industries with respect to environmental management and stresses the need to incorporate an **environmental vision in business strategies**.

- **Integrated circuits (IC)**. Recommendations have been included for improving production processes, as regards technological issues, materials and equipment utilized.
- **Integrated circuits packing**. This process consists of encapsulating and integrating circuits to enable their connection to electronics systems. Environmental issues concern the solvents utilized to wash circuits, the materials used to solder or glue components, and the fact that chemicals used at various stages of the assembly process are toxic or have adverse effects on health. The Guide recommends the development of environmentally neutral substitutes.
- **Printed circuit cards and their assembly**. These serve as the foundations on which most electronics products are built. Nearly half of such cards are inputs for the computer industry. The rest are used in the auto industry, communications and in a variety of instruments, etc. Chips and other electronic circuits are integrated into these panels, which is what enables their operation in an integrated system. Their use raises the same problems as integrated circuits packing in terms of the solvents, glues and soldering utilized. Consequently, environmental solutions must be sought by the same means suggested in the preceding point.
- **Monitors and screens**. The traditional cathode ray tube technology is used in both computer monitors and television screens. Disposal of these items represents an environmental problem due to their lead content, which, along with other toxic substances, are integrated into screens and, as a consequence, are difficult to separate from glass and other components. The more recently introduced flat screens are also problematic for reasons similar to those concerning semiconductors.
- **Final disposal**. The electronics industry must see the reutilization and recycling of electronics products as a priority issue.

In each of the categories mentioned, the Guide offers a list of priorities, based on the seriousness of the problems at issue. It also suggests ways to tackle problems and the specific tasks that must be carried out to solve them. In some cases, these tasks require research and laboratory testing to find substitutes for chemicals presently used. In other cases, changes are suggested regarding the production process and the inputs used.

Source: Microelectronics and Computer Technology Corporation (MCC) (1994), *Electronics Industry Environmental Roadmap*, Washington, D.C., Environment Protection Agency (EPA), and U.S. Department of Energy.

Finally, apart from the standards prevailing in the developed countries, there are several "eco-labels" that have been designed for electronics products or parts. The most recent and comprehensive one is TCO99 (see Box 2). In the United States, there also is the "Energy Star" eco-label, which is only concerned with reduced energy consumption in electrical and electronics appliances. In the case of computers, for example, this standard entails compliance with the rule that if the machine remains inactive, it must enter into low energy mode, i.e., consume 15 watts or less. Three other eco-labels of importance are "Nordic Swan", "Blue Angel" and the Canadian Environmental Choice Program.

In 2001, Japan became the first country to enact a law requiring the recycling of consumer electronics appliances. Computers will probably soon be added to this list of products. The electronics industry in Japan has built waste recycling plants for its products throughout the country. However, the initial operations are still in the red. By 2003, there were 40 plants of this type.[13]

1. The Response of the Transnational Corporations

An intense debate has taken place involving governments and the electronics industry on the issue of environmental policy and standards, specifically with respect to the business community's responsibilities and the pollution generated by the electronics industry and electronics products. For example, in a joint declaration by the industry, consumers and environmental organizations on producer responsibility in the WEEE (2002), required a commitment by manufacturers to make an effort to improve future products was achieved,. Regarding historically accumulated computer wastes the declaration proposed that recycling costs be shouldered by all sectors. As for retail merchants of electronics products in the United States, they would rather not assume any responsibility at all concerning product recovery and recycling. Manufacturers are reluctant to assume any such responsibilities too due to the higher costs that it would entail. Even the costs related to providing the public with the pertinent instructions for the recycling arrangements were seen as a burden to them.[14] The issue of taking responsibility for historically accumulated wastes has created greatest resistance.

All in all, as mentioned above, electronic products' environmental standards are being improved.[15] In the fourth annual *Computer Report Card* (2003), initiated by the Computer TakeBack Campaign, an initiative intended to guide consumers on the basis of the environmental performance of electronics products, assembled data to rank 28 different electronics companies in accordance with their environmental behavior.

[13] http://www.japantoday.com/e/?content=feature&id=207.

[14] Executive Summary of the Strategic NGOs and EPR Meeting, Soesterberg, 14-15 May 1999.

[15] For example, on June 24 2003, Dell presented two models of its redesigned *UltraSharp* and *UltraSharpTM* line of flat screen monitors incorporating advanced characteristics. Each monitor's panel can be detached with a rapid unhooking mechanism, not requiring tools, to facilitate easy wall mounting. The new flat screen monitors include analogue and digital inputs, contain much less lead and use less energy than traditional CRT3 monitors. (http://www.dell.com/la/la/es/gen/corporate/press/pressoffice_la_2003-06-24-rr-001.htm).

Box 2
TCO99: ECO-LABELING FOR PERSONAL COMPUTERS CERTIFYING MONITORS AS ENVIRONMENTALLY ACCEPTABLE

TCO99 was jointly developed by TCO (Swedish Confederation of Professional Employees), *Svenska Naturskyddsforeningen* (Swedish Society for Nature Conservation) and *Statens Energimyndighet* (Swedish National Energy Administration).

Certification of this label requires compliance with standards related to the environment, ergonomic issues, functionality, electrical and magnetic field emissions, energy consumption, and electrical and fire safety issues.

The environment related requirements impose restrictions on the presence and use of heavy metals, chromium and chlorine fire retardant materials, CFCs (freons or refrigerants) and solvents containing chlorine, etc. The product must be designed to facilitate recycling and the manufacturer must have an environmental policy for every country. Furthermore, the product must incorporate an energy-saving mechanism.

The TCO99 standards supercedes TCO92 and TCO95, which set limits on emissions in manufacturing plants and on the use of toxic substances like lead and mercury in the manufacturing processes. In addition to those standards, TCO99, also sets stricter acceptable levels on screen reflection, inconsistencies in color uniformity and temperature, and in screen refresh rates, i.e., phenomena that induce stress by tiring eyesight.

Bromated Flame-Retardants (BFRs): These are contained in circuit boards, printed circuit cards, cables, wiring, casings and other parts. Approximately 30% of the plastic contained in computer casings is composed of such substances. Furthermore, a large portion is made of chromium and chlorine, which is also combined with PCBs, another toxic substance. All of these substances may generate negative health consequences.

TCO99 requires that plastic components weighing over 25 grams do not contain any flame-retardants chemically related to chromium and chlorine. Flame-retardants are permissible in circuit panels and printed circuit cards, as no substitutes are presently available.

Cadmium. This substance is present in rechargeable batteries and in certain color-generating layers in some computer screens. Cadmium alters the nervous system and is toxic in high doses. TCO99 requires that no cadmium be contained in batteries, in color-generating layers of computer screens, or in electrical or electronics components.

Mercury. Is found in some batteries, regulators and switches. It damages the nervous system and is toxic in high doses. TCO99 prohibits mercury in batteries. Nor is it permissible in electrical and electronics components associated with an "eco-labeled" unit. Nevertheless, due to a lack of substitutes, mercury is still permitted in the light system of flat screens.

CFCs (chlorofluorocarbons). TCO99 requires that neither CFCs nor hydrochlorofluorocarbons (HCFCs) be used during the manufacture and assembly of electronics products, as these substances damage the ozone layer. CFCs are often used for washing printed circuit cards.

Lead. It is contained in cathode ray tubes, screens, soldering and capacitors. Lead is harmful for the nervous system and in high doses causes poisoning. TCO99 expressly requires permits for the inclusion of lead in processes and uses for which substitutes do not as yet exist.

Source: http://www.pcworld.com.ve/n23/articulos/monitores.html

Nine of these were from the United States, [16] eleven from Japan,[17] two were European,[18] three Korean[19] and three Taiwanese.[20] The maximum possible score for any firm was 68 points. However, the best actual score was only 35 points (obtained by a Japanese firm), nine other companies were tied for second with 34 points (seven were from Japan and two from the United States) and three obtained between 22 and 26 points (two from Japan and one from the United States). The sixteen remaining companies scored between zero and sixteen points (three were Korean, three Taiwanese, two European, six American and only two were Japanese). The study based its evaluation of the selected companies' environmental performance on the information that each one of them provided on its WebPage regarding its environmental policy.[21] Particular attention was paid to extended producer responsibility, the use of hazardous substances, the health and safety conditions of plant workers, and access to information.[22] Some companies' environmental performance improvement between 2001 and 2002 was especially outstanding with respect to public statements in support of greater producer responsibility on the issue of recycling.[23] (Apple, Hewlett-Packard/Compaq, Matsushita/Panasonic, Seiko Epson and Brother.)

