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Trade, Foreign Investment and the Environment: The Brazilian Experience

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The Working Group on Development and Environment in the Americas, founded in 2004, brings together economic researchers from several countries in the Americas who have carried out empirical studies of the social and environmental impacts of economic liberalization. The Working Group's goal is to contribute empirical research and policy analysis to the ongoing policy debates on national economic development strategies and international trade. The Working Group held its inaugural meeting in Brasilia, March 29-30, 2004. This paper is one of eight written for the Brasilia meetings. They are the basis for "**Globalization and the Environment: Lessons from the Americas,"** a policy report published by the Heinrich Böll Foundation in July 2004.

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Introduction

The basis of Brazilian trade policies in the last decade has consistently been greater openness, both in commercial and financial terms. Some of the arguments in favor of these market-oriented policy reforms state that economic liberalization reduces static inefficiencies arising from resource misallocation and that economic liberalization enhances learning, technological change, and economic growth.[1] The objective is to deepen modernization and competitiveness of the production sectors in order to increase their participation in global markets.

Nevertheless, there are strong criticisms of the way these policies are being implemented in Brazil. The most conventional arguments are related to concerns about deindustrialization and a return to the stage of dependence on natural resource-based activities. The reversal of the trade balance and massive unemployment in the industrial sector observed in the mid-nineties are usually pointed to as negative consequences of the accelerated trade liberalization program. This issue is complex and is already receiving considerable attention by researchers.

But another crucial point has not yet penetrated the trade liberalization discussions in Brazil: the environmental consequences associated with freer trade. The theoretical debate over trade and environment is not new,[2] but its importance has increased substantially with the trade liberalization processes that have been taking place around the world. The hypotheses about the trade and environment link can be divided in two groups. On one side, there exists the possibility that countries with lower environmental standards would develop a comparative advantage in dirty industries. This is associated with the so-called pollution haven hypothesis.[3] From another perspective, there exists the possibility that imposing environmental controls and regulation in order to avoid the pollution intensive specialization, a country would create additional costs and thus lose competitiveness in world markets.[4]

This is the main focus of this research: if economic growth recovers with a strong component of export-led activities (as expected by policy experts in the government and in the international agencies), what are the long-term consequences of this strategy? Is expanding Brazilian exports (and production as a whole) compatible with the prevention of worsening pollution problems? On the other hand, what would be the economic costs of improving pollution control and other mitigation measures?

Therefore, this study will be divided in two parts. The first one will deal with the consequences of rising industrial output (particularly those associated with exports) for urban pollution. This section will examine the impact of greater openness to trade – proxied here by industrial exports – on the level of urban pollution. The methodology will be based on the use of input-output modeling techniques, whereby pollution emission coefficients are linked with industrial activities. The aim is to estimate the total amount of emissions required to obtain a specified industrial export volume (exogenously determined).

The second part of the study will emphasize the consequences of pollution control/mitigation costs for export competitiveness. This section will be an extension of the previous one. Given the impact of industrial exports on urban pollution, what would be the impact on external competitiveness of the adoption of pollution controls? The analyses will make use of a combination of (estimated) mitigation costs and price elasticities of the demand for industrial exports, also considering chain effects through input-output modeling. There will be, additionally, an effort to estimate employment impacts of pollution abatement expenditures.

2 Trade and the Environment in Brazil: A Historical Perspective

The deep distrust of the environmentalist movement about the consequences of increasing openness is strongly related to the role played thus far by foreign markets in Brazilian history. The 500 years since the arrival of the Portuguese in Brazil (22 April 1500) has been dominated by environmental degradation caused directly or indirectly by trade relations. The early occupation of the colony was already determined by trade, and even the name of the country was after a commodity: the once upon abundant pau-*brasil* tree (*Caesalpinia echinata*), which was highly demanded in European markets as a source of red tincture used to color fabrics. The depletion was so accelerated that, in less than 60 years after discovery, the best reserves could only be found 20 km away of the shore (Bueno, 1998). In the first century after discovery, an estimated 2 million trees were cut down and shipped to Europe, and by 1605, growing scarcity led the Portuguese Crown to ask for action against unplanned logging, and forest rangers were distributed along the Brazilian coast (Bueno, 1998). Not surprisingly, the *pau-brasil* tree became almost extinct in Brazilian native forests.

The other economic cycles during colonial times were also dominated by the overexploitation of natural resources in order to provide goods to be shipped abroad – the main purpose of the colony was to profit via trading commodities based on the abundant natural resources (Furtado 1959). The sugarcane cycle in the Northeast and Southeast, which took place in the first two centuries of Portuguese settlement, was the first wave of massive destruction of the Atlantic rainforest (*Mata Atlântica*). There were two reasons why forests were endangered: demand for agricultural land and for timber and fuelwood. The technological pattern used by the Portuguese (and the Dutch, during their brief occupation of the sugarcane plantations in the Northeast) in the processing of sugar was not very different from the one that resulted in the total depletion of native forests in the Madeira island.[5]

In the XVII and XVIII centuries, the gold cycle in Minas Gerais and other interior parts of the country resulted not only in the quick exhaustion of reserves (which lasted less than two centuries), but also in considerable damage to the environment caused by mining techniques. Changing the natural courses of rivers became a common practice to search for gold, and an even more harmful technique was to deviate the river flow against its margins, “washing” the embankments to reveal the precious ore (Dean 1996). Cattle raising was not directly connected to trade relations with Europe, but was indirectly encouraged by them, as the rising demand for meat in the mining areas established cattle migration routes and increased the pressure for overgrazing, which has seriously damaged natural pasture areas, particularly in the interior of the Northeast.

Another crucial element in the economic formation of Brazil was slavery. The development of international trade routes, followed by the industrial revolution, cannot be dissociated from the triangular trade between Europe, Africa and the Americas, even though this issue is usually neglected in the current debate, which tends to forget this tragic consequence of the development of international trade routes in the past. Brazil was the place which received the highest number of Africans, and almost four centuries of slavery has brought scars that are yet to be healed, including the deepest social inequality in the Western world. Slaves were an essential part of the sugarcane production, the mining of gold and other precious ores, and almost any other commodities produced for foreign markets (such as tobacco and cotton).

Independence did not change this pattern, and coffee plantations were a main driver of the Imperial economy. This new commodity was again destined for foreign markets (this time without the interference of the metropolis, with the increasing importance of the British Empire and the United States as trade partners) and the rising exports were accomplished through the massive destruction of the Mata Atlântica. The State of Rio de Janeiro was the first one to suffer the invasion of coffee plantations: Dean (1996) estimated that around 18% of the total area of the state was cleared for coffee plantations, employing around 140,000 slaves. However, the unsustainable practices led to the fast decline of production, up to its complete eradication. At present, most of these areas in the state of Rio de Janeiro are used for cattle raising with very low productivity.

Slavery was abolished only in 1888 and, not by coincidence, one year after the Republic was proclaimed. However, the expansion of coffee exports at the expense of clearing native rainforests was not disturbed by this change. Using migrants from Southern Europe (mainly Italians), coffee remained the main economic factor in Brazil until the world recession during the 1930s. The more appropriate soils in the State of São Paulo (*terra roxa*) and less erosive practices have resulted in more permanent cultivation, but the clearing of forest areas remained the main means of output expansion. The wave of forest clearing has also migrated to the states of Paraná and (Southern) Minas Gerais. The final balance of this and other forest-consuming activities (such as charcoal production in Minas Gerais, and pulp and paper production in Paraná and Santa Catarina) is the reduction of the Mata Atlântica to less than 7% of its original area.

One exception of this trend was the natural rubber boom in the Amazon in the late 19th century and early 20th century. This was an important economic cycle directed to foreign markets that was based in extractive practices with little harm to the environment (since the trees are not destroyed during the latex extraction). Unfortunately, this mostly sustainable activity could not face the competition of rubber tree plantations in Southeastern Asia (which have had important deforestation consequences in these regions), and the decline in production has resulted in the paradoxical situation of Brazil currently being a net importer of natural rubber.

The 1930s crisis represented an important change in policy making in Brazil. So far, all major economic relations were oriented towards foreign markets, and there was little integration of activities aiming at domestic markets. Even the spatial distribution of the country was shaped according to the proximity to export ports. The economic dependence on the exports of a natural commodity resulted in a cycle of crisis, caused by falling prices in external markets when supply increased over demand, which usually happened after a period of boom when prices had previously gone up. Therefore, in the 1940s and, especially in the 1950s, a new strategy of growth was adopted, based on the idea that Brazil (as other developing countries) would have to increase its participation in the global markets as a supplier of industrialized goods. Otherwise it would become permanently relegated to a second-class position. This strategy was heavily influenced by the so-called Latin American Structuralist school, following the pioneering studies of Raúl Prebisch, which has shown that an outward-oriented economy based on primary goods (and, therefore, not incorporating the benefits of technical progress) would never develop to its full potential.[6] A new pattern of development was required, in which industrialization would become the main objective.

The golden age of industrialization in Brazil (1950s, 1960s and 1970s) resulted in rapid economic growth and structural changes in the productive structure. Nevertheless, the social and environmental consequences of this process were far from desirable. There is already a considerable number of studies on social exclusion in the Brazilian industrialization process, but the consequences for the environment are yet to be researched in detail. The expansion of industrial activities was not followed by the establishment of pollution control authorities: the first environmental agency (FEEMA, in the State of Rio de Janeiro) was created only in 1977, when the industrialization process was already losing its momentum and the rates of investment and output growth rates were declining from their historical averages. Indeed, the first effective national environmental law was created only in 1981. The pollution consequences of this lack of standards and mitigation procedures were dramatic, as exemplified by the tragedy of Cubatão industrial area (in the state of São Paulo).[7] Therefore, the shift towards more inward-oriented development did not result in improvements in the environmental area.

One common misunderstanding is the belief that, during the import-substitution process, export-oriented policies were not important. In fact, exports played a major role in financing the industrialization process, which was intensive in imports, particularly machinery and intermediate inputs. For instance, the II National Development Program (1975-79), a crucial stage in completing the industrial structure, included among its main targets the expansion of export capacity in intermediate goods, such as metallurgy, petrochemicals, and pulp and paper. Providing fiscal and credit incentives to these sectors, characterized by their high consumption intensity of energy and other natural resources, has created a pattern of high emission activities that has considerably affected the Brazilian industrial export capacity. The environmental consequences of this shift in the export structure towards more energy (and pollution) intensive goods will be discussed in this study.

An important shift towards trade liberalization and privatization has occurred in the 1990s. Import barriers were lifted, there were legal changes in order to ease foreign investment, and the process of economic integration within the South American free trade agreement (Mercosul) gained speed. The impact of these measures has been concentrated mainly in deregulation and the increase of imports, particularly as a result of the overvaluation of the exchange rate after the Real economic plan (1994).

Measured in terms of proportion to the GDP, there was no significant improvement in the export level, or the sum of exports and imports. But other changes can be more easily identified: industrial output increased, but industrial employment fell. The environmental changes associated with these transformations are analyzed in the following sections.

In summary, the environmentalist's position is strongly influenced by the past and present consequences of international trade in Brazilian history, which has plenty of examples of how natural resource depletion and degradation were a hidden cost of increasing exports. Therefore, they tend to be very skeptical about the argument that the future is not necessarily a reproduction of the past and that, under certain ideal conditions (full implementation of property rights in order to resolve market failures, and the correction of public policies that encourage the overexploitation of natural resources), improvements in trade relations will not represent an additional threat to the environment. Indeed, they tend to consider that implementation of these policy reforms is either unrealistic under the social and political structure of Brazil, or, even worse, they would result in further harm to the environment, since the economic groups that tend to benefit from trade expansion are not concerned with the social and environmental damages caused by it. Nevertheless, their refusal to accept both the outward-looking model imposed by globalization and the inward-looking economic growth experienced in the industrialization period (also harmful to the environment) has not yet been accompanied by feasible policy suggestions.