One of the problems in raising environmental standards is that while certain companies are indeed starting to take serious initiatives in this area, they do not transfer such standards abroad. Research shows that several transnational corporations are capable of improving standards, but only do so when forced to by the national requirements of the countries where they manufacture their products and/or sell them. Thus, the Japanese company Sony complies with Japan's environmental legislation on recycling, but adapts to the local regulations affecting its subsidiaries outside of Japan. This worries environmental groups in the United States—which is the source of 32% of Sony's production—as US environmental legislation is more lax in this respect than Japan's. The same company mentions in its environmental performance report that it is continuing to introduce lead-free soldering in its products, "especially those made in Japan and Asia." Products such as Sony's VAIO®MXS1 computer do not contain lead soldering in its printed circuit cards. However, they are not available among the computers sold on-line in the US market, nor in any other market other than the Japanese market. Likewise, Dell produces some computers with environmental characteristics in compliance with EU standards—and

[16] Apple, Dell, e-Machines, Gateway, Hewlett-Packard (Compaq), IBM Lexmark, Micron PC (MPC), and Viewsonic.

[17] Brother, Canon Fujitsu, Hitachi, Matsushita-Panasonic, NEC, Oki, Seiko Epson, Sharp, Sony, and Toshiba.

[18] Philips and NEC International.

[19] Daewoo, Lucky Goldstar, and Samsung.

[20] Acer, AST, and Wyse Technologies.

[21] In addition, a complementary survey was done with each of the companies to gather additional information not provided by them on the Internet. The environmental performance of 11 companies was better than indicated on their respective WebPages—that said, this was not taken into consideration during the assessment of each company's score regarding their environmental performance.

[22] As for companies whose progress was not entirely reflected in their WebPages, six were from the United States and five from Japan.

[23] Most of these companies have maquiladora plants in Mexico. However, it is not possible to determine with certainty which ones do, as their subsidiaries do not always operate under the same brand names as their parent companies.

which are only for sale in the EU. IBM maintains lines of production that contain more *Bromated Flame-Retardants* (BFRs) than the rest of its computers and sells them are for sale in the Australian, New Zealand and Chinese markets. Another example is Matsushita/Panasonic, which recognizes that some products from suppliers outside of Japan and the United States contain lead, whereas all production within these two countries is lead-free (www.svtc.org.cleancc/pubs/2002report.htm).

It may be inferred from the above-mentioned cases that two different final markets are in formation: in one market, products satisfy the high environmental demands of consumers in European countries and Japan (demands that are reflected in environmental laws and standards); in the other market, in developing countries—or even in the United States—consumers are less demanding, environmentally speaking, and environmental laws and standards are less strict.

This phenomenon seems to be inducing an incipient differentiation in electronics products. Firstly, in production processes, which need to adapt to the environmental standards of the countries where they take place. Secondly the final product also has to have the characteristics required by the, norms of the markets where they are sold, i.e., in response to consumer and government demand. Consequently, different technological paths and market segmentation are apparently arising from the above-mentioned environmental standards. That, in turn, would indicate a partial change in the trend towards the generalization and standardization of production processes of the parts and components of electronics products. This is perhaps even more marked in those instances where large transnational electronics corporations subcontract local companies, a rapidly growing trend (Lüthje, 2003). In fact, the company selling the final product under its brand name may disassociate itself, at least partially, from its subcontractor's production processes. In this sense, "flexible standardization," as it is called — may have its virtues as regards satisfying different types of demand for electronics products— but may prove counterproductive in environmental terms, if it evolves towards producing goods that are comparatively cheap due to low environmental standards. The differentiation in environmental criterion in the electronics industry is partly rooted in the tremendous competition prevailing in it. In this sector, the components' prices show a constant tendency to fall and companies constantly endeavor to reduce costs (Kenney and Curry, 2003). As long as there are markets where consumers are not particularly concerned about the product's environmental impact and where price is the only determining factor, products assembled in countries like Mexico may have as their final destination either markets with greater environmental protection or, alternatively, markets that are less stringent environmentally and where prices are more competitive. Moreover, with the onset of the world recession in 2001 and the over-production of both electronics parts and finished products, competition has only intensified (Dussel, 2003). This may lead some producers to postpone even more their environmental objectives.

Notwithstanding the preceding discussion, not all large transnational electronics corporations adopt different environmental policies depending on the country's standards where they operate. Hewlett-Packard, for example, which has facilities in 110 countries, has launched a "Product Stewardship Program" (see Box 3) in order to improve health and safety standards, and the environmental performance of its products worldwide. This effort, therefore, encompasses HP's subsidiaries. Similarly, Intel's subsidiary in the Philippines has followed the environmental policy of its head office. Concretely, this has entailed substituting solvents for de-ionized water for washing microchips and eliminating chlorofluorocarbons (CFCs) in its production processes, among other practices. Intel's manager in the Philippines cites that country's high environmental standards (Salazar, 1998) to justify these practices.[24]

Box 3

HEWLETT-PACKARD'S WORLDWIDE PRODUCT STEWARDSHIP PROGRAM

Hewlett-Packard has implemented a service that allows consumers and businesses in California to recycle no longer wanted computers and equipment, regardless of the brand. This service includes equipment pick-up, shipping, and evaluation of its potential for continued use, donation or recycling. The assessed value of the returned product depends on it quality and what type of product it is.

To operate this program, Hewlett-Packard selected as its partner Micro Metallics Corporation, a subsidiary of Noranda Inc. (TSE:NOR), a Canadian mining company. MMC's role was to develop an innovative system for assessing the recovered equipment, extracting the parts that can be reused and recycling the rest. The processing line, which cost four million dollars, includes grinding equipment to enable separation of the different components, mainly plastics and metals, for recycling.

A similar products recovery program will be developed in European countries and Canada, as well as in Latin America and Asia.

Source: http://www.newenvironmentalism.org/ecology2.cfm?ID=36.

Finally, information on health and safety conditions for workers in the electronics industry—a question closely linked to the environmental characteristic of production processes—is usually difficult to obtain from large international electronics companies. As a consequence, the use of lead as an input in soldering, the use of certain types of glue and other inputs in the manufacturing or assembly of computer parts, are issues that have not attracted due attention in developing countries, though it is precisely the labor-intensive stages of the production process have been transferred to such countries.

2. The Environment and the Maquiladora Electronics Industry in Mexico

The electrical/electronics industry in Mexico has experienced considerable growth in the last decade. Between 1992 and 2001, exports of electronics products to the United States

---

[24] In 2002, Intel received the "Success Story Citation for Environmental Excellence" from the Pollution Control Association of the Philippines (PCAPI). This distinction is awarded to companies that go beyond compliance with basic standards and contribute to improving environmental conditions in the industry. In the Philippines at that time, Intel had succeeded in reducing water consumption by 50 million gallons since October 2001 (http://www.intel.com/intel/other/ehs/stewardship/philippines.htm).

quintupled in value (see Diagram 1). The early 90s boom in Mexico's electronics industry[25] originated in the large investment flows from Japan and the Republic of Korea. These flows were part of a strategy seeking to evade the import levies applicable to various Asian countries, which the United States had imposed on these types of products.

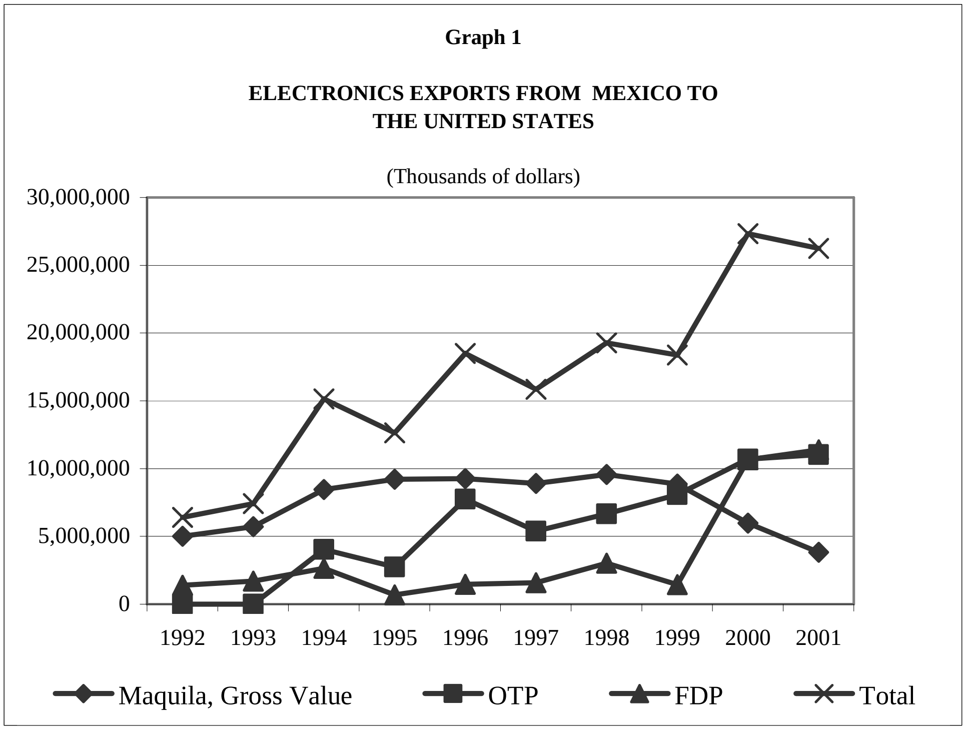
Another incentive to FDI in this sector, was the opportunity to enjoy the preferential tariffs granted by the United States to Mexico if they were in compliance with FTA rules of origin (Romo Murillo, 2002). The portion of exports attributable to maquiladora plants, as such, stagnated or declined after 1994. However, this was due to the fact that many of the exports originally classified under the tariff categories 806/807[26] started entering the United States as products of Mexican, American or Canadian origin, i.e., as tariff-free products under the "Other Preferential" (OTP) category, which includes North American Free Trade Agreement goods, or under the "Full Duty Payment" (FDP) category, which covers products assembled in Mexico that do not, however, comply with rules of origin due to inputs from third countries.

In Mexico, in contrast with developed countries, the environmental standards applicable to the non-maquiladora electronics sector are of a general rather than specific character. These include: Official Mexican Standard NOM-001-Ecol-1996, which stipulates the maximum permissible limits for pollutants in waste water discharges and in national final products; NOM-039-Ecol-1993, which stipulates the maximum permissible limits for atmospheric emissions of sulfur dioxide, sulfuric trioxide and sulfuric acid mists, in plants generating sulfuric acid; and NOM-043-Ecol-1993, which stipulates the maximum permissible limits for atmospheric emissions of solid particles emitted by fixed sources.

Transnational electronics corporations registered under the maquiladora system have the obligation of returning hazardous wastes generated during production processes to the country of origin. This is established in the Mexican Official Standard NOM-052-ECOL-1993, which defines the characteristics regarding wastes that are hazardous to the environment, including all substances that have corrosive, reactive, explosive, toxic or inflammable characteristics (CRETI), and which, consequently, must be "properly managed and disposed of to ensure that they do not affect human beings and their environment." (http://www.cce.org.mx/cespedes/publicaciones/otras/contenido.html).

[25]Including both the maquiladora and the non-maquiladora sectors, especially regarding the production of television sets and other mass consumer electronics items.

[26] "806" is an abbreviation for tariff category HTSUS 9802.00.60, while "807" is an abbreviation for tariff category HTSUS 9802.00.80.



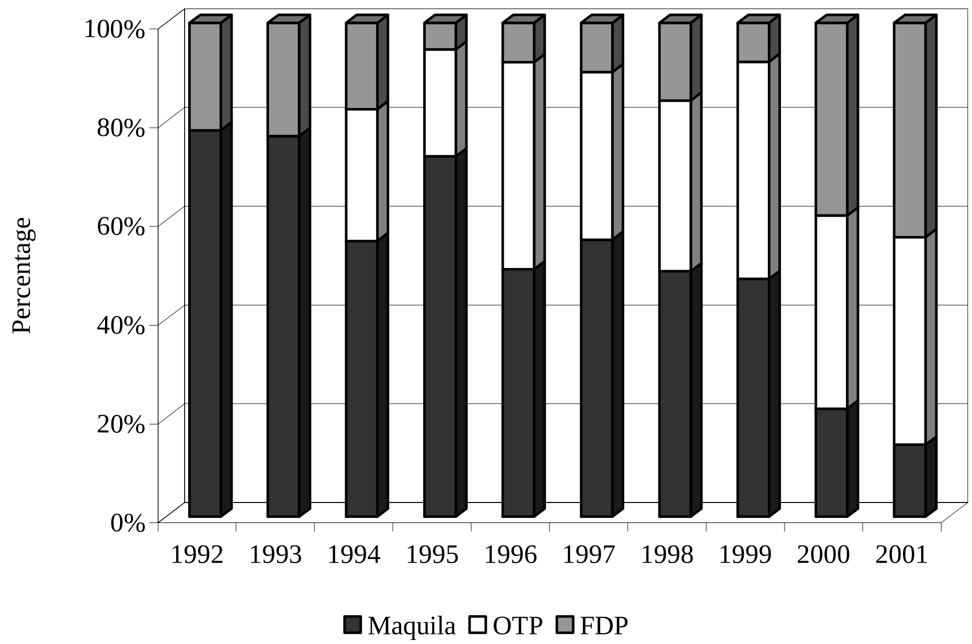
Source: *Journal of the Flagstaff Institute,* various issues.

The Maquila category includes United States imports from Mexico entering under the tariff categories 806 and 807. These only consider the value added in Mexico for tariff purposes and exclude the value of inputs from other countries, including the United States, assembled and re-exported by the Maquiladora industry. The OTP category (*Other Preferential*) includes imports with other preferential treatments (mainly all goods entering under the auspices of NAFTA). In this case, the product's total value is included for tariff purposes without distinguishing between value added in Mexico and value added elsewhere. Tariffs imposed on the total value of these products are either less than those on imports from third countries—or they pay no tariffs at all. FDP (*Full Duty Paid*) refers to imports paying full tariffs upon entry into the United States. The total includes the total value of imports of electronics products from Mexico entering the United States, minus the inputs originating from the United States that are assembled in Mexico.

Finally, regarding environmental policy, the maquiladora industry must comply with the provisions contained in the *Ley General de Equilibrio Ecológico y Protección al Ambiente*-LGEEPA (General Law of Ecological Equilibrium and Environmental Protection), enacted in 1988 and amended in 1996. One clause in this code is specifically designed for the maquiladora industry and the question of hazardous wastes: Article 55 of the LGEEPA stipulates that "the hazardous wastes generated in production, transformation and assembly processes under the maquiladora regime shall be returned to the country of origin, if they involve raw materials introduced into the country under the category of temporary imports." In 1996, the maquiladora sector in Mexico [27] produced about 60,000 tons of wastes requiring special management; 60% of these wastes were returned to the United States, which was their place of origin,; 12% were disposed of in Mexico in known sites; and, as for the remaining 28%, the method of their final disposal is unknown[28] (CESPEDES and CEC, 2001).

Graph 2

MEXICAN ELECTRONIC MAQUILA EXPORTS TO THE UNITED STATES



Source: *Journal of the Flagstaff Institute,* various issues.

As Mexico is a signatory to several international environmental agreements, such as the Montreal Protocol and the Stockholm Convention on persistent organic pollutants, which aim at eliminating ozone layer depleting substances, the maquiladora industry will have to eliminate the use of CFCs and polychlorinated biphenyls (PCBs) in its production processes. The maquiladora electronics industry must also comply with environmental protection standard NOM-133-ECOL-2000, which mandates the elimination of PCBs. Similarly, this sector must comply with requirements contained in the cooperation agreements signed by the three NAFTA signatories. The Sound Management of Chemicals Plan (SMOC, see Box 4) figures prominently among such agreements, and one of its objectives is to eliminate two of the toxic substances used in the electronics industry: mercury and lead. Hence, setting more standards for this sector could help attain Mexico's international commitments as well.

[27] According to the *Instituto National de Estadística, Geografía e Informática* (INEGI) figures, the maquiladora electronics sector represented 14% of the total Mexican maquiladora sector in 1999.
[28] Information specific to the maquiladora electronics sector is not available.

The maquiladora industry in Mexico is monitored by Profepa, *la Procuraduría Federal de Protección al Ambiente* (Office of the Federal Attorney for Environmental Protection). In 2002, Profepa inspected 445 maquiladora plants and detected 274 minor violations of the standards currently in force. In 170 plants, no violations were found. Only a single plant was closed temporarily. Thus, only 38.2% of the plants inspected were in full compliance with the required environmental standards. Though this degree of compliance with standards is rather low, it must be mentioned that it is nevertheless 12% higher than the average national rate of compliance of 26.3%.[29] Notwithstanding the lack of information specific to the electronics industry, both maquiladora and non-maquiladora, the above data gives a general idea of the environmental practices of maquiladoras in Mexico. In recent years, the trend has been towards considerably fewer Profepa plant inspections. Between 1994 and 2000, for example, the average number of inspections in the maquiladora industry was over 800 per year. In 2002, this number had fallen by nearly half (Semarnat/Profepa, 2000, 2003). In fact, when calculating the coverage of Profepa's annual visits in maquiladora plants that were in operation every year, for which information is available, a major reduction is evident. Thus, whereas in 1995 coverage was 46%, in 1996 it was 37%, in 1997, 29%, and in 2001 and 2002 it had fallen to 21% and 15%, respectively. These trends reveal that for budgetary, or other reasons, environmental requirements and supervision have become generally less stringent in the maquiladora sector.[30]

Box 4

NORTH AMERICAN COMMISSION FOR ENVIRONMENTAL COOPERATION

Sound Management of Chemical Substances (SMOC)

"This is an ongoing initiative to reduce the risks of toxic substances to human health and the environment in North America. The project provides a forum for: a) identifying priority chemical pollution issues of regional concern; b) developing North American Regional Action Plans (NARAPs) to address these priority issues; c) overseeing the implementation of approved NARAPs; and d) facilitating and encouraging capacity building in support of the overall goals of SMOC, with emphasis on the implementation of NARAPs."