3 The Environmental Debate in the Economic Literature

If the environmentalist movement (and NGOs in general) have shown deep concern about the consequences of trade for the environment because of ideological positions (mostly motivated by historical events), part of the economic literature on the subject tends to present the opposite vision. The most important arguments presented by those who defend the positive environmental aspects of international trade are that higher competition would close down companies operating with old and inefficient equipment. These are the companies with higher probability of being environmentally harmful, either because of old machinery/technology or wastefulness in their production processes. A more competitive atmosphere would force them to adopt modern ways of production, which tend to be more efficient in all aspects, including those relating to the environment (in terms of emission avoidance and raw materials savings).

Eliminating subsidies or other incentives for energy-intensive sectors are an incentive to reduce energy consumption and, therefore, emissions and pollution. These sectors tend also to be capital intensive, and according to the theory of comparative advantages, free trade policies would favor a shift in developing countries towards labor-intensive activities, which tend to be less polluting.

The reduction of trade barriers would favor the imports of modern, state-of-the-art equipment. Since this machinery is developed to follow the tough environmental standards of developed countries, the acquisition of this equipment results in an overall improvement of the environmental performance of the importing country.

Consumers in developed countries are showing growing concern about the environmental standards of products they buy. This is forcing the adoption of environmentally friendly production patterns, certified by green labels, for those willing to export to these markets. Because of the demonstration effect, this behavior also ends up being adopted by producers aiming at domestic markets, and local consumers become more aware of the environmental implications of the production and consumption of the products they buy.

To understand the differences between those who object to trade and those who do not, it is crucial to bear in mind that most of these analytical studies are not based on historical analysis, but rather are deeply rooted in theoretical arguments derived from idealized models of reality (which, again, are strongly related to ideological positions). The recent document issued by the World Trade Organization (WTO 2000) is a good example of the belief that, under "ideal" circumstances, promoting free market is always the best policy:

"In the best of all worlds, governments would use proper environmental policies to 'internalize' the full environmental costs of production and consumption – the 'Polluter Pays Principle'. . . . In this idealized world, trade liberalization would unambiguously raise welfare" (WTO 2000, p.2)

Hence, the "conclusion" of this argument is simply a consequence of the fact that problems are eliminated by construction of any idealized world according to the beliefs of whatever ideology – including the one behind the free market. The "ideal world" is considered to be perfect exactly because it is the best application of that set of beliefs.[8] Nevertheless, this kind of argument is repeatedly used by governments and multilateral development agencies in their justification to deepen reforms towards more openness (for a critical analysis of the environmental consequences of adjustment policies, see Young 1997). Once problems are identified with the implementation of reform policies, it is usually considered not a fault of the policy itself but a "failure" of the real economy, in the sense that it does not behave according to the "perfect" world proposed by theory. The answer is that even more reforms are needed in a way to turn the real world "more perfect" – i.e., closer to the idealized theoretical model.

Nevertheless, once more realistic assumptions are considered, even neoclassical theoretical models present results showing that improving trade relations may result in damages to the environment. Three counter-arguments are commonly used to justify a change in the current regulatory framework concerning international trade that disallowed restrictions justified by environmental factors (WTO 2000):

1. The legal argument: the existing rules provide legal cover for foreign countries to challenge domestic environmental policies that interfere with their trading rights.

2. The political economy argument: the competitive pressure from the world market sometimes makes it impossible to forge the necessary political support at home to upgrade environmental standards.

3. The market failure argument: in the existing institutional conditions of developing countries, international trade may magnify the effects of poor environmental policies in the world (increasing the tendencies of overexploitation of natural resources). Or, in more general terms, that economic growth driven by trade may speed up the process of environmental degradation unless environmental safeguards are put in place.

The basic assumption of these arguments is that environmental standards are weaker in developing countries, stimulating the migration of pollution-intensive industries to such countries (for a review of these arguments, see Leonard, 1988, and Weil *et al*., 1990). Empirical evidence shows that polluting industries have in fact expanded faster in developing countries than the average rate for all industries (Lucas *et al*., 1992; Low and Yeats, 1992). However, the evidence is not clear about the existence of a migration process of dirtier industries from developed countries. Using trade and investment figures for US-based industries, Leonard (1988) concludes that, taken in the aggregate, the years immediately following the emergence of stringent environmental regulations in the United States did not witness widespread reallocation of pollution-intensive industries to countries with drastically lower regulatory requirements. Pollution abatement and control expenditures seem not to have significant effects on competitiveness in most industries, since they are small in comparison with total costs. Other reasons can be listed (Low, 1992), such as the fear of liability in the event of an accident; the reputation damages in the originating countries if it happens; the costs of 'unbundling' technology; potential claims of environmentally concerned consumers in export markets; expectations of more stringent local environmental standards in the future; and the relatively high costs of retrofitting aging capital equipment instead of starting up with 'top of the line' equipment. It has been observed empirically that open developing economies became less pollution intensive than closed economies in the 1970s and 1980s (Lucas *et al*., 1992; Birdsall and Wheeler, 1992).

This lack of a definitive answer to these opposing arguments is consistent with the results of recent surveys of theoretical models dealing with the issue (Ulph 1998):

> The literature has been timely in that the issue (the link between environmental policy and international trade) has been one of considerable public debate, and the literature has been well placed to address some of the issues raised by that debate, since the literature has focused on imperfect competition and the potential scope for governments to manipulate environmental policy for strategic reasons. I have shown that this recent analysis is capable of providing starkly different predictions of environmental policy under liberalized trade regimes from those derived from the traditional literature, but there is a severe problem of non-robustness of results. This is especially problematic when it comes to trying to draw policy conclusions from this new literature, although the analysis does not support some of the policy prescription discussed in popular debates (Ulph 1998, p.237-238).

The need for empirical findings is common ground in all studies which reject *a priori* statements such as “trade is good” or “trade is bad” for the environment – there is a strong need to improve our understanding of these links in the real economy. This is main the objective of the following sections: to provide a systematic empirical analysis of the link between international trade (more precisely, industrial exports) and the environment in recent decades in Brazil, in order to contribute to policymaking in the future.

The overall conclusion is that both sides of the debate are partially correct, in the sense they have considered only part of the whole process: trade reforms may, at the same time, improve and worsen environmental conditions. The main message for public policymaking is, therefore, that neither blocking trade relations nor *laissez-faire* policies are appropriate for improving environmental conditions in developing countries (or at least in Brazil). Trade is an important source of effective demand and employment generation, but there are important failures to be considered and corrected. The tendency of specialization in resource-intensive activities, empirically observed in Latin America for a long time (and the basis of the structuralist approach), results in higher than average emission coefficients in the export sector. On the other hand, the higher pressure for environmental standards imposed by some OECD consumer markets, plus a more environmentally friendly behavior by companies of global insertion, leads to a counter-effect of disseminating environmental innovations in the productive structure.

The question is how to reduce the first trend and accelerate the second one. The encouragement and diffusion of environmental innovations and a wider comprehension of the social dimensions of the pollution problem, coupled with the elimination of policy failures that encourage the establishment of pollution-intensive industries (an issue particularly important in the recent "fiscal war" among Brazilian states, which offer all kinds of subsidies and incentives to attract investments) are among the policy options to be pursued.

4 Industrial Emission Model

Input-output model

The objective of the input-output model is to describe the interdependence of the economy, given the current levels of production and consumption. Assuming that all the (*n*) sectors of an economy keep a constant share in the market of each product, and that the production processes of all these sectors are technologically interdependent and characterized by a linear relation between the amount of inputs required and the final output of each sector, it is possible to obtain a system containing *n* equations relating the output of every sector to the output of all other sectors. The model also considers an autonomous sector (final demand) which is determined exogenously to the model. The sales of each sector should be equal to autonomous consumption (related to the categories of final demand) plus the amount of production destined to the intermediate consumption of all the other sectors (Dorfman, 1954).

In formal terms:

$$x_i = \sum_{i=1}^{n} x_{ij} + C_i + I + G_i + E_i - M_i \qquad (1)$$

where x_{ij} is the amount of output from sector i demanded as intermediate consumption to sector j, and C_i, I_i, G_i, E_i, M_i and x_i are, respectively, the private consumption, investment, public administration consumption, exports, imports, and domestic production of sector i (Prado, 1981).

The basic assumption is that the intermediate consumption is a fixed proportion of the total output of each product:

$$x_i = \sum_{j=1}^{n} a_{ij} \cdot x_j + d_i \qquad (2)$$

where a_{ij} is the technical coefficient determining the amount of product of sector i required for the production of one unit of product in sector j, and d_i is the amount of final demand for products from sector i ($d_i = C_i + I_i + G_i + E_i - M_i$). In matrix terms, this is expressed by:

$$x = Ax + d \qquad (3)$$

Where x is a nx1 vector with the total product of each sector, d is a nx1 vector with sector final demand, and A is a nxn matrix with the technical coefficients of production.

Since the final demand is exogenously determined, the intermediate consumption can be obtained by the following equation:

$$x = (I - A)^{-1} d \qquad (4)$$

Where $(I - A)^{-1}$ is the nxn matrix containing the input-output coefficients for the relations between sectors.

The same formula is valid for calculating the direct and indirect effects of exports or any other component of the final demand, instead of its aggregate:

$$x_f = (I - A)^{-1} d_f \qquad (5)$$

Where x_f is the nx1 vector containing the total production per sector necessary to obtain the nx1 vector of the f-category of final demand (d_f).

Therefore, the input-output model allows the determination of the level of economic activity in each productive sector as a function of the final demand for each product.

Introducing Emission Coefficients

The use of extended input-output tables to estimate emissions and other discharges of residuals has become an important instrument to assess environmental problems at the macroeconomic level (for a review, see Førsund, 1985; the methodology adopted in this section is based on Pedersen, 1993). The most common procedure is to assume that emissions are linearly related to the gross output of each sector, in a way that each industry generates residuals in fixed proportions to the sector output. The emission coefficient of pollutant h by sector i (ef_{hi}) can be obtained by dividing the total emission of a sector (em_i) by the total output of the same sector (x_i):

$$ef_{hi} = \frac{em_{hi}}{x_i} \qquad (6)$$

Given this assumption, it is possible to obtain the total emission caused by the f-category of final demand through the use of emission coefficients for each sector. In formal terms, this is expressed by:

$$z_{hf} = diag(ef_h) \cdot x_f = diag(ef_h) \cdot (I - A)^{-1} d_f \qquad (7)$$

Where z_{hf} is the nx1 vector containing the total emission of pollutant h per sector associated to the f-category of final demand, and $diag(ef_h)$ is the nxn matrix containing in its principal diagonal the emission factors of pollutant h for each sector, and zeroes elsewhere (Pedersen, 1993).

Measuring the Composition Effect

It is possible to disaggregate the changes in the emission pattern of the industry in three different effects:

a) Scale effect: refers to changes in emissions caused by the changes in the overall output level caused by the expansion (or retraction) of activities associated with more exposure to the world economy.

b) Composition effect: refers changes in emissions caused by the industrial restructuring that takes place because of that higher exposure to the world market. In other words, the composition effect considers the change in emissions because some sectors have their share increased in the economy's total output, while others have it reduced.

c) Technology (or technique) effect: refers to changes in emissions caused by innovations introduced because of the openness of the economy.

The input-output model allows the identification of the scale and composition effects, but the technology effect cannot be captured because of the use of fixed emission coefficients. In analytical terms, the argument of specialization in "dirty" activities is usually associated with the composition effect. The composition effect occurs when the proportion of emissions directly or indirectly associated with exports in relation to the total emissions exceeds the ratio between the value of production associated with exports and the total value of production of the economy. In formal terms:

$$\frac{[1]_{1\times n}(I - A)^{-1} d_x}{[1]_{1\times n}(I - A)^{-1} d} < \frac{[1]_{1\times n}\, diag(e_h).(I - A)^{-1} d_x}{[1]_{1\times n}\, diag(e_h).(I - A)^{-1} d} \qquad (8)$$

where:

$[1]_{1xn}$ is a line-vector with the number 1 in every cell; n is the number of sectors in the economy; $(I-A)^{-1}$ is the nxn Leontief inverse matrix; $diag(ef_h)$ is the nxn diagonal matrix containing the emission factors of pollutant h for each sector, and zeroes elsewhere (obtained in equation); d_x is the vector containing the exports of each of the n sectors; d is the vector containing the final demand of each of the n sectors.

The left side of expression (8) represents the proportion of the output directly and indirectly required by the exports compared to the total output, and the right side represents the emissions of pollutant h directly or indirectly caused by exports divided by the total emissions of this pollutant. If the right side is bigger than the left side, the composition of goods destined to foreign markets is more intensive in emissions of pollutant h than the average of the economy.

5 Application to Brazil

This section describes the procedures used to estimate equation (7) for the Brazilian economy, combining the input-output tables (42x42 activities) prepared by the Brazilian Institute of Geography and Statistics (IBGE) and four different sets of emission coefficients, for local and global pollutants. The objective is to empirically test the hypothesis of a composition effect in the sense that Brazilian industrial exports are specialized in relatively dirty activities if compared to the production destined for the domestic market.

The IPEA Emission Coefficients (Local Pollutants)

The first set of emission coefficients (for local pollutants) was calculated using the results from empirical studies carried out by the Environmental Economics Research Division at IPEA (Serôa da Motta *et al.*, 1993; Mendes, 1994; Serôa da Motta, 1993a, 1993b, 1996). These studies estimated the effectiveness of abatement policy and the status of current water and air industrial pollution in Brazil, based on indicators of water and air quality for 13 states where systematic monitoring is undertaken.[9] This database was built using pollution emission and abatement estimates for the year 1988 according to a World Bank funded project denominated PRONACOP (Brazilian National Program of Pollution Control), covering 12 states, plus similar information for the state of São Paulo for the year 1991, using data from the state's environmental agency (CETESB). The parameters considered were biochemical oxygen demand (BOD) and heavy metals for water pollution, and particulate matter, sulfur dioxide (SO_2), nitrogen oxides (NO_x), and hydrocarbons (HC) for air pollution.

The estimates of potential emissions were obtained by multiplying the potential output of every industrial establishment registered at the respective state environmental agency by emission parameters obtained from the technical literature (taken mostly from the World Health Organization). These potential pollution emissions were considered as a measure of the level of pollutant emitted by the industrial establishment without any treatment.

The second stage was to estimate the level of remaining emissions (potential emissions minus abatement capacity), considered a better proxy for the effective level of industrial emissions. The pollution treatment capacity of every industrial unit was calculated according to the potential for emission treatment at the source points (i.e. every industrial establishment registered in the database). The indicators of (remaining) emissions were then divided by the value added of the respective industrial sectors, at the state level, in order to produce the emission intensity coefficients (for more details, see Mendes 1994).[10] Tables 1 and 2 present the average values for the 13 states.

Table 1: Water pollution: potential and remaining emission intensity coefficients, by industrial sector (g/US$ of value added), IPEA

Industrial sector	Biochem. Oxygen Demand		Heavy Metals	
	Potential	***Remaining***	***Potential***	***Remaining***
Metallurgy	**1.12**	**0.04**	**1.73**	**0.85**
Mechanical	**0.73**	**0.60**	**0.16**	**0.07**
Transport equipment	**0.49**	**0.18**	**0.13**	**0.05**
Wood products	**19.83**	**8.82**	**0.00**	**0.00**
Paper & cellulose	**37.35**	**12.91**	**0.00**	**0.00**
Chemicals	**86.85**	**16.15**	**0.03**	**0.03**
Drugs & medicine	**2.25**	**1.47**	**0.00**	**0.00**
Cosmetics & soap	**7.02**	**4.58**	**0.00**	**0.00**
Textiles	**7.11**	**4.40**	**0.00**	**0.00**
Leather & footwear	**45.36**	**21.69**	**1.84**	**0.76**
Food products	**27.96**	**11.31**	**0.00**	**0.00**
Beverages	**105.11**	**40.98**	**0.00**	**0.00**
Source: Mendes (1994)				

Table 2: Air pollution: potential and remaining emission intensity coefficients, by industrial sector (g/US$ of value added), IPEA

	Partic. matter		SO_2		NO_X		HC	
Sectors	***Potential***	***Remaining***	***Potential***	***Remaining***	***Potential***	***Remaining***	***Potential***	***Remaining***
Non-metallic minerals	**689.1**	**261.4**	**51.2**	**51.0**	**10.9**	**10.9**	**0.2**	**0.2**
Metallurgy	**247.0**	**111.4**	**50.7**	**50.7**	**17.2**	**17.2**	**6.2**	**6.2**
Mechanics	**5.8**	**1.1**	**1.3**	**1.3**	**0.1**	**0.1**	**2.0**	**2.0**
Electric materials	**0.4**	**0.1**	**0.2**	**0.2**	**0.0**	**0.0**	**2.2**	**1.6**
Transport equip.	**0.4**	**0.1**	**0.2**	**0.1**	**0.0**	**0.0**	**0.6**	**0.5**
Wood products	**42.2**	**42.1**	**2.5**	**2.5**	**9.7**	**9.7**	**2.9**	**2.9**

Paper & cellulose	**133.8**	**28.2**	**16.0**	**15.8**	**32.5**	**32.5**	**0.7**	**0.7**
Rubber products	**0.4**	**0.4**	**3.3**	**3.3**	**0.5**	**0.5**	**0.1**	**0.1**
Chemicals	**41.4**	**18.3**	**61.4**	**59.9**	**45.7**	**45.6**	**38.8**	**18.4**
Drugs & medicine	**0.4**	**0.4**	**2.0**	**1.9**	**5.5**	**5.5**	**0.1**	**0.1**
Domestics & soap	**8.8**	**4.5**	**32.3**	**32.3**	**2.9**	**2.9**	**0.1**	**0.1**
Textiles	**26.4**	**24.3**	**13.8**	**13.4**	**11.2**	**11.2**	**0.4**	**0.3**
Leather & footwear	**1.0**	**0.9**	**5.5**	**5.5**	**0.7**	**0.7**	**0.7**	**0.7**
Food products	**27.5**	**21.8**	**72.5**	**72.5**	**8.8**	**8.8**	**0.2**	**0.2**
Beverages	**68.1**	**58.2**	**35.7**	**35.7**	**17.4**	**17.4**	**0.4**	**0.4**
Source: Serôa da Motta et al. (1993)								

Table 3 presents the results of associating the above coefficients to the input-output tables, as stated in equation (7), in order to obtain (remaining) emission coefficients for each category of final demand.

Table 3: Pollution intensity per unit of output (kg/US$ Millions)

Parameter/year	Investment*	Exports	Public Consumption	Private Consumption	Total
BOD					
1985	**569**	**1420**	**361**	**1298**	**1043**
1990	**436**	**1292**	**277**	**1243**	**936**
1995	**453**	**1370**	**288**	**1116**	**861**
Metals (water)					
1985	**31**	**44**	**3**	**14**	**21**
1990	**24**	**50**	**3**	**13**	**17**
1995	**24**	**47**	**2**	**10**	**15**
Particulates (air)					
1985	**9364**	**7760**	**1296**	**4118**	**5553**
1990	**9390**	**8497**	**1041**	**3938**	**5035**

1995	**8232**	**8549**	**1034**	**3398**	**4441**
SO_2					
1985	**4146**	**6957**	**1134**	**4268**	**4278**
1990	**3520**	**6441**	**884**	**3983**	**3652**
1995	**3356**	**6442**	**855**	**3528**	**3298**
NO_X					
1985	**1878**	**3243**	**860**	**2011**	**2029**
1990	**1613**	**2969**	**646**	**1918**	**1763**
1995	**1574**	**3029**	**666**	**1672**	**1603**
HC					
1985	**674**	**1105**	**188**	**585**	**636**
1990	**575**	**974**	**148**	**554**	**537**
1995	**566**	**880**	**138**	**430**	**448**
CO					
1985	**40265**	**51294**	**4525**	**14781**	**24792**
1990	**32104**	**58715**	**3519**	**13318**	**20030**
1995	**31445**	**55460**	**3113**	**10899**	**17855**
* *Investment includes changes in stocks*					

For all pollutants analyzed, the amount of emissions required to produce one unit of export-related output exceeds the average of the economy. Indeed, the intensity of pollution is higher in export-related activities than in any other group for all but one parameter (particulates, in which exports are the second highest). In other words, exports are more pollution-intensive than the average of the economy for almost every pollutant considered.

In sector terms, it is clear that a few sectors account for most industrial water and air pollution. These 'dirty' industries are usually related directly or indirectly to export-oriented activities, such as metallurgy (input for the automobile industry and other industrial export goods), paper and cellulose, and footwear (leather products). The most important polluting industries are: chemicals, food products, and paper and cellulose for BOD; metallurgy for heavy metals; non-metallic minerals and metallurgy for particulate matter; chemicals, metallurgy and non-metallic minerals for SO_2; chemicals, metallurgy, paper and cellulose, and food products for NO_X; and chemicals for HC.

Table 4: Pollution intensity per unit of output (kg/US$ Millions)

Parameter/year	Investment*	Exports	Public Consumption	Private Consumption	Total
BOD					
1985	**569**	**1420**	**361**	**1298**	**1043**
1990	**436**	**1292**	**277**	**1243**	**936**
1995	**453**	**1370**	**288**	**1116**	**861**
Metals (water)					
1985	**31**	**44**	**3**	**14**	**21**
1990	**24**	**50**	**3**	**13**	**17**
1995	**24**	**47**	**2**	**10**	**15**
Particulates (air)					
1985	**9364**	**7760**	**1296**	**4118**	**5553**
1990	**9390**	**8497**	**1041**	**3938**	**5035**
1995	**8232**	**8549**	**1034**	**3398**	**4441**
SO_2					
1985	**4146**	**6957**	**1134**	**4268**	**4278**
1990	**3520**	**6441**	**884**	**3983**	**3652**
1995	**3356**	**6442**	**855**	**3528**	**3298**
NO_X					
1985	**1878**	**3243**	**860**	**2011**	**2029**
1990	**1613**	**2969**	**646**	**1918**	**1763**
1995	**1574**	**3029**	**666**	**1672**	**1603**
HC					
1985	**674**	**1105**	**188**	**585**	**636**
1990	**575**	**974**	**148**	**554**	**537**
1995	**566**	**880**	**138**	**430**	**448**

CO					
1985	**40265**	**51294**	**4525**	**14781**	**24792**
1990	**32104**	**58715**	**3519**	**13318**	**20030**
1995	**31445**	**55460**	**3113**	**10899**	**17855**
* *Investment includes changes in stocks*					

If the (fixed) emission coefficients estimated by IPEA with data for the Brazilian industry (for the 1988/91 period) are applied to a time series up to 1995, there is a clear trend of declining average intensity of emissions per unit of output for all parameters considered. This indicates that the composition of the Brazilian industrial output has changed towards less (potentially) polluting activities. However, the emissions intensity in the export complex for metals, particulates and CO would have increased, showing an increase in the dependence of Brazilian industrial exports in (potentially) dirty activities.