The objective of the first NARAP was to eliminate PCBs, DDT and chlordane; other NARAPs under way or in the process of being approved concern:

Mercury (a two-phase process)
Dioxins, furans and hexachlorobenzenes (HCBs)
Lead

At least two of the substances included in the NARAPs—mercury and lead—are among the substances considered as hazardous and which are used in the production of certain electronics industry products.

[29] Semarnat (Secretariat of Environment and Natural Resources)/Profepa, 2003.

[30] Visits by Profepa inspectors are limited to verifying compliance with environmental standards on solid and hazardous wastes. The National Water Commission is responsible for supervising compliance with environmental standards related to water. Atmospheric emissions are not a significant issue, as the assembly process carried out in Mexico entails little combustion.

Source: (www.cec.org).

Few studies have specifically analyzed the environmental performance of the maquiladora electronics sector in northern Mexico. One study gave it an intermediate ranking on environmental performance in comparison with two other sectors: metal machining, which rated worse than the electronics industry, and the plastics industry, which rated better (Montalvo, 2002). Consequently, in examining the environmental policy of maquiladora electronics plants in Mexico one must take into account their role in global production networks. The maquiladora electronics industry corresponds to a specific segment of the value chain that is outsourced from the country of origin to Mexico, where costs may be reduced due to low labor costs, among other factors. The predominant characteristic of these localizations remains their status as "cost centers." Consequently, plant mobility is high—i.e., plant openings and closings are frequent—due to the constant search for geographical locations offering cost advantages. In a word, the industrial organization of the maquiladora sector is not particularly conducive to an active company environmental policy (Montalvo, 2002).

The Philippines represents an interesting comparison. Over half of that country's exports are presently composed of electronics products, particularly semiconductors, which are largely integrated into international lines of production (Salazar, 1998). The expectation there is that as the transnationals with plants in the Philippines are pressured into producing environmentally friendly goods, they will in turn require that their suppliers or subsidiaries in developing countries supply them with products that comply with the higher environmental standards that they, the transnational corporations, are endeavoring to respect. With this perspective in mind, in 1996, the Development Bank of the Philippines, in collaboration with Natural Resources Department contractor AF-IPK and the Semiconductor Electronics Industries Foundation (SEIFI), elaborated an Environmental Management Plan for the semiconductors industry. The principal objectives of the plan were to minimize the industry's environmental impact, and develop mechanisms enabling the industry to close the technological gap with the developed countries, in terms of environmental standards.

Nevertheless, in practice the plan encountered a variety of problems, such as: a significant gap between regulations and the objective technical and economic realities in the sector; a lack of human and material resources in both the business community and government; deficient *in situ* environmental performance auditing mechanisms; little awareness of environmental problems in civil society and among industrialists; a conflict of interests between the goals of protecting the environment and other government objectives, such as saving jobs and promoting growth whatever the cost (Salazar, 1998). In short, the environmental issue goes beyond compliance with standards and regulation, even though the latter are starting points for environmental policy.

Despite progress in recent years, Mexico's environmental policy is not moving towards an approach based on designing standards specific to most manufacturing sectors (including the electronics sector), as is the practice in many developed countries. Specific standards do exist concerning maximum permissible emissions in various economic sectors, such as the cement and glass industries. However, these are lacking in the electronics industry. If standards were decreed, if incentives and the inspections system for monitoring compliance were strengthened (e.g. on substitutes for toxic or hazardous materials used in production processes), Mexico could avoid becoming a supplier of electronics products to environmentally backward markets, markets which are destined to become smaller if environmental standards are increasingly adopted by importing countries.

II. THE ELECTRONICS INDUSTRY IN NORTHERN MEXICO: ANALYSIS OF A SURVEY

1. General Characteristics and Results of the Survey

This section analyses the electronics maquiladoras environmental commitment in northern Mexico (Tijuana, Mexicali and Ciudad Juarez). The central question in this part of the study is to what extent these enterprises consider an environmental policy to be a normal part of operations in their plants. For those maquiladoras for which this is true, the next issue is what led them to adopt an environmental policy and implant anti-pollution technologies, i.e., to adopt an active environmental policy.[31] The analysis is based on the results of a survey carried out by *El Colegio de la Frontera Norte* (COLEF, 2002) on technological learning and industrial upgrading in electronics maquiladora industries. Over one half of the sample turned out having an active environmental policy. The factors that helped environmental policies to develop in the plants were found to be: the plant's permanence through time in the same location; the sector they belong to and the type of production it carries out; the size of the multinational they are part of and the production supporting units and departments the plant has.

The survey includes interviews with 298 plants, representing 76% of the establishments in the maquiladora auto industry and electronics sectors (including suppliers), in the study's three cities, at the time the survey was carried out. Out of this total figure, 200 plants were in the electronics sector, 78% of which were maquiladora plants as such, while the remaining 22% were suppliers of goods and services. The following results are derived from the analysis of the survey's electronics sector sub-sample.[32]

Analysis of the survey data indicates that the largest concentration of plants is in Tijuana (51%), followed by Ciudad Juarez (29%) and Mexicali (20%). Over half of these plants were opened in the 1990s, even though the maquiladora model was originally sanctioned back in 1965.

As for the size of the operations in Mexico, as measured by the number of employees,[33] 22% were small, 20% medium-sized, and the majority was either large or very large companies

---

[31] Specifically, the relevant survey questions were: “Does the company have an explicit environmental policy that applies to this plant?” and “Has this plant installed anti-pollution technologies?

[32] For an analysis of the environmental behavior of the automobile and electronics sectors as a whole (including suppliers), see the relevant chapter in Carrillo, García and Gomis (2003).

[33] Plant size is a function of the number of employees: small means up to 100 employees, medium-sized is from 101 to 250, large is between 251 and 1,000, and very large means over 1,000 employees. Plant size does not always correspond to the corporation's size in Mexico, as some companies have more than one plant in the country. Unfortunately, information on plant sizes is not available.

(58%).[34] As for the size of these same companies internationally, 72% of the plants surveyed belonged to very large corporations.

As for the national origin of investors, 55% of the plants surveyed indicated that the controlling interest (51%) was American, 27% were Asian owned (the Republic of Korea, Malaysia, Singapore, Taiwan, China, etc.), 13% were Japanese, 11% Mexican and the remaining 7% European. Consequently, most of the head offices of the plants surveyed are in the United States (64%)—and over 30% of these are located in the United States near the border with Mexico, specially in California. Seven percent of the head offices were in Japan, 11.5% in other Asian countries, 4% in European countries, and 3% in Mexico (information is not available for the other 10.5% of the plants surveyed, as this particular question was not answered).

The main activities of these plants, both maquiladoras and their suppliers of goods and services, are the manufacturing of finished products, product assembly, assembly of parts, components or subassemblies, packaging and product tests. These plants have little involvement in the manufacture of inputs, components, machinery and equipment (see Table 1).

Table 1

PLANT ACTIVITIES ACCORDING TO THE SURVEY

Activities	Number of plants in each activity	Percentage of plants carrying out activity with an active environmental policy
Product manufacturing	85	78.7
Manufacturing of inputs/components	42	38.9
Tool-making	41	38.0
Manufacturing of machinery and equipment	20	18.5
Assembly of finished products	84	77.8
Assembly of parts, components or Subassemblies	95	88.0
Packaging	91	84.3
Automatic insertion of components	42	38.9
Plastics injection molding	31	28.7
Machined parts	37	34.3
Product design	22	20.4
Research and development	29	26.9
Product testing	95	88.0
Elaboration of prototypes and blueprints	50	46.3

Source: Responses of maquiladora plants to the survey "Encuesta de aprendizaje tecnológico y escalamiento industrial en plantas maquiladoras," COLEF, 2002. CONACYT Project No. 36947-s, "Aprendizaje tecnológico y escalamiento

[34] Nearly 25% of the plants surveyed belong to large corporations and 33% to very large corporations.

industrial. Perspectivas para la formación de capacidades de innovación en las maquiladoras en México," COLEF/FLACSO/UAM.

The principal factor in terms of these plants' competitiveness is price and quality, with competitiveness largely determined by their relations with their head offices and demand in the United States market. Although these plants have made recent improvements in their competitiveness, as attested to by a reduction in rejects and reworked products due to improved quality in over 90% of cases, the present international context marked by recession and uncertainty has had a negative impact on them. As for the main problem areas hurting both their competitiveness and perspectives for future growth, the issues most frequently identified were international factors and national institutions. As to the international problems faced by them, the following were specifically mentioned: the world recession (and especially the recession in the United States), the over-valuation of the peso, Article 303[35] of NAFTA, the new customs law,[36] a significant increase in international competition, the surfeit of administrative procedures and the high levels of corruption and public safety issues afflicting the country (for analysis of the environmental behavior of the maquiladora electronics and automobile sectors as a whole, see Carrillo, García and Gomis).

The fact that these maquiladoras plants are located on the border helps their interaction with plants and suppliers in the United States. In fact, in over 80% of the cases an office (or plant) located in southern California or Texas carries out activities such as: purchasing, distribution, sales, warehousing, accounting and administration and manufacturing (in 39% of the cases), as well as providing technical assistance (53% of the cases). For 56% of the plants surveyed, the main supplier of raw materials, inputs and components was located in the United States, 25% were in Asia, 7.5% were in both, 4% in Mexico, 2.5% in both the United States and Mexico, and only 1% were in all three places (the main suppliers of the remaining 4% were located elsewhere). This data indicates a very limited degree of integration with local or national suppliers of inputs and raw materials. The same situation prevails regarding services, as most of the plants surveyed (68%) seek them in the United States. Finally, regarding environmental consulting services, 24% of the plants hire them in the United States.[37]

[35] Among the main changes that NAFTA introduced in the maquiladora model in Mexico, one might mention the content of Article 303, under which "duty drawbacks" or "refunds of duties" were eliminated for inputs from non-NAFTA member countries, from the year 2001 on, even when the final products incorporating these inputs were subsequently exported to another treaty signatory. In such cases, some portions had to pay tariffs, albeit only temporarily.

[36] Before NAFTA started in 1994, there was no agreement between Mexico and the United Status on double taxation and therefore, it was very difficult for Mexican authorities to force U.S. firms, among them, the maquiladora plants, to pay the due taxes. Once such agreement was signed, this started to change and the maquiladoras had to use adequate transfer prices so as to reflect their real income in their financial balances and pay their income taxes, accordingly. If the enterprises complied, then they would have the taxes on their assets waved. Notwithstanding different fiscal measures, up to date the maquila industry pays none or negligible taxes. Still, firms complain about the constantly changing rules regarding taxes. For an in-depth analysis on this issue, see R. Schatan (2004.)

[37] Among the main services that the plants hire in the United States are shipping (68%), brokerage services (82%), information technology (48%), technical and professional training (46%), credit and banking (51.5%), and equipment procurement (60%).

It is precisely when the head office is located in the United States (as is true in 64% of the cases), that the firm in Mexico receives technical assistance and will probably have research and development centers (R&D). For example, 52% of these plants receive technical assistance from their head offices in human resources training, 84% are provided with market demand information, 76% are supported in inputs and components purchasing, as well as supply logistics, 68% in tools and machinery purchasing, 51% in the provision of innovations and patents, 68% in production processes, 73% in quality control, 57% in equipment installation and repair, and 64% in product design. Finally, the head offices of the plants surveyed have 170 technical or R&D centers, of which 15% are located in Mexico (information on where the other centers are located is not available).

A general finding of the survey is that the maquiladora electronics industry remains very intensive in unskilled labor—despite the increasing number of engineers and technicians in recent years, in over 30% of the plants.[38] This trend is consistent with Carrillo's (2003) emphasis on industrial scaling-up, which posits that plants have certain characteristics in terms of physical and human capital in accordance with the generation they belong to: first generation plants have a low technological level and greatly depend on intensive unskilled manual labor; second generation plants have a higher technological level and more skilled workers, technicians and engineers; and, finally, those of the third generation demonstrate high capacities in engineering and technology, oriented towards design and R&D, and have highly trained personnel.

The majority (58%) of maquiladora electronics plants surveyed had recently provided training to its engineers and technicians, especially on specific aspects of the production process. However, the situation was different in the case of workers, despite the fact that many plants mentioned their need for more qualified personnel. This situation is largely due to the high turnover in the maquiladora workforce, which does not make worker training a good investment.

As for environmental policy, 54% of the 200 plants surveyed have an active environmental policy. Furthermore, 57% of them increased their spending on environmental protection in the preceding three years, 63% possess an environmental unit or are under environmental auditing[39] and, as already mentioned, nearly a quarter (46 plants) hire environmental consulting services from the United States.[40] However, when asked what percentage of inputs was devoted to environmental technologies in 2001, fewer than half estimated that between 1% and 5% of inputs was used for such purposes.

It is worth asking what induces plants to modify their environmental practices: is it in response to voluntary measures or a question of complying with regulatory standards and laws?[41] On this issue, the survey found that 43% of the companies surveyed apply a voluntary self-

[38] In over 60% of the plants surveyed, the workforce was mostly comprised of workers (70% to 90% of total personnel). Information is not available on staffing numbers in the technical or R&D centers.

[39] Environmental auditing ("auditoria ambiental") is a voluntary agreement between the firm and the government to reduce emissions and improve environmental performance, according to specific pre-established targets.

[40] The survey question was: does this plant utilize environmental consulting services in the United States?

[41] Alfonso Mercado García (2000) observed that in Mexico the application of governmental environmental requirements depends on the size of maquiladora plants. As one goes from smaller plants to medium-sized plants, government regulation tend to become stricter. However, this trend is reversed as one passes from medium-sized plants to large ones. Finally, very large plants are subject to the least stringent regulation. On the other hand, as for the companies themselves, it was discovered that the larger the plant, the stricter the company environmental policy.

managed environmental program attributable to a number of reasons, including: the awareness some firms have regarding the international trends towards a cleaner electronics industry; the transmission of environmental concerns by head offices to their subsidiaries; pressure from communities living close to plants; or, lastly, avoiding the possibility of temporary or permanent closings should national environmental regulatory institutions so decree. Consistent with these tendencies, over half the plants stated that they had undertaken environmental protection measures on their own will, while just 18% had apparently done so in response to pressure from environmental agencies, mainly Profepa.

While it is true that 67% of the plants surveyed have some type of relationship with the various private and/or public institutions involved in the solution of environmental problems,[42] the quality of such services is strongly questioned. In fact, three-fourths of the companies surveyed considered the support from public institutions—whether at the federal, state or municipal levels—deficient. It is possible that this perception is related to the fact that the plants surveyed expressed as their principal needs—regarding changes required in government environmental policy to foster improvements in their environmental performance—fiscal policies, such as incentives, subsidies and exemptions, as well as simplification of administrative procedures. In fact, just 15 plants (7.5% of the total surveyed) had received financial incentives from the government.[43] On the other hand, the support provided by private institutions (business associations or organizations) and professional consulting services is generally highly regarded.

Furthermore, very little training is provided on environmental issues. For example, out of the 190 plants that had provided training to engineers and technicians, only three had done so in relation to environmental standards. Based on this data, one could conclude that for some transnational corporations protecting the environment is not a priority in their subsidiaries, at least as far as the training expenses of their plants in Mexico would indicate.

In light of the specifics of environmental requirements adopted on the international level, of the environmental progress already made by many transnational corporations, and the speed with which environmental friendly changes are being introduced in production processes and with respect to the entire life cycle of electronics products, the results of this analysis suggest that in Mexico maquiladora plants and their suppliers have some catching up to do in environmental policy.

As for the benefits derived from the adoption of environmental protection measures, among the plants that implemented an active environmental policy 49% stated that they had reduced toxic emissions, 5.6% that they have reduced energy consumption, 4.6% said they had introduced cleaner technologies, 12% that they had reduced recycling costs and/or input substitution costs, and 23% held that they performed permanent monitoring of pollution emissions and of working conditions. Many of the enterprises (36%) which have an environmental policy complained that the adoption of such policy increased their production costs and had to face excessive bureaucratic procedures (58%).

---

[42] Support was mainly provided by private entities localized in municipalities such as ECO2000 and *Consorcio Environmental*, among others. Much less support was provided by federal institutions, such as SEMARNAP and Profepa.

[43] As the pertinent survey question asked whether a plant had received government financial incentives in general, it is not possible to specify whether such incentives were related to environmental policy or not.

2. Estimation of a LOGIT Model

The analysis of the survey's results indicated that over half of the plants (54%) have an active environmental policy. In order to identify the determining factors regarding the implementation of this type of policy a LOGIT[44] model was applied. This type of model is appropriate due to the dichotomous nature[45] of the dependent variable to be estimated, i.e., whether a plant adopts an active environmental policy or not. In this type of model the probability function has the characteristics of a cumulative distribution function (CDF) which, as its name indicates, uses the logistical distribution function. This latter ensures that the estimated probabilities fall within a probability range of: 0-1, and that these probabilities are related to the explanatory variables in a non-linear manner.[46] Specifically, the LOGIT model used to identify the explanatory factors behind the adoption (or not) of an active environmental policy in the maquiladora plants included in the survey was the following:

$$P(Y) = \frac{1}{1+e^{-Y}}$$

where Y is the discrete variable that indicates the adoption or not of an active environmental policy by the plant, such that $Y = 1$ if the plant adopts an active environmental policy and $Y = 0$ if it does not do so. $e = 2.71828$.