Note that it is important to bear in mind the many limitations involved in this approach. Among them, three are particularly important. First, the emission estimates were not obtained directly from observations of the quality of water and air at the emission points but indirectly, from the specifications of the industrial plants surveyed. However, the environmental impact of a specific pollutant is affected by many other variables that were not considered in the exercise.[11] Second, a linear relationship is assumed between value added and the level of emissions – it is possible that this relationship is far more complex. Third, only the establishments that were registered with the environmental agencies could be considered. It is possible that the total amounts of emission were underestimated. This point would be important in the case of sectors where a very large number of only marginally polluting establishments are responsible for a considerable amount of the total emissions.

IPPS Emission Coefficients (Local Pollutants)

Production and emissions data from 200,000 factories in the United States (1987) were merged to obtain estimates of sector pollution intensity (pollution per unit of activity), and used by the World Bank as the basis for the Industrial Pollution Projection System (IPPS). Although the estimates based on the IPPS are not actual emissions, they can be useful as a guideline in order to rank industrial sectors in terms of their potential emissions.[12]

The IPPS index expresses the pollutant output intensity for six types of air pollutants (SO_2, NO_2, CO, VOC, PM10, TP), three types of water pollution (BOD, TSS and metal) and metals disposed in landfills.[13] Pollution intensity is expressed as pollutant output divided by total manufacturing. The total manufacturing activity can me measured by many variables, but the main choice is between the value and the output quantity. Only industrial activities are covered.

The IPPS provides emission coefficients based on the value of production (shipment value), value added, or employment. Since the input-output coefficients usually refer to the first of these categories, the coefficients used in this exercise refer to emissions divided by the value of production. Additionally, it is very important to mention that the EPA data used to calculate the

IPPS coefficients only cover facilities releasing pollutants over a threshold level of emissions. Consequently, pollution intensities based on these data may be biased. In this study, it was decided that the *lower bound* coefficients were more appropriate to estimate the Brazilian industry environmental performance. These coefficients assume the hypothesis that non-reporting facilities had no emissions (i.e., they were assigned with zero emissions). Hence, there is an underestimation bias in the calculation of emissions using these coefficients.[14]

The use of IPPS coefficients in the estimate of Brazilian industrial emissions also assumes that there were no significant technical differences between the production sectors in both countries (at least in terms of average emissions per unit of output). Therefore, since the effective degree of emission treatment in Brazil is unknown, it is very likely that errors result from the application of the IPPS coefficients. Moreover, since the denominator is expressed in monetary terms (value of production), an additional assumption is that the relative price structures in both countries are the same, which is very unlikely to occur in real terms. Finally, there is the problem of translating the classification of IPPS coefficients to the IBGE input-output classification. The aggregation level of IPPS is the International Standard Industrial Classification (ISIC) level 4, more detailed than the classification level 80 adopted in the input-output tables of IBGE. This also includes the problem of non-equivalence in the translation of classifications, such as the lack of IPPS emission coefficients for the coffee industry (for which emission coefficients were considered to be zero) and alcohol processing (aggregated to sugar processing in the IPPS, but considered by IBGE together with chemical elements).

In summary, the results obtained through these coefficients (tables 5 to 13), must be examined with extreme caution because of the methodological problems described above and, as already warned, they can only be considered to be *potential* indicators of actual emissions (which are, in fact, unknown).

Table 5: Emission intensities: BOD, kg/US$ millions (1987), IPPS coefficients

Year	Consumption	Investment	Exports	Total
1985	**310**	**130**	**195**	**252**
1990	**315**	**126**	**245**	**265**
1991	**316**	**130**	**242**	**268**
1992	**316**	**118**	**235**	**265**
1993	**299**	**121**	**227**	**253**
1994	**287**	**117**	**244**	**246**
1995	**283**	**113**	**285**	**248**
1996	**285**	**125**	**276**	**253**

Table 6: Emission intensities: Total Suspended Solids, kg/US$ millions, IPPS coefficients

Year	Consumption	Investment	Exports	Total
1985	**3713**	**9587**	**11726**	**6368**
1990	**3771**	**8405**	**14368**	**6091**
1991	**3502**	**8095**	**14973**	**6094**
1992	**3354**	**8407**	**13893**	**6216**
1993	**3314**	**8599**	**13786**	**6158**
1994	**3520**	**8969**	**13187**	**6131**
1995	**3488**	**8428**	**12976**	**5781**
1996	**3507**	**8765**	**13202**	**5792**

Table 7: Emission intensities: SO_2, kg/US$ millions, IPPS coefficients

Year	Consumption	Investment	Exports	Total
1985	**1904**	**2871**	**3492**	**2389**
1990	**1977**	**2724**	**3817**	**2368**
1991	**1944**	**2762**	**3654**	**2356**
1992	**1915**	**2712**	**3498**	**2352**
1993	**1876**	**2758**	**3459**	**2322**
1994	**1884**	**2704**	**3538**	**2308**
1995	**1850**	**2558**	**3704**	**2244**
1996	**1853**	**2735**	**3678**	**2263**

Table 8: Emission intensities: NO_2, kg/US$ millions, IPPS coefficients

Year	Consumption	Investment	Exports	Total
1985	**1142**	**1339**	**1726**	**1287**
1990	**1210**	**1327**	**1663**	**1292**
1991	**1195**	**1354**	**1576**	**1283**
1992	**1197**	**1352**	**1536**	**1288**
1993	**1163**	**1343**	**1515**	**1259**
1994	**1159**	**1300**	**1543**	**1247**
1995	**1131**	**1217**	**1616**	**1213**
1996	**1127**	**1304**	**1562**	**1218**

Table 9: Emission intensities: CO, kg/US$ millions, IPPS coefficients

Year	Consumption	Investment	Exports	Total
1985	**1743**	**2447**	**3152**	**2141**
1990	**1793**	**2280**	**3520**	**2114**
1991	**1757**	**2267**	**3520**	**2117**
1992	**1717**	**2285**	**3339**	**2118**
1993	**1685**	**2332**	**3329**	**2097**
1994	**1725**	**2344**	**3339**	**2102**
1995	**1671**	**2218**	**3388**	**2013**
1996	**1683**	**2347**	**3410**	**2037**

Table 10: Emission intensities: VOC, kg/US$ millions, IPPS coefficients

Year	Consumption	Investment	Exports	Total
1985	**835**	**788**	**1176**	**885**
1990	**875**	**788**	**1076**	**881**
1991	**868**	**799**	**996**	**873**
1992	**864**	**787**	**991**	**873**
1993	**854**	**792**	**981**	**865**
1994	**852**	**781**	**1008**	**862**
1995	**828**	**742**	**1032**	**837**
1996	**825**	**781**	**1002**	**840**

Table 11: Emission intensities: Fine particulates, kg/US$ millions, IPPS coefficients

Year	Consumption	Investment	Exports	Total
1985	**264**	**753**	**546**	**417**
1990	**268**	**723**	**610**	**408**
1991	**264**	**756**	**584**	**408**
1992	**266**	**763**	**568**	**414**
1993	**256**	**755**	**578**	**406**
1994	**257**	**707**	**565**	**396**
1995	**264**	**662**	**585**	**390**
1996	**261**	**717**	**584**	**391**

Table 12: Emission intensities: Total particulates, kg/US$ millions, IPPS coefficients

Year	Consumption	Investment	Exports	Total
1985	**514**	**880**	**844**	**649**
1990	**519**	**849**	**904**	**638**
1991	**518**	**885**	**836**	**637**
1992	**523**	**882**	**832**	**647**
1993	**504**	**877**	**842**	**634**
1994	**503**	**825**	**855**	**623**
1995	**506**	**775**	**928**	**618**
1996	**501**	**839**	**907**	**619**

Table 13: Emission intensities: Metals - land, kg/US$ millions, IPPS coefficients

Year	Consumption	Investment	Exports	Total
1985	**138**	**331**	**363**	**219**
1990	**140**	**292**	**465**	**213**
1991	**132**	**289**	**470**	**212**
1992	**124**	**284**	**438**	**211**
1993	**124**	**298**	**434**	**211**
1994	**129**	**305**	**431**	**212**
1995	**128**	**291**	**439**	**203**
1996	**129**	**306**	**453**	**206**

Despite the differences in the source of the coefficients from the previous exercise, the conclusions tend to be very similar: the emissions intensity of the export complex is always higher than the average emissions intensity of the economy and, in almost all cases, the highest emissions intensity is exactly the one of the export complex.

The average emissions intensity of the economy for all parameters has declined between 1985 and 1996 (with the exception of BOD, which has remained almost the same); nevertheless, the emissions intensities in the export complex have increased for all but two parameters (NO_2 and VOC).

The emissions intensities estimated according to the IPPS coefficients are considerably lower than the values obtained using the IPEA coefficients; this is a strong indication that the environmental profile of the Brazilian industry in the late 1980s was considerably worse than the US one.

These results are very consistent, showing a trend that exports are dependent on production chains that are potentially dirtier (according to the IPPS) than the average of the economy. Despite the methodological problems discussed previously, this is a strong indication of a composition effect in the direction of specialization in (potentially) contaminating industries.

IPEA-IE/UFRJ Emission Coefficients Inventory (Local Pollutants)

The third database used to estimate the emissions of local pollutants by Brazilian industry was built specifically for this study using data from CETESB (the environmental agency for the State of São Paulo). The calculation of industrial emissions generated in São Paulo was based on the information declared by local production units about their potential emissions and their capacity to abate them (obtaining, by residual, the level of remaining emissions) according to the CETESB inventory. Note that, again, these data do not refer to actual emissions, but to information given by the industries to the environmental agency (in that case, up to the end of 1996); therefore they also refer to “theoretical” (rather than observed) emissions.

These figures were then divided by the value of production (or value added, or employment) for every industrial sector in the State of São Paulo, in order to generate the emission coefficients. Ideally, the production data would have been obtained directly from the same local units surveyed by CETESB. However, since this comparison is impossible, the value of production of São Paulo industry, by sector, estimated by the Annual Industrial Survey (PIA/IBGE) for the year 1996 was used. Once the coefficients were estimated, they were applied to the industrial value of production for the country as a whole (assuming that the environmental performance of industries in São Paulo reflect the average behavior of Brazilian industry).

The emission coefficients obtained using these procedures were as follows: water pollutants (organic and inorganic); air pollutants (sulfur dioxide (SO_2) and particulates (total)). Table 14 presents the results using the emission coefficients estimated according to the CETESB inventory.

These results have important differences from the previous exercises. First, it is important to note that the emission coefficients are considerably smaller than the ones based on the IPEA data, but higher than those from IPPS. Considering the estimates for 1995, the average intensity for organic matter (equivalent to BOD) based on the IPEA-IE/UFRJ coefficients is 747 kg/US$ million, in contrast to 861 kg/US$ million estimated with the IPEA coefficients, and 248 kg/US$ million using the IPPS. The intensity for particulates obtained from the IPEA-IE/UFRJ coefficients is 2,608 kg/US$ million, while the same estimate using IPEA’s coefficients is 4,441 kg/US$ million and 618 kg/US$ million using the IPPS. The only exception is SO_2: the estimate of emission intensity based on the IPEA-IE/UFRJ coefficients (962 kg/US$ million) is smaller than the other two estimates (3,298 kg/US$ million using IPEA, and 2,244 kg/US$ million using IPPS). This may be evidence of the improvement in the environmental performance of the Brazilian industry during the 1990s, even though it still emits more than the US industry emitted a decade before (with the exception of SO_2).