After reviewing the data collected in the survey, analyzing certain variables and running correlations with the dependent variable, the following explanatory variables were identified as the ones to be estimated in the model:

$$Y_i = \beta_1 \sec tor + \beta_2 age + \beta_3 sizew + \beta_4 korigen + \beta_5 headoff + \beta_6 \sup p + \beta_7 compet + \beta_8 certific + \beta_9 assem + \beta_{10} envdep + \beta_{11} as \sin n + \upsilon_i$$

where *sector* refers to whether plants are electronics maquiladoras or suppliers of goods and services; *age* is the number of years that the plant has been in operation; *sizew* is the number of

[44] According to William H. Green, in his book *Econometric Analysis*, in dichotomous cases, when choosing between a LOGIT or PROBIT model, there are no grounds in statistical theory for preferring one over the other. In fact, in many applications there would be no difference whatsoever in the results. When the sample size is small, the resulting distributions may differ significantly. However, as results are very similar when samples are large, the selection of a LOGIT model to make estimations in this document does not present a problem.

[45] Dichotomous variables are variables that take mutually exclusive qualitative values. They are generally assigned the values of either zero or one.

[46] This is not a complex model since it uses the probability ratio logarithm. Moreover, while it has the appearance of a non-linear model, in reality it is linear in its parameters as these may be estimated via Ordinary Square Minima (OSM), in the standard fashion.

employees the corporation has in Mexico or world-wide, as the case may be; *korigen* is the country of origin of the controlling interest (over 51% of total ownership); *headoff* refers to the country where the plan's head office is located; *supp* is the country where the main suppliers of raw materials, inputs and components are located; *compet* is the location of the principal competitors; *certific* indicates whether a maquiladora plant has been quality certified, i.e., is ISO9001 or ISO9002 certified;[47] *assem*[48] refers to the specific activity of finished products assembly; *prodept* refers to whether a production or environmental policy department exists in the plant, [49] as the case may be; and *envdep* refers to the type of technical assistance that the head office provides to the plant, specifically with respect to innovation or inputs and components purchasing; *assim* indicates whether the head office provides technical assistance on innovation and patents to the plant. Finally, β_i are the coefficients of the explanatory variables to be estimated and υ_i denotes the error term. For more details, see Table A-1 in the Appendix.

As for an active environmental policy, in the specific case of the *sector* variable it was found that 60% of the maquiladora plants have such a policy, but only a little over 30% of supplier companies do (see Table 2).

Table 2

ENVIRONMENTAL POLICY IN THE PLANTS SURVEYED

Sector	Total No. of plants surveyed	Plants with an active environmental policy	Plants with an active environmental policy (%)
Total	200	108	54
Maquiladoras	156	94	60
Maquiladora suppliers	44	14	32

Source: Survey forms completed by plants surveyed for "Encuesta aprendizaje tecnológico y escalamiento industrial en plants maquiladoras," COLEF, 2002. Proyecto CONACYT no. 36947-s, and "Aprendizaje tecnológico y escalamiento industrial. Perspectivas para la formation de capacidades de innovation en las maquiladoras en Mexico," COLEF/FLACSO/UAM.

[47] The dichotomous variable denoting whether a plant has some kind of environmental certification, either ISO14001 or ISO14002, was not statistically significant based on the value of the z-statistic.

[48] This estimation was also done for activities such as product manufacturing, assembly of parts, components or subassemblies, packaging and product tests. However, in the resulting estimated regressions, none of these activities proved statistically significant, based on the value of the z-statistic, which must be greater than 2.

[49] The rest of the departments (or units) were not statistically representative.

As to the influence of geographical location of plants on their environmental behavior, the data showed that whereas in Tijuana and Mexicali a little less than half of the plants adopted an active environmental policy, in Ciudad Juarez 66% of the plants had done so. It would be of interest to deepen analysis of this issue in future research to determine whether local market factors exist, such as state legislation, the existence of clusters or other such elements, which might influence the pattern of geographical distribution/concentration observed. In the specific case of plants with a production department and/or an environment department, they are more likely to also have an active environmental policy. Moreover, among the plants that do have such a policy, those with a production unit constitute 54% of the total, while those with an environmental unit constitute 44%. As for quality certification, among plants with an active environmental policy, 76% do have such certification.[50]

3. Results from the LOGIT Model Estimations

In this part, we will show the results of the model, indicating the main determinants of the adoption, or not, of an active environmental policy by the maquiladora plants. The LOGIT model applied to the 200 plants of the maquiladora electronics sector—of which 108 plants adopted an active environmental policy ($Y = 1$) and 92 plants did not ($Y = 0$)—generated the estimated regressions shown in Table A-2 of the Appendix. An important clarification in this study is the statistical significance of the coefficients is of greater importance than their magnitudes, as it is the former that indicate their relevance as explanatory factors regarding whether or not maquiladora electronics plants adopt an active environmental policy.

According to the results obtained, the location in the customer-supplier value chain was among the principal factors explaining whether or not a plant implemented an environmental policy—in fact, maquiladoras are more likely to adopt an active environmental policy than their suppliers, regardless of the size of the corporation.[51] As may be seen in regressions 5, 6 and 8 in Table A-2 of the Appendix, this variable is significant at the 5% level, given the value of the z-statistic. The type of activity carried out is another explanatory factor; thus, plants that assemble parts, components or subassemblies or those which assemble final products, are more likely to have such a policy. In regressions 2 and 5, the coefficient is significant at 10%, and in regressions 6, 7 and 8 it is significant at 5%. Furthermore, in regressions 1, 2 and 8 one may observe that the older a plant is, and by the same token the greater its experience, the greater the probability they will have an active environmental policy. One may infer from regressions 1 to 3 that the size of the multinational, and thus of its scale economies at the international level, also has a favorable effect on the adoption of such a policy. In contrast, in no case was the size of the firm in Mexico a relevant factor.

The fact that a plant has a production (or unit) or an environmental department was identified as a factor associated with the adoption of an active environmental policy (these variables were statistically significant according to the z-statistic at 5%, with the exception of

[50] Only 26% of them had environmental certification (ISO14001 and/or ISO14002) and only 14% were QS9000 certified.

[51] Concerning the corporations that are the owners of maquiladoras and suppliers, in both cases 85% are large or very large companies internationally, as defined by the above-mentioned size classification regime. It therefore follows that corporation size is not a factor affecting this result.

regression 3). The type of assistance that a plant receives from its head office also influences whether an active environmental policy is implemented or not. Thus, a plant is more likely to have an active environmental policy when its head office provides assistance on innovations and patents, as well as on inputs and components purchasing, including supply logistics, than in the cases where no such support is given (see regressions 1, 3, 4, 5 and 7). Likewise, possession of quality certification was closely linked to the adoption of an active environmental policy, as attested by the fact that in every regression this coefficient was significant at the 1% or 5% level.

Finally, contrary to expectations, the countries where the head office, the main suppliers and competitors are located are not explanatory factors in the adoption of an active environmental policy in maquiladora plants. Nor is the national origin of the controlling capital. In short, while there are differences in environmental performance among transnational corporations that are due to the national origin of their ownership, these differences are not reflected in the behavior of their subsidiaries in Mexico. This is consistent with—and indeed is evidence of—the premise presented above indicating that transnational corporations apply double standards in the area of environmental policy. As already mentioned, in the case of Japan and Europe, these nations comply with high environmental standards in their home countries, but usually they do not transfer these standards to their subsidiaries, i.e., Mexico in the present case, or to other final destination markets. Instead, they simply comply with local Mexican environmental standards, which are more lax and less specific than those in the United States, European Union and Japan.

Most of these results are consistent with a study done by Mercado (2000),[52] which identified maturity (i.e., plant age) and scale economies as important factors in relation to the environmental behavior of maquiladora plants. On the other hand , the result indicating that the national origin of the controlling interest is not related to the environmental behavior of plants concords with a study done by Kopinak (2002), which holds that the utilization of the most advanced environmental practices depends more on company policy than on that of the country where the investment came from. In great detail, this author argues that when maquiladoras belong to an earlier stage of evolution their environmental performance is more a function of the local country's regulatory system. However, when a maquiladora belongs to a second or third stage of evolution, its environmental performance depends more on the foreign head office, which imposes given practices as company policy, or alternatively, acts in response to the client's or buyer's demand for better practices.

In short, according to our findings, the implementation of an active environmental policy in a maquiladora plant is related firstly to how old the plant is. This is quite understandable, since an established plant will be willing to cover environmental protection costs if it has the perspective of staying in the country for long enough as to be able to amortize this kind of investment. Also, a firm that has been in the country some time will probably have had inspections by environmental authorities and be forced to respond to their requirements. A second important determinant of the development of an active environmental policy within the

[52] Mercado's study determined that the following variables may influence maquiladoras to pursue environmentally friendly behavior: the level of development of the sector in which they operate (the more developed and modern, the more eco-friendly), the size of the plant (the larger it is, the more scale economies it enjoys), it's age and technology (the more current, the better). The inference made is that the greater efficiency arising from scale economies and current technology is normally linked to better environmental conduct.

plant was the size of the multinational corporation that owns it. Notwithstanding that some transnational corporations have implemented double standards in terms of their environmental policies, depending on where they operate, the largest of these seem to be more consistent with their home environmental policies throughout their plants than the rest of such corporations. A third variable that appeared to be important in determining the environmental behavior of the firm was whether it carried out assembly processes or whether they were providers of goods and services for the maquiladora. The latter were found to have an active environmental policy much more frequently than their goods and services providers. These are in general smaller firms that have less access to environmental knowledge and technology and that are not inspected as often as the maquiladoras. Another interesting variable that influenced positively the environmental behavior of the firm was whether it already had been certified for their products' quality. If this was so, then there seemed to be a logical impulse to proceed to upgrade the environmental performance as well. Finally, whether the firm received assistance from the head office concerning the transfer of innovations and patents; supply logistics; and tools and machinery purchasing, seems to be important too for the firm to take care of their environmental standards.

III. CONCLUSIONS

One of this paper's objectives has been to portray the international scene regarding environmental standards and policies in which the electronics maquiladoras of Mexico operate. Another has been to identify the efforts that these maquiladoras are presently undertaking in this area, without losing sight of the performance of the leading electronics companies at the international level. Consideration of the environmental problems related to this sector is taking on special importance considering the pace at which it has expanded over the last two decades, and the change the international environmental requirements on this industry is going through.

The rapid change in environmental policies is evident, especially in the developed countries, with the United States advancing at a relatively slower pace, at least at the federal level. The tendency is to focus on the entire life cycle of electronics products, i.e., from product design to final disposal. The assembly of final products by maquiladoras which are to be re-exported to another country (particularly the United States, in Mexico's case), is an important part of this cycle. Hopefully, the stricter requirements of consumers and governments in the final destination countries of the products assembled in Mexico might influence the way processes are carried out in this country. But the developed countries themselves have a long way to go. Until recently, just three electronics companies in the United States offered obsolete equipment recovery services—entirely at the customer's expense. European and Japanese companies are more advanced in this respect.

There has been, without a doubt, progress on environmental issues in many electronics plants in northern Mexico. This study found that over half of the plants surveyed in three border cities (supplier plants included) had adopted environmental measures, i.e., they had some kind of environmental policy, and had incorporated technologies to mitigate pollution emissions. From one perspective, these measures appear admirable, especially if one considers that a significant portion of these plants apply such measures voluntarily, while they face certain obstacles such as international mobility of firms and high labor turnover, which makes it difficult to make capacity building and environmental investments to work in the long run.

On the other hand, despite the progress in environmental standards for the electronics sector in the developed world, as well as the increasing environmental demands on the part of the governments and consumers in final destination countries, nearly half of the companies surveyed in northern Mexico had taken no environmental measures. The greatest proportion of firms without and active environmental policy is found among the maquiladora suppliers, as compared to the assembly industry itself (32% *vs* 60%, respectively). According to our findings, environmental measures adopted by companies become weaker as one descends from the head office to the subsidiaries and the same trend continues as one moves further along the chain from the subsidiary to its suppliers. A policy inducing the maquiladora electronics industry into taking environmental issues into account, as regards the inputs and services used, would also help to improve the environmental performance of suppliers.

The situation described is also consistent with the existence of environmental double standards on the part of some transnational corporations. In Europe and Japan specific laws have been enacted with the purpose of solving the pollution problems caused by the electronics industry, and transnational corporations have had to comply with these laws. However, not all have done so by introducing the required changes in all of their production facilities throughout the world. The result is the creation of two final products markets: one with high environmental requirements, and another with few of them.

This phenomenon was observed while analyzing maquiladora plants practices. From the application of a LOGIT model, it was concluded that the national origin of a plant's ownership is not a determining factor on whether it implements an active environmental policy or not. Thus, no major difference in environmental behavior was observed as a function of whether the majority ownership of a plant was Mexican, Asian, European or American. This indicates that standards in maquiladoras do not necessarily coincide with those followed in the country of origin of the maquila capital. Although 89% of the plants surveyed were foreign owned and many of their parent companies had introduced significant environmental measures in their countries of origin, only slightly over half of the plants analyzed had implemented an active environmental policy. This suggests that environmental policy could be introduced for foreign companies to be consistent with their home standards when operating in Mexico.

In Mexico, maquiladora electronics plants are not required to comply with clearly established and industry-specific environmental standards. Instead, applicable standards are general in character and do not necessarily require a company to implement a sophisticated environmental policy. For example, the Mexican environmental authorities mainly focus their monitoring of the maquiladora electronics industry on the issue of solid wastes management, a portion of which—those that are hazardous—must be repatriated to the country of origin. However, these authorities are not responsible for monitoring whether other kinds of improvements are implemented. Compliance with water standards is also monitored. However, this falls under the jurisdiction of another agency (the Water Commission). In short, what is lacking is an integrated vision of the environmental behavior of businesses. The foregoing suggests that it is the absence of specific national standards in Mexico which enables some transnational corporations to operate with double standards. In fact, although they are capable of improving the environmental performance of their subsidiaries, they often only act when required to do so by local legislation.

Moreover, according to the results of the survey, the influence exercised by the head office is far from negligible. Thus, when the latter provides expertise regarding the transfer of innovations and patents, or concerning the purchase of inputs and components, or when they help with the form’s logistics, subsidiaries are more likely to have an active environmental policy.

In view of the major technological transformation process that electronics industry is undergoing in the developed markets—and indeed, albeit to a lesser extent, in some developing countries as well, such as Mexico, it appears that an opportunity is being lost to introduce improvements in the assembly process, namely less use of toxic substances in both the production and assembly processes and in the materials incorporated into the assembled product. The consequences of a failure to do so are negative for the health of workers in such maquiladoras and for the competitiveness of their assembled products in the markets of developed countries. This is so since recent technological innovations are strongly influenced by the new environmental standards. In these circumstances, electronics products assembled in Mexico could be increasingly directed towards "second-tier" markets, in environmental terms, and thus excluded from higher value added and more competitive niches.

At the same time, due to the lack of a policy specifically designed for this sector and its ever-growing lag behind international standards, Mexico is also missing the opportunity to avoid environmental problems of its own. Such problems will necessarily arise as solid wastes accumulate from the country's own computers and television sets, in the absence of regulations on the full protection of the environment in relation to these products over their entire life cycle.

Finally, it is worth observing that in a context of slow or non-existent world economic growth, generalized trade liberalization, and the strengthening of competitors (such as China) in the international race to attract investments for maquiladora-type production, one could conclude that these are reasons *not* to broaden environmental standards and their application—when in fact this is precisely the right moment to elaborate a more explicit environmental policy with respect to this industry. Developing such a policy would foreclose the temptation on the part of the existing maquiladora sector in Mexico benefit from comparative advantages based on a lax environmental policy. This path would lead to increasingly lag behind industry leaders at the international level, hence, to missing an opportunity to become a key-piece in that particular niche's production chain. Perhaps, by introducing more advanced environmental measures and policies that help capacity building, Mexico could instead reposition itself at the international level within a more modern, higher added value, and cleaner electronics industry.

BIBLIOGRAPHY

Bureau of the Census (2001), *Statistical Abstract of the United Status: 2000; The National Data Book*, Washington, D.C.

Carrillo, Jorge, Humberto García and Ridi Gomis (2003), “Desempeño ambiental y evolución productiva en la industria maquiladora de exportación”, Project: Aprendizaje tecnológico y escalamiento industrial, Mexico City, April.

CESPEDES/CCE (Centro de Estudios del Sector Privado para el Desarrollo Sustentable/ Consejo Coordinador Empresarial) (2001), *Infraestructura ambiental: necesidades; alianza público/privada*, Mexico City.

COLEF (Colegio de la Frontera Norte) (2002), “Encuesta aprendizaje tecnológico y escalamiento industrial en plantas maquiladoras”, Department of Social Studies, Tijuana, Mexico.

Commission for Environmental Cooperation ,NAFTA, http://www.cec.org

Dussel, E. (2003), “La industria electrónica en México y en Jalisco”*, La industria electrónica en México: problemática, perspectivas y propuestas*, E. Dussel Peters, J. J. Palacios Lara y G. Woo Gómez (coords.), Guadalajara, Universidad of Guadalajara, Mexico.

Environmental Protection Agency (EPA) (2001), “Greening your purchase of electronics”, *Environmentally Preferable Purchasing Guide,* http://ww.epa.gov/oppt/epp December.

GAO (United States General Accounting Office) (2003), *Mexico’s Maquiladora Decline Affects U.S. Mexico Border Communities and Trade; Recovery depends in part on Mexico’s Action. International Trade, Report to Congressional Requesters* (GAO-03-891), Washington, D.C., July.