Another important point is that the difference between the emission intensities of the export complex and the average of the economy is not as accentuated as in the previous cases. Indeed, the export complex intensity drops below the average intensity in some cases, particularly for SO_2. Nevertheless, in general terms, the conclusions are similar to the previous ones: the export complex tends to be more intensive in emissions than the rest of the economy (even though the difference from the other sectors is less accentuated).

Table 14: Emission Intensities, kg/US$ millions, IPEA-IE/UFRJ coefficients

Pollutant/year	Consumption	Investment	Exports	Total
Organic				
1985	**956**	**203**	**534**	**723**
1990	**937**	**203**	**590**	**736**

1991	**973**	**210**	**591**	**766**
1992	**972**	**199**	**623**	**764**
1993	**932**	**196**	**625**	**740**
1994	**925**	**184**	**647**	**732**
1995	**923**	**177**	**779**	**747**
1996	**903**	**190**	**744**	**744**
Inorganic				
1985	**7.7**	**7.6**	**8.8**	**7.9**
1990	**7.4**	**7.2**	**10.4**	**7.7**
1991	**6.9**	**7.2**	**10.5**	**7.5**
1992	**6.5**	**7.1**	**10.9**	**7.4**
1993	**6.8**	**7.4**	**11.4**	**7.7**
1994	**7.0**	**7.5**	**10.5**	**7.6**
1995	**6.8**	**7.3**	**10.5**	**7.4**
1996	**6.6**	**7.2**	**11.5**	**7.4**
Particulates				
1985	**2542**	**2839**	**2186**	**2542**
1990	**2378**	**2811**	**2384**	**2472**
1991	**2514**	**3019**	**2427**	**2601**
1992	**2617**	**3018**	**2470**	**2666**
1993	**2351**	**2974**	**2550**	**2503**
1994	**2445**	**2723**	**2843**	**2563**
1995	**2350**	**2549**	**3983**	**2608**
1996	**2388**	**2794**	**3667**	**2634**
SO_2				
1985	**928**	**1150**	**1026**	**992**

1990	**946**	**1158**	**943**	**991**
1991	**965**	**1232**	**894**	**1008**
1992	**977**	**1231**	**889**	**1009**
1993	**952**	**1220**	**890**	**991**
1994	**949**	**1129**	**919**	**981**
1995	**934**	**1058**	**945**	**962**
1996	**934**	**1151**	**939**	**976**

Carbon Dioxide Emissions from Fossil Fuel Consumption (Global Pollutant)

A recent study by COPPE/UFRJ (1998) estimated carbon dioxide (CO_2) emissions from fossil fuel consumption in Brazil during the period 1990/94. These data were obtained using the methodological procedures of the Intergovernmental Panel on Climate Change (IPCC) since they were used in the Brazilian official inventory of greenhouse gas emissions. Table 15 summarizes the main results.

Table 15: CO2 Emissions from Fossil Fuels Consumption, Brazil (1990/94)

Sector	1990		1991		1992		1993		1994	
	1000t CO_2	**%**	**1000t CO_2**	**%**	**1000t CO_2**	**%**	**1000t CO_2**	**%**	**1000t CO_2**	**%**
Energy	**13226.3**	**7.3**	**11875.2**	**6.3**	**12462.4**	**6.5**	**13471.4**	**6.7**	**13954.0**	**6.6**
Residential	**13767.5**	**7.6**	**14140.6**	**7.4**	**14650.2**	**7.6**	**15184.1**	**7.5**	**15188.4**	**7.2**
Commercial & Public	**2546.4**	**1.4**	**2428.0**	**1.3**	**2458.0**	**1.3**	**2411.6**	**1.2**	**3523.9**	**1.7**
Agriculture	**9997.8**	**5.5**	**10425.5**	**5.5**	**10726.2**	**5.6**	**11851.1**	**5.9**	**12516.4**	**5.9**
Industrial	**59850.3**	**33.2**	**65771.8**	**34.7**	**66635.1**	**34.6**	**69839.0**	**34.6**	**72272.2**	**34.3**
Transport	**81142.2**	**44.9**	**85165.7**	**44.9**	**85807.6**	**44.5**	**89214.8**	**44.2**	**93331.3**	**44.3**
Total	**180530.5**	**100.0**	**189806.9**	**100.0**	**192739.5**	**100.0**	**201972.1**	**100.0**	**210786.2**	**100.0**
Source: COPPE (1998)										

Using the same approach of the other exercises, based on equation (7), Table 16 presents the intensity coefficients (CO_2 per unit of output) in each production chain.

Table 16: Emission Intensity per Unit of Output (kg CO2/R$ 1994)

Year	Exports	Consumption*	Investment	Total	Annual change (%)
1990	**0.634**	**0.264**	**0.275**	**0.302**	
1991	**0.702**	**0.270**	**0.316**	**0.324**	**7.1%**
1992	**0.637**	**0.275**	**0.294**	**0.325**	**0.3%**
1993	**0.607**	**0.279**	**0.283**	**0.320**	**-1.5%**
1994	**0.635**	**0.281**	**0.303**	**0.326**	**1.,7%**
Change 94/90(%)	0.1%	6.7%	9.9%	7.8%	

The tables above clearly indicate that in every year considered, the relative contribution of the export complex to CO_2 emissions was always around twice the equivalent value of their contribution to total output. In other words, the production of export goods and their respective inputs is considerably more emission intensive than in the other chains. Even though the intensity of CO_2 per output unit remained relatively stable (while it increased in the rest of the economy), it remained almost as the double of the average intensity of the economy. This is additional strong evidence that the Brazilian economy has exported goods and services based on "dirty" activities.

In sector terms, again, most of the emissions are concentrated in a small number of 'dirty' activities, directly or indirectly related to exports: metallurgy, chemicals, agriculture (the high increase in agricultural emissions is a consequence of the mechanization process, resulting in more fuel consumption) and the transportation sector.

On the other hand, despite the accelerated growth in imported goods, the average emission intensity increased (more emissions required to produce the same amount of output). Therefore, the empirical evidence goes against the hypothesis that free trade and capital flows would lead to higher efficiency in environmental standards.

We conclude that despite all limitations (pollution estimates were not directly observed; the environmental impact of a specific pollutant is affected by many other variables which were not considered in the exercise; linear relationships between output and emissions may not be realistic; etc.) the results from these exercises are very consistent in showing the relatively high contribution of export-oriented activities to air and water pollution problems in Brazil. The convergence of these results with other empirical studies on the same issue (Veiga *et al.* 1995, Torres *et al.* 1997), but with a less aggregate perspective, is another strong element confirming the relative specialization in dirty industrial exports. Therefore, any expansion of export activities based on the existing set of parameters will lead to problems of increasing the level of industrial emissions more than a similar rise in domestic-oriented activities.

Nevertheless, it is crucial to note that only the composition effect was considered in these exercises. Most of the argument that more openness brings benefits to the environment is based on another aspect, the technological effect. This issue is discussed further in section 6.

6 Imports and Emission "Savings"

Estimating Emission Savings

An integrated analysis of the environmental impacts of international trade has to consider that liberalization may have an important impact on pollution because import goods reduce domestic levels of emissions. Since they are produced abroad, imports "divert" the associated emissions to the country where the good was made – the idea is that if no trade relations took place, they would have been produced domestically, increasing the level of emissions.

In this section, we examine the emission "savings" caused by the fast growth of industrial imports in Brazil after the trade liberalization policies took effect. These emission savings were estimated through the hypothetical increase in emissions if these import goods were made in Brazil. In methodological terms, this can be done using the same input-output and emission coefficient tables presented in the exercises in the previous section, but with a change – the table of the supply and demand of import goods was used (table 4 of the input-output matrix of IBGE), instead of the supply and demand tables of domestic products (table 3 of the input-output matrix). The emission coefficients were obtained from the aforementioned Industrial Pollution Projection System (IPPS) of the World Bank.

The flagship of the liberalization process was automobile imports, which increased 1,380% in the 1990-96 period. Other industrial sectors with very high rates of import growth where plastics (307%), textiles (286%), wood and furniture (248%), electronics (246%), other industries (220%), other metallurgic goods (200%), car components (200%), electrical equipment (199%) and vegetable oils (193%). The average increase in industrial imports was 148%, and the sectors with the lowest rates of import growth were slaughtering (-41%), sugar production (73%), footwear (78%) and chemical elements (88%).

Table 17 shows the aggregate emission savings for each pollutant in the 1990-1996 period. The average change in the associated level of (potential) emissions was 46%. At a first sight, this suggests a relative stability in the composition of imports in terms of emissions. However, one can observe that there were considerable differences among pollutants. In the case of metal emissions for water and BOD, for example, the growth in domestic emission savings was considerably below the average, showing that the composition of imports changed towards goods with low intensity in this water pollutant. On the other hand, the presence of import goods intensive in air pollutants (VOC, metals, SO_2, and NO_2) has increased in the same period, indicating that the emission savings effect have grown for these parameters.

Table 17: Emission savings (tons), IPPS coefficients, 1990-96

Pollutant	1990	1996	Change
BOD	**6,183.86**	**14,262.22**	**131%**
Total Suspended Solids	**175,387.86**	**429,782.33**	**145%**
SO_2	**65,818.26**	**167,426.61**	**154%**

NO_2	**32,209.98**	**82,996.04**	**158%**
CO	**60,391.33**	**150,209.10**	**149%**
VOC	**23,963.26**	**63,944.79**	**167%**
Fine Particulates	**7,666.07**	**19,514.42**	**155%**
Particulates (total)	**12,870.87**	**33,092.61**	**157%**
Metals – air	**13,569.27**	**35,060.37**	**158%**
Metals – land	**28,751.79**	**66,923.65**	**133%**
Metals – water	**2,520.36**	**5,344.16**	**112%**
Imports	**20,602.72**	**51,017.03**	**148%**

Combining the emission savings in physical units with their output value, it is possible to estimate the avoided emission intensity per unit of imports (shown in table 18). Following the same pattern described previously, there is an asymmetry between water and air pollutants: while there was a decrease in the emission intensity of water and land pollutants per unit of imports, the air pollutants presented an opposite trend of increasing emission intensities.

Table 18: Emission intensity per unit of imports (g/US$), IPPS coefficients, 1990-96

Pollutant	1990	1996	Change
BOD	**0.30**	**0.28**	**-6,86**
Total Suspended Solids	**8.51**	**8.42**	**-1.04**
SO_2	**3.19**	**3.28**	**2.73**
NO_2	**1.56**	**1.63**	**4.06**
CO	**2.93**	**2.94**	**0.45**
VOC	**1.16**	**1.25**	**7.76**
Fine Particulates	**0.37**	**0.38**	**2.80**
Particulates (total)	**0.62**	**0.,65**	**3.83**
Metals – air	**0.66**	**0.69**	**4.34**
Metals – land	**1.40**	**1.31**	**-6. 00**
Metals – water	**0.12**	**0.10**	**-14. 37**

Comparing Export and Import Emission Intensities

The exercise that is most important for policy analysis is the comparison between the import and export emission intensity coefficients. This is shown in table 19, based on the results of this and the previous section. It is clear that the potential emission per unit of exports is always superior to its equivalent for imports for every parameter considered. The reason for this is that the composition of the production chain associated with Brazilian industrial exports is more concentrated in potentially dirty activities than the production chain that would be required if the imports were produced domestically. In other words, Brazil is a net "exporter" of sustainability, in the sense that its insertion in the international market is through the production of potentially polluting industrial goods, while it consumes products that are less harmful to the environment.