Green, William H. (2002), *Econometric Análisis*, Prentice Hall, 4th Edition, United States.

Gujarati, Damodar N. (1997), *Econometría básica*, 3rd Edition, McGraw-Hill.

INEGI (Instituto Nacional de Estadística, Geografía e Informática) (2002), *Programa para la competitividad de la industria electrónica y de alta tecnología*, Consejo para la Competitividad, Mexico City.

Journal of the Flagstaff Institute, varios números, The Flagstaff Institute, Arizona, United States.

Kenney, M. and J. Curry (2003), “Ganándole al reloj: la respuesta corporativa al cambio rápido en la industria de cómputo”, *La industria electrónica en México: problemática, perspectivas y propuestas*, E. Dussel Peters, J. J. Palacios Lara and G. Woo Gómez (coords.), Guadalajara, Universidad of Guadalajara, Mexico.

Kopinak, Kathryn (2003), “Maquiladora industrialization of the Baja California Peninsula: the coexistence of thick and thin globalization with economic regionalism”, *International Journal of Urban and Regional Research*, vol. 27, Nº 2.

_____ (2002), “Environmental implications of new Mexican industrial investment: the rise of Asian origin maquiladoras as generators of hazardous waste”, *Asian Journal of Latin America Studies*, vol. 15, Nº 1.

Low, P. and A. Yeats (1992), “Do dirty industries migrate?”, *International Trade and the Environment,* P. Low (ed.), World Bank Discussion Paper, Nº 159, Washington, D. C.

Lüthje, B. (2003), “Manufactura electrónica por contrato: Producción global y la división internacional del trabajo en la era de la Internet”, *La industria electrónica en México: problemática, perspectivas y propuestas*, E. Dussel Peters, J. J. Palacios Lara and G. Woo Gómez (coords.), Guadalajara, Universidad of Guadalajara, Mexico.

Microelectronics and Computer Technology Corporation (MCC) (1994), *Electronics Industry Environmental Roadmap*, Washington, D.C., Environment Protection Agency (EPA), and U.S. Department of Energy.

Mercado, Alfonso (2000), “El comportamiento de las maquiladoras con respecto al cumplimiento de las normas ambientales”, El Colegio de México and El Colegio de la Frontera Norte, October.

Montalvo, C. (2002), “Challenges for Cleaner Production in International Manufacturing Subcontracting: the Case of the Maquila Industry in Northern Mexico”, document presented at the International Workshop “Industrial Innovation and Environment Regulation: Towards an Integrated Approach”, Maastricht, University of the United Nations, October.

New Environmentalism, http://www.newenvironmentalism.org/ecology2.cfm?ID=36

PCWorld, http://www.pcworld.com.ve/n23/articulos/monitores.html

Romo Murillo, David (2002), “Foreign Direct Investment in the Mexican Industry: Spillovers and the Development of Technological capabilities”, PhD Thesis, Princeton University.

Salazar, Chito (1998), “Semi Conductors from the Philippines”, document presented at tha Conference “Global Product Chains: Northern Consumers, Southern Producers, and Sustainability”, Asian Institute of Management, Philippines, mimeo.

Schatan, Roberto (2004), *La maquiladora de exportación en México, recesión, impuestos y apoyos fiscales*, Mimeo.

SEMARNAP (Secretaría del Medio Ambiente, Recursos Naturales y Pesca) (2000), *Informe 1995-2000*, Mexico City.

SEMARNAT (Secretaría del Medio Ambiente, Recursos Naturales) (2003), *Informe Anual PROFEPA, 2002,* Mexico City.

Von Moltke K. and O. Kuik (1998), *Global Product Chains and the Environment* (2-26-98), United Nations Environmental Program (UNEP.)

Annex

Table A-1

VARIABLES IN THE LOGIT MODEL

Independent Variables	Posible values
Sector	1 if the plant is an electronic maquiladora and 0 otherwise
Age	The number of years that the plant has been in operation
Sizew	The number of employees the corporation has world-wide
Sizem	The number of employees the corporation has in Mexico
Capital	1 when USA is the country of origin of the controlling interest (over 51% of total ownership), 2 when it is Japan, 3 when it is Europe, 4 when it is Mexico and 5 when it is Asia
Headoff	1 when USA is the country where the plan's head office is located, 2 when it is Asia and 0 otherwise
Supp	1 when USA and Canada are the countries where the main suppliers of raw materials, inputs and components are located, 2 when they are located in Asia, 3 when they are in the same city as the plant and 4 when they are in any other part of Mexico but not the same city as the plant
Compet	1 when the principal competitors are located in the same city as the plant, 2 when they are in Mexico but not the same city as the plant, 3 when they are in another country and 0 otherwise
Certific	1 if the maquiladora plant has been quality certified, i.e., is ISO9001 or ISO9002 certified, and 0 otherwise
Assem	1 if the plant does finished products assembly activity and 0 otherwise
Prodep	1 if a production department exists in the plant and 0 otherwise
Envdep	1 if an environmental policy department exists in the plant and 0 otherwise
Assinn	1 if the head office provides to the plant technical assistance with respect to innovation and patents, and 0 otherwise
Asspurch	1 if the head office provides to the plant technical assistance with respect to components purchasing, and 0 otherwise

Discrete Dependent Variable: Whether a plant adopts an active environmental policy or not

	Regressions							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Independent Variables								
SECTOR	0.564	0.650	-0.012	0.319	0.889	0.857	0.389	0.857
z-Statistic	1.001	1.222	-0.022	0.615	1.995	1.985	0.910	1.985
Prob.	0.317	0.222	0.982	0.539	0.046	0.047	0.363	0.047
AGE	0.074	0.079	0.028	0.036	0.043	0.044	0.008	0.044
z-Statistic	1.996	2.202	0.875	1.088	1.538	1.603	0.315	1.603
Prob.	0.046	0.028	0.381	0.277	0.124	0.109	0.753	0.109
SIZEW	0.000	0.000	0.000	0.000				
z-Statistic	2.040	1.834	1.753	1.581				
Prob.	0.041	0.067	0.080	0.114				
SIZEM					0.000	0.000	0.000	0.000
z-Statistic					1.494	1.483	1.199	1.483
Prob.					0.135	0.138	0.231	0.138
CAPITAL	0.094	0.067	0.069	0.009	-0.033	-0.023	-0.053	-0.023
z-Statistic	0.482	0.349	0.369	0.049	-0.220	-0.152	-0.353	-0.152
Prob.	0.630	0.727	0.712	0.961	0.826	0.879	0.724	0.879
HEADOFF	0.334	0.422	-0.434	-0.179	0.253	0.287	-0.316	0.287
z-Statistic	0.649	0.877	-1.050	-0.433	0.632	0.732	-0.911	0.732
Prob.	0.516	0.381	0.294	0.665	0.527	0.464	0.362	0.464
SUPP	-0.054	-0.150	-0.432	-0.378	-0.034	-0.077	-0.310	-0.077
z-Statistic	-0.155	-0.469	-1.287	-1.243	-0.127	-0.300	-1.217	-0.300
Prob.	0.877	0.639	0.198	0.214	0.899	0.764	0.224	0.764
COMPET	-0.007	0.002	-0.291	-0.262	-0.158	-0.104	-0.363	-0.104
z-Statistic	-0.029	0.008	-1.293	-1.188	-0.814	-0.549	-1.969	-0.549
Prob.	0.977	0.993	0.196	0.235	0.416	0.583	0.049	0.583

CERTIFIC	1.137	1.120	0.967	1.118	1.059	1.037	0.876	1.037
z-Statistic	2.300	2.381	2.026	2.356	2.845	2.837	2.340	2.837
Prob.	0.021	0.017	0.043	0.019	0.004	0.005	0.019	0.005
ASSEM	0.672	0.809	0.068	0.454	0.734	0.800	0.370	0.800
z-Statistic	1.333	1.665	0.149	0.985	1.907	2.108	1.015	2.108
Prob.	0.183	0.096	0.881	0.325	0.057	0.035	0.310	0.035
PRODEP	-3.384	-2.564			-2.295	-1.912		-1.912
z-Statistic	-2.838	-2.278			-2.620	-2.138		-2.138
Prob.	0.005	0.023			0.009	0.033		0.033
ENVDEP			0.614	0.988			0.990	
z-Statistic			1.240	1.996			2.536	
Prob.			0.215	0.046			0.011	
ASSINN	1.341		1.042		0.791		0.570	
z-Statistic	2.839		2.321		2.205		1.607	
Prob.	0.005		0.020		0.028		0.108	
ASSPURCH		-0.413		-1.004		-0.186		-0.186
z-Statistic		-0.786		-1.912		-0.471		-0.471
Prob.		0.432		0.056		0.638		0.638
				-	-	-	-	-
Log likelihood	-61.099	-61.099	-61.188	61.989	95.578	97.956	96.088	97.956
Num. Observ.	123	123	123	123	176	176	176	176