Table 19: Difference between export and import emission intensities (g/US$)

Pollutant	1990	1991	1992	1993	1994	1995	1996
BOD	**0.03**	**0.03**	**-0.01**	**0.08**	**0.06**	**0.14**	**0.08**
TSS	**11.73**	**11.83**	**9.37**	**10.29**	**8.72**	**7.31**	**8.23**
SO_2	**2.10**	**1.83**	**1.24**	**1.64**	**1.56**	**1.31**	**1.50**
NO_2	**0.65**	**0.58**	**0.33**	**0.51**	**0.55**	**0.42**	**0.47**
CO	**1.93**	**1.84**	**1.29**	**1.63**	**1.41**	**1.16**	**1.33**
VOC	**0.28**	**0.18**	**0.04**	**0.14**	**0.18**	**0.04**	**0.10**
Particulates	**0.50**	**0.48**	**0.37**	**0.47**	**0.42**	**0.42**	**0.42**
Fine particulates	**0.67**	**0.61**	**0.45**	**0.63**	**0.60**	**0.63**	**0.63**

Again, it is important to bear in mind that these results reflect the composition structure of exports and imports based on the hypothesis of fixed emission coefficients. One argument in favor of the trade liberalization process is the improvement of the environmental performance of industries because capital goods can be imported more easily, thus introducing better emission standards (since they are designed for the more restrictive markets of developed countries). However, this cannot be empirically verified in exercises using fixed emission coefficients, such as the ones carried out in this report. The improvement in data availability for the effective environmental performance of the industry, instead of proxies based upon fixed emission coefficients, is needed for a better understanding of the connections between economic and environmental variables.

We conclude that a positive environmental effect of the fast expansion of imports in the 1990s in Brazil was the avoidance of emissions associated with these goods. However, this counterbalancing effect was much attenuated by the composition of the import goods basket, compared to the exports: the growth in industrial imports was concentrated in relatively clean activities, while the structure of industrial exports remained associated with more emission intensive sectors. Therefore, the overall reduction in the (potential) emission of pollutants in the Brazilian industry caused by imports growth was smaller than it could have been if these imports were concentrated in "dirtier" activities.

7 Brazilian Competitiveness and the Control of Water Pollution

The previous sections showed that the presence of emission-intensive products in the composition of Brazilian industrial exports is significant.

This conclusion brings two kinds of problems: first, the welfare losses caused by pollution which, because of the lack of an environmental accounting system, are not accounted for if external markets become more rigorous in terms of environmental standards, and the treatment costs being high, the competitive advantage of lower production costs for being "dirty" turn out to be a disadvantage.

The first issue has already been analyzed by specialists warning that *laissez faire* environmental policies may end up with social costs higher than the benefits. This chapter discusses the second issue, which has received less attention from the literature. In other words, how much it would cost to clean up production and what would the trade losses be if export prices went up because of the former?

Theoretical Model

The analysis in this chapter follows the approach by Pasurka (1984) to estimate the direct and indirect price effects caused by higher environmental protection costs. The idea is that pollution control costs raise prices of various products and their respective inputs at the domestic level, but not the prices in international markets (assuming that Brazilian firms are price-takers). The price increases for inputs must be transmitted to the outputs, generating a chain of inflation in the economy. In terms of the input-output approach, the final price increase can be represented by:

$$\Delta P = v\,(I - A)^{-1} - v^{*}\,(I - A^{*})^{-1} \qquad (9)$$

where ΔP is a vector of the absolute as well as proportionate price changes, V is the vector representing the sum of the costs of direct labor and capital services used in the production and pollution control activities, v^* is the v matrix only respective to production activities, and A^* is the matrix of direct intermediate input coefficients only respective to production activities.

Assuming that the exchange rate is not affected, the international price of the good is increased and its competitiveness reduced. The dimension of the impact will be dependent on the demand price-elasticity of Brazilian export goods.

Some additional hypotheses were necessary for this approach. The intermediate consumption for the pollution abatement activities could not be included because of the lack of data (to fix this, the whole input-output table would have to be modified). Another assumption is that the costs of treating pollution do not affect the technical coefficients of the matrix. It is also assumed that the production factors necessary for pollution control activities are not employed for other activities, as it would otherwise have generated a reallocation of production factors incompatible with the existing composition of the aggregate value. Finally, since it refers to a short term, partial equilibrium analysis, the impacts of pollution control on investment (and, consequently, economic growth) could not be considered. This is equivalent to considering that all costs associated with environmental protection are fully incorporated in prices (mark up hypothesis), characterizing these markets as of imperfect competition at the domestic level (despite the export goods are considered as price takers).

Control Costs for Water Emissions from Industry

For the simulation exercise, emission control costs were obtained from simulations based on original parameters developed by Mendes (1994). Only the costs for controlling water emissions from industrial sources were considered, corresponding to organic matter (BOD) and toxic metals, including investment costs.[15] The estimates were based on the emission volume calculated according to the IPEA coefficients, and the cost parameters developed by Mendes (1994), which were partially derived from a World Bank study based on Brazilian data that estimated the costs of pollution control, and economic data for the Brazilian industry from IBGE.

The costs of emission control were calculated for three different scenarios: removal of 50%, 75% or 100% of the pollutants. Each one of these scenarios can be thought as different degrees of requirement in the legislation referring to pollution control. As stated previously, the emission control costs were disseminated through the production chain according to the relative weight of each input to the overall production costs, according to the methodology proposed by Pasurka (1984).

Table 20 presents the estimation of cost increases per sector. In general terms, the increase in costs is not very large: 93% of the economic activities presented cost increases in the range between 0% to 3% of the value added. Even when the total removal is imposed (100% scenario), most sectors would have an increase of costs lower than 1.0% of the value added.[16]

As expected, the sectors with higher (direct) control costs are the ones that present higher increases in total costs. The more problematic industries are non-ferrous metallurgic, other metallurgic, and footwear. Only these three sectors would have costs superior to 3% in the three scenarios, indicating that more dramatic impacts of losing competitiveness associated with tougher environmental measures would be concentrated in a few industries.

The sectors with cost increases between 1% and 3% represent 26% of the sectors in the most demanding scenario (100% removal). However, this proportion falls to less than 10% with the smallest level of exigency (50% removal), and includes machinery and equipment, electric material, vehicle parts and other vehicles, and wood and furniture.

It is interesting to note that these low values are compatible with a questionnaire survey carried out recently that showed that most Brazilian industrial companies (65%) declared operational environmental costs to be in the lowest range indicated by the survey (less than 5% of operational revenues) (BNDES/CNI/SEBRAE 1998). In any case, it is also important to highlight that the BNDES/CNI/SEBRAE survey asked about costs already faced by the industry, while the Mendes (1994) coefficients refer to the expenditures that are necessary to remove emissions but that have not yet been implemented.

Table 20: Proportion of direct and indirect costs for controlling industrial water emissions, as a proportion of the sector value added

Activities	50%	75%	100%	50%	75%	100%
Agriculture	**0. 00%**	**0.00%**	**0.00%**	**0.13%**	**0.17%**	**0.31%**
Mineral extraction	**0.00%**	**0.00%**	**0.00%**	**0.31%**	**0.36%**	**0.55%**
Oil and natural gas	**0.00%**	**0.00%**	**0.00%**	**0.27%**	**0.31%**	**0.47%**
Non-metallic minerals	**0. 00%**	**0.00%**	**0.00%**	**0.28%**	**0.33%**	**0.51%**
Iron and steel	**0.00%**	**0.00%**	**0.00%**	**0.52%**	**0.61%**	**0.92%**
Non-ferrous metallurgic	**5.30%**	**6.18%**	**8.99%**	**7.71%**	**9.00%**	**13.15%**
Other metallurgic	**5.30%**	**6.18%**	**8.,99%**	**6.55%**	**7.64%**	**11.15%**
Machinery and equipment	**0.00%**	**0.00%**	**0.00%**	**1.10%**	**1.28%**	**1.89%**
Electric material	**0.00%**	**0.00%**	**0.00%**	**1.54%**	**1.80%**	**2.66%**
Electronic material	**0.00%**	**0.00%**	**0.00%**	**0.47%**	**0.55%**	**0.81%**
Motor vehicles	**0.00%**	**0.00%**	**0.00%**	**0.99%**	**1.15%**	**1.72%**
Vehicle parts and other vehicles	**0.00%**	**0.00%**	**0.00%**	**1.41%**	**1.64%**	**2.42%**
Wood and furniture	**1.00%**	**1. 06%**	**1.37%**	**1.56%**	**1.70%**	**2.34%**
Pulp, paper and paperboard	**0.16%**	**0.18%**	**0.55%**	**0.46%**	**0.54%**	**1.22%**
Rubber industry	**0.00%**	**0.,00%**	**0.00%**	**0.28%**	**0.33%**	**0.53%**
Chemical industry	**0.39%**	**0.57%**	**1.19%**	**0.62%**	**0.84%**	**1.63%**
Petroleum refineries	**0.00%**	**0.,00%**	**0.00%**	**0.17%**	**0.20%**	**0.32%**
Other chemical products	**0.39%**	**0.57%**	**1.19%**	**0.72%**	**0.98%**	**1.91%**
Pharmacy and veterinary products	**0.03%**	**0.03%**	**0.06%**	**0.28%**	**0.34%**	**0.59%**
Plastic products	**0.00%**	**0.00%**	**0.00%**	**0.20%**	**0.24%**	**0.39%**
Textiles	**0.48%**	**0.53%**	**0.74%**	**0.92%**	**1.03%**	**1.48%**
Wearing apparel	**0.48%**	**0.53%**	**0.74%**	**0.98%**	**1.09%**	**1.64%**
Footwear	**5.01%**	**5.96%**	**16.01%**	**6.42%**	**7.64%**	**20.24%**
Coffee industry	**0.13%**	**0.14%**	**0.29%**	**0.28%**	**0.33%**	**0.63%**

Other vegetable products	**0.13%**	**0.14%**	**0.29%**	**0.35%**	**0.40%**	**0.71%**
Meat industry	**0.13%**	**0.14%**	**0.29%**	**0.31%**	**0.36%**	**0.68%**
Dairy products	**0.13%**	**0.14%**	**0.29%**	**0.44%**	**0.50%**	**0.89%**
Sugar factories and refineries	**0.13%**	**0.14%**	**0.29%**	**0.43%**	**0.50%**	**0.87%**
Vegetable oils	**0.13%**	**0.14%**	**0.29%**	**0.48%**	**0.55%**	**0.95%**
Other food products	**0.13%**	**0.14%**	**0.29%**	**0.46%**	**0.53%**	**0.95%**
Other industries	**0.00%**	**0.00%**	**0.00%**	**0.53%**	**0.62%**	**0.95%**
Public utilities	**0.00%**	**0.00%**	**0.00%**	**0.14%**	**0.16%**	**0.25%**
Civil construction	**0.00%**	**0.00%**	**0.00%**	**0.75%**	**0.87%**	**1.28%**
Commerce	**0.00%**	**0.00%**	**0.00%**	**0.07%**	**0.09%**	**0.15%**
Transportation	**0.00%**	**0.00%**	**0.00%**	**0.17%**	**0.20%**	**0.31%**
Communications	**0.00%**	**0.00%**	**0.00%**	**0.13%**	**0.15%**	**0.24%**
Financial institutions	**0.00%**	**0.00%**	**0.00%**	**0.03%**	**0.03%**	**0.06%**
Services to households	**0.00%**	**0.00%**	**0.00%**	**0.25%**	**0.29%**	**0.46%**
Business services	**0.00%**	**0.00%**	**0.00%**	**0.07%**	**0.08%**	**0.16%**
Renting	**0.00%**	**0.00%**	**0.00%**	**0.11%**	**0.12%**	**0.18%**
Public administration	**0.00%**	**0.00%**	**0.00%**	**0.07%**	**0.09%**	**0.15%**
Non-mercantile private sectors	**0.00%**	**0.00%**	**0.00%**	**0.04%**	**0.05%**	**0.08%**
Source: Mendes (1994)						

Impacts on Brazilian Exports

An exercise was carried out in order to identify the potential impacts of emission control costs on the competitiveness of Brazilian exports based on exports data from CHELEM.[17] Three destination areas were considered: the European Union, NAFTA, and Latin America. Table 21 presents the importance of the three selected regions for Brazilian exports.

Table 21: Brazilian Exports (US$ Millions, current prices)

Region	1980/84	1985/89	1990/94	1995/96
Latin America (excluding Mexico)	**2993**	**3636**	**6655**	**10345**
NAFTA	**5581**	**8444**	**8757**	**9658**
European Union	**6390**	**8501**	**10774**	**12415**
Total	**22255**	**28911**	**36434**	**46429**
Source: CHELEM				

It can be seen that the three selected areas are responsible for most of the demand for Brazilian exports. Trade within Latin America is the most dynamic, mainly because of the Mercosul integration process. The diversification of exports is considerable, but the exports of basic and semi-manufactured goods predominate.

In order to obtain the trade diversion estimates, it is also necessary to determine how much demand would vary if prices were altered (the price-elasticity of demand for Brazilian export goods). There are only a few empirical studies on the subject and almost none at the sector level.[18] Another problem is related to changes in trade patterns and macroeconomic conditions, particularly changes in the exchange rate that affect the system of relative prices, which has great importance for the evolution of exports.

In this report, the choice adopted was to use values close to the ones estimated by Cavalcanti *et al.* (1998) for the price-elasticity of the exports quantum – even though they are very aggregate, they were obtained in the same time period of the cost estimation. Cavalcanti *et al.* (1998) present two estimates of price elasticities, one for the semi-manufactured goods (-0.34) and another for the manufactured ones (-0.78). These values were then applied to the estimates of cost increases in each sector from table 20. Given the uncertainties in the exercise, a sensitive analysis was carried out assuming a minimum and a maximum value for all sectors. Hence, the estimation of trade diversion are presented under two scenarios: optimistic (elasticity of -0.34) and pessimistic (elasticity of -0.78). Tables 22 and 23 present the results in US$, and tables 24 and 25 present them as percentages of the observed exports.

Table 22: Pessimistic Scenario: Export Losses Caused by Emission Control Costs, US$ Millions (current); elasticity: - 0.78

	1980/84	1985/89	1990/94	1995/96
Removal of 50% of emissions				
Total	**154**	**255**	**366**	**467**
Latin America	**27**	**31**	**66**	**103**

NAFTA	**59**	**110**	**127**	**136**
European Union	**31**	**56**	**86**	**98**
Removal of 75% of emissions				
Total	**180**	**299**	**429**	**548**
Latin America	**32**	**36**	**77**	**120**
NAFTA	**69**	**129**	**150**	**161**
European Union	**36**	**66**	**101**	**115**
Removal of 100% of emissions				
Total	**333**	**555**	**790**	**982**
Latin America	**49**	**55**	**121**	**192**
NAFTA	**143**	**265**	**311**	**328**
European Union	**69**	**125**	**192**	**218**

Table 23: Optimistic scenario: export losses caused by emission control costs, US$ Millions (current); elasticity: - 0.34

	1980/84	1985/89	1990/94	1995/96
Removal of 50% of emissions				
Total	**67**	**111**	**160**	**204**
Latin America	**12**	**13**	**29**	**45**
NAFTA	**26**	**48**	**55**	**59**
European Union	**13**	**24**	**37**	**43**
Removal of 75% of emissions				
Total	**79**	**131**	**187**	**239**
Latin America	**14**	**16**	**33**	**52**
NAFTA	**30**	**56**	**65**	**70**
European Union	**16**	**29**	**44**	**50**
Removal of 100% of emissions				

Total	**145**	**242**	**344**	**428**
Latin America	**22**	**24**	**53**	**84**
NAFTA	**62**	**115**	**136**	**143**
European Union	**30**	**54**	**84**	**95**

Table 24: Pessimistic scenario: export losses caused by emission control costs, % of observed exports; elasticity: - 0.78

	1980/84	1985/89	1990/94	1995/96
Removal of 50% of emissions				
Total	**0.7%**	**0.9%**	**1.0%**	**1.0%**
Latin America	**0.9%**	**0.8%**	**1.0%**	**1.0%**
NAFTA	**1.1%**	**1.3%**	**1.5%**	**1.4%**
European Union	**0.5%**	**0.7%**	**0.8%**	**0.8%**
Removal of 75% of emissions				
Total	**0.8%**	**1.0%**	**1.2%**	**1.2%**
Latin America	**1.1%**	**1.0%**	**1.2%**	**1.2%**
NAFTA	**1.3%**	**1.5%**	**1.7%**	**1.7%**
European Union	**0.6%**	**0.8%**	**0.9%**	**0.9%**
Removal of 100% of emissions				
Total	**1.5%**	**1.9%**	**2.2%**	**2.1%**
Latin America	**1.7%**	**1.5%**	**1.8%**	**1.9%**
NAFTA	**2.6%**	**3.1%**	**3.6%**	**3.4%**
European Union	**1.1%**	**1.5%**	**1.8%**	**1.8%**

Table 25: Optimistic scenario: export losses caused by emission control costs, % of observed exports; elasticity: - 0.34

	1980/84	1985/89	1990/94	1995/96
Removal of 50% of emissions				
Total	**0.3%**	**0.4%**	**0.4%**	**0.4%**
Latin America	**0.4%**	**0.4%**	**0.4%**	**0.4%**
NAFTA	**0.5%**	**0.6%**	**0.6%**	**0.6%**
European Union	**0.2%**	**0.3%**	**0.3%**	**0.3%**
Removal of 75% of emissions				
Total	**0.4%**	**0.5%**	**0.5%**	**0.5%**
Latin America	**0.5%**	**0,4%**	**0.5%**	**0.5%**
NAFTA	**0.5%**	**0.7%**	**0.7%**	**0.7%**
European Union	**0.2%**	**0.3%**	**0.4%**	**0.4%**
Removal of 100% of emissions				
Total	**0.7%**	**0.8%**	**0.9%**	**0.9%**
Latin America	**0.7%**	**0.7%**	**0.8%**	**0.8%**
NAFTA	**1.1%**	**1.4%**	**1.6%**	**1.5%**
European Union	**0.5%**	**0.6%**	**0.8%**	**0.8%**

Some important conclusions are suggested by these results. Given the relatively low costs of environmental control, the estimated loss of exports is not high. The total loss would remain between 1% and 2% of the total value of exports. These figures are close to the ones obtained by Repetto (1995) in his analysis of US industry, indicating that the costs of pollution abatement are not as high as is argued by those opposing more effective environmental controls.

On the other hand, the impacts may be very differentiated in terms of sectors and destination markets. Some industries are more problematic, and the loss in the exports may reach considerable amounts in sector terms. The most important cases are footwear (loss of up to 15.8% in the pessimistic case, assuming 100% removal), non-ferrous metallurgic (maximum loss of 10.3%) and other metallurgic (maximum loss of 8.7%). The higher concentration of exports of these goods in some specific markets where buyers are more environmentally conscious may lead to more important trade losses. This is characteristic of the European Union, but fortunately, this is a destination that receives goods less dependent on production activities with environmental liabilities. On the other hand, NAFTA receives the most concentrated basket of goods that require more expenditure on environmental control. If trade barriers based on environmental claims were accepted, exports to North America would face important restrictions.

One last comment refers to the possible impacts on imports. In the exercise, this impact was not considered, but it is very likely that imports would increase if the similar domestic goods became more expensive. This point is very difficult to estimate but is crucial to understanding the potential impacts in terms of higher regional integration via Mercosul. The simultaneity between more rigorous emission standards in Brazil and the removal of trade barriers with its neighbors may lead to an increase in imports of the goods currently produced under worse environmental conditions. Even though the aggregate result may be of relatively minor dimension, localized impacts in terms of regions and/or sectors may result from the disparity between the relatively more rigorous standards in Brazil and the lack of environmental control in other Mercosul countries.

However, it is important to highlight the problems and limitations of these exercises. The results discussed above are entirely dependent on the reliability of the information on direct control costs, in addition to all other restrictions that were necessary in estimation of emissions. There are considerable problems in adequately evaluating the impacts of the differentiation of environmental control costs, including its own dimension. Control costs depend on the assimilative capacity of the environment (not considered in the exercise) as well as the level and composition of the economic activity. Moreover, only the end-of-pipe costs are usually available. Hence, this calculation may lead to unrealistic conclusions, since it neglects the importance of investment in new technologies and modern equipment, which are cleaner and, at the same time, more efficient in economic terms.

The point is that this approach ignores the role of innovation, which systematically changes the effective relationship between production and environmental control costs. This is associated with the so-called technological effect, which has not been considered in the analysis so far. The following chapter aims at exactly this point: once the dynamic process of environmental innovations is considered, the conclusions concerning trade and the environment may change completely.

8 Environmental Innovation and Openness in the Brazilian Industry[19]

The previous chapters have discussed the relative specialization of the export complex in "dirty" activities, emphasizing the so-called "composition effect." However, the input-output analysis that has empirically supported this hypothesis is essentially a static approach, in the sense that it does not consider the technological changes over time. But many of the arguments in favor of the idea that openness has positive effects on the environment are exactly based on the argument that a better environmental performance is essential for keeping their competitiveness. This chapter discusses the issue of environmental innovation, trying to assess whether companies with global insertion (either because of capital ownership or trade flows) have a different behavior when compared to nationally owned, domestic-oriented ones.

The empirical evidence is based on data for the state of São Paulo obtained for the year using the PAEP/SEADE survey. This survey refers to the year 1996, reaching a total of 43,900 industrial companies, from all sectors. The answers were voluntary, explaining the difference in the number of answers in each table.

The first hypothesis to be tested was that companies with global interests (at least part of its property is owned by foreigners) tend to adopt environmental innovations and to perceive the environment as a business opportunity (thus with potential losses if inadequate environmental procedures are adopted) to a higher degree than the others.[20]

In the PAEP/SEADE questionnaire, the following variables were chosen to test whether the firms are concerned with environmental issues:

- Business opportunities – if the answering company considered that the development of environmentally friendly products and processes is a source of increasing its business activity. Possible answers: yes/no;
- Environmental implications: market losses – if the answering company considered that its environment performance has resulted in the loss of markets, domestically or internationally. Possible answers: yes/no;
- Environmental implications: higher costs – if the answering company considered that the activities associated with its environmental performance have resulted in higher costs (investment in control measures, fines and levies, etc.). Possible answers: yes/no.

Tables 26 and 27 present the results from crossing the variables above with the origin of capital ownership. Table 26 shows that, of the 843 companies with global interests (capital owned at least partially by foreigners), 52.4% believe that the development of products and processes less harmful to the environment may turn out to be a business opportunity. If the companies that are solely owned by foreigners are considered, the percentage of positive answers increases to 54.9%. Among the companies owned exclusively by nationals, the percentage drops to 29.2%. Therefore, this result confirms the hypothesis that firms with global interests are more inclined to see environmental questions as business opportunities than the nationally owned ones.

Table 26: Firms that consider the environment as a business opportunity, according to their ownership, 1996

		BUSINESS OPPORTUNITY – ENVIRONMENTALLY FRIENDLY PRODUCTS AND PROCESSES		
FIRM'S CAPITAL OWNERSHIP (IN 12/31)	**Data**	**1 = YES (A)**	**2 = NO (B)**	**Total (C)**
1 = NATIONAL	**Number Of Firms**	**11,702**	**28,367**	**40,069**
	Percentages A/C And B/C	**29.2**	**70.8**	
2 = FOREIGN	**Number Of Firms**	**322**	**264**	**586**
	Percentages A/C And	**54.9**	**45.1**	

	B/C			
3 = NATIONAL AND FOREIGN	**Number Of Firms**	**120**	**137**	**257**
	Percentages A/C And B/C	**46.7**	**53.3**	
Total No. of firms		**12,144**	**28,768**	**40,912**
	Percentages A/C And B/C	**29.7**	**70.3**	
Source: Fundação Sistema Estadual de Análise de Dados - SEADE. Pesquisa da Atividade Econômica Paulista – PAEP 1996.				

Nevertheless, only 11.4% of the companies with global interests admitted market losses because of the environmental effects of their activities. This percentage falls to only 4.3% for the nationally owned companies, and rises to 12.3% if the answers are restricted to the companies exclusively owned by foreigners. So, most of the answers (95.6%), independently of the origin of capital, pointed out that they did not perceive any losses in either domestic or international markets as a consequence of their actions towards the environment.

Table 27: Firms that consider market losses caused by the environmental consequences of their actions, according to their ownership, 1996

		ENVIRONMENTAL CONSEQUENCES – MARKET LOSSES		
FIRM'S CAPITAL OWNERSHIP (IN 12/31))	**Data**	**1 = YES (A)**	**2 = NO (B)**	**Total (C)**
1 = NATIONAL	**Number of firms**	**1,721**	**38,326**	**40,047**
	Percentages A/C and B/C	**4.3**	**95.7**	
2 = FOREIGN	**Number of firms**	**72**	**511**	**583**
	Percentages A/C and B/C	**12.3**	**87.7**	
3 = NATIONAL AND FOREIGN	**Number of firms**	**24**	**234**	**258**
	Percentages A/C and B/C	**9.3**	**90.7**	
Total No. of firms		**1,817**	**39,072**	**40,889**

	Percentages A/C and B/C	**4.4**	**95.6**	
Source: Fundação Sistema Estadual de Análise de Dados - SEADE. Pesquisa da Atividade Econômica Paulista – PAEP 1996.				

Table 28 shows that 41.1% of the companies with global interests considered that their costs were increased because of environmentally related activities. This percentage is reduced to 14.8% for the nationally owned companies. In total, 84.7% considered that there were no cost increases because of environmental questions.

Table 28: Firms that consider rising costs caused by the environmental consequences of their actions, according to their ownership – 1996

		ENVIRONMENTAL CONSEQUENCES – RISING COSTS		
FIRM'S CAPITAL OWNERSHIP (IN 12/31)	**Data**	**1 = YES (A)**	**2 = NO (B)**	**Total (C)**
1 = NATIONAL	**Number of firms**	**5,919**	**34,131**	**40,050**
	Percentages A/C and B/C	**14.8**	**85.2**	
2 = FOREIGN	**Number of firms**	**242**	**341**	**583**
	Percentages A/C and B/C	**41.5**	**58.5**	
3 = NATIONAL AND FOREIGN	**Number of firms**	**104**	**155**	**259**
	Percentages A/C and B/C	**40.2**	**59.2**	
Total No. of firms		**6,265**	**34,627**	**40,892**
	Percentages A/C and B/C	**15.3**	**84.7**	
Source: Fundação Sistema Estadual de Análise de Dados - SEADE. Pesquisa da Atividade Econômica Paulista – PAEP 1996.				

To conclude, nationally owned companies do not perceive the environmental issues in the same way as do companies with global interests, confirming the hypothesis previously presented. However, most of the companies did not consider market losses because of environmental protection measures, thus refuting another of the hypotheses previously discussed. Note that a better definition of companies with global interests would also have to consider the domestically owned companies which export a considerable share of their production; it is possible that with this new classification the differences between the two groups of companies would become even greater.

The variables present in the survey chosen to reflect the adoption of environmental innovations were:

- Factors motivating the company to innovate (from 1994 to 1996): environmental preservation –indicates the degree of importance given by the answering company to the strategy of environmental preservation as a motivation factor to innovate. Possible answers: indifferent, less important, important, very important, or crucial.
- Investment: changes in the production process for environmental reasons (from 1994 to 1996). Possible answers: yes/ no.

Table 29 shows the relationship between the first variable and the origin of capital. The vast majority (85.5%) of the firms with global interests consider the strategy of environmental preservation to be important, very important, or crucial as a motivation factor for the company to innovate. This percentage falls to 78.4% for domestically owned companies. This shows that most of the companies are more inclined to innovate because of environmental questions, and that this behavior is more evident in the companies with global interests.

Table 29: Degree of importance of the environment protection strategy as a factor which motivated the firm to innovate, according to their ownership – 1996

		FIRM'S CAPITAL OWNERSHIP (IN 12/31)			
FACTORS WHICH MOTIVATED THE FIRM TO INNOVATE – ENVIRONMENT PROTECTION (94-96)	**Data**	**1 = NATIONAL**	**2 = FOREIGN**	**3 = NATIONAL AND FOREIGN**	**Total**
1 = INDIFFERENT (A)	**Number of firms**	**1,095**	**10**	**16**	**1,121**
	Percentages A/F	**14.7**	**3.3**	**14.8**	
2 = LESS IMPORTANT (B)	**Number of firms**	**518**	**22**	**12**	**552**
	Percentages B/F	**6.9**	**7.2**	**11.1**	
3 = IMPORTANT (C)	**Number of firms**	**2,361**	**113**	**22**	**2,496**
	Percentages C/F	**31.6**	**36.8**	**20.4**	
4 = VERY IMPORTANT (D)	**Number of firms**	**2,458**	**109**	**41**	**2,608**
	Percentages D/F	**33.0**	**35.5**	**38.0**	
5 = CRUCIAL (E)	**Number of firms**	**1,028**	**53**	**17**	**1,098**
	Percentages E/F	**13.8**	**17.3**	**15.7**	
Total No. of firms (F)		**7,460**	**307**	**108**	**7,875**

Source: Fundação Sistema Estadual de Análise de Dados - SEADE. Pesquisa da Atividade Econômica Paulista –

PAEP 1996.

Table 30 presents the companies which did or did not invest in changes in the production process aiming at the reduction of environmental problems. Again, the companies with global interests showed a different behavior, with 40.8% answering positively, as compared to only 18.3% of the domestically owned companies. Therefore, it can be concluded that companies with global interests tend to be more prone to adopt environmental innovations than the domestically owned ones, even though most of the latter also consider the environment a factor that induces innovation.

Table 30: Firms that made investments in changes in their production processes for environmental reasons, according to their ownership – 1996

	FIRM'S CAPITAL OWNERSHIP (IN 12/31)			
INVESTMENT – CHANGES IN PRODUCTION PROCESSES	**1 = NATIONAL**	**2 = FOREIGN**	**3 = NATIONAL AND FOREIGN**	**Total**
1 = YES (A)	**7,294**	**251**	**92**	**7,636**
Percentages A/C and B/C	**18.3**	**43.1**	**35.5**	**18.7**
2 = NO (B)	**32,674**	**331**	**167**	**33,173**
Percentages A/B and B/C	**81.7**	**56.9**	**64.5**	**81.3**
Total of firms (C)	**39,968**	**582**	**259**	**40,809**

Source: Fundação Sistema Estadual de Análise de Dados - SEADE. Pesquisa da Atividade Econômica Paulista – PAEP 1996.

Another possible hypothesis is that innovative firms are the ones with the highest investment in R&D. In other words, companies spending more resources in R&D are more inclined to adopt innovations, including environmental ones. The variable chosen to reflect R&D efforts was "Internal sources for innovation activities, 1994 to 1996 – R&D department," indicating the degree of importance of the internal department of R&D as a source of innovation development inside the company. The possible answers were indifferent, less important, important, very important, or crucial.

Table 31 shows the proportion of companies that invested in changes in the production process aiming at the reduction of environmental problems, according to the importance attributed to their internal R&D department for the innovative behavior of the company. The higher the importance of the R&D department, the greater the proportion of companies that invested in changes in the production process to solve environmental problems. Thus, only 28% of the companies that declared indifference to internal R&D department invested in changes in the production process. This proportion rises to 49% for the companies that declared that their own R&D departments were crucial for the innovation process inside the firm.

Table 31: Firms that invested in changes in their production processes for environmental reasons, according to the degree of importance of their own R&D department – 1996

		INTERNAL SOURCES OF INNOVATIVE ACTIVITIES – R&D DEPARTMENT (94-96)					
INVESTMENT – CHANGES IN THE PRODUCTION PROCESSES	**Data**	**1 = INDIFFERENT**	**2 = LESS IMPORTANT**	**3 = IMPORTANT**	**4 = VERY IMPORTANT**	**5 = CRUCIAL**	**Total**
1 = YES (A)	**Number of firms**	**242**	**193**	**1,277**	**789**	**380**	**2,880**
	Percentages A/C	**27.8**	**38.3**	**39.6**	**42.6**	**49.0**	**39.9**
2 = NO (B)	**Number of firms**	**629**	**311**	**1,945**	**1,063**	**395**	**4,343**
	Percentages B/C	**72.2**	**61.7**	**60.4**	**57.4**	**51.0**	**60.1**
Total of firms (C)		**871**	**504**	**3,221**	**1,852**	**775**	**7,223**

Source: Fundação Sistema Estadual de Análise de Dados - SEADE. Pesquisa da Atividade Econômica Paulista – PAEP 1996.

Table 32 shows the relationship between the degree of relevance attributed to preservation as a motivation factor for innovation and the degree of importance of the internal R&D department. The results point out that there is an increase in the proportion of companies that consider relevant to invest in internal R&D activities according to the importance attributed to the environment as a motivation factor for innovations.

Table 32: Degree of importance of the environment protection strategy as a factor which motivated the firm's innovation according to the degree of importance of their own R&D department – 1996

	INTERNAL SOURCES OF INNOVATIVE ACTIVITIES – R&D DEPARTMENT (94-96)					
FACTORS WHICH MOTIVATE INNOVATION – ENVIRONMENTAL PROTECTION (94-96)	**1 = INDIFFERENT**	**2 = LESS IMPORTANT**	**3 = IMPORTANT**	**4 = VERY IMPORTANT**	**5 = CRUCIAL**	**Total**
1 = INDIFFERENT (A)	**182**	**46**	**296**	**151**	**132**	**808**
Percentages A/F	**25.2**	**10.4**	**10.8**	**9.8**	**21.0**	**13.3**
2 = LESS IMPORTANT (B)	**49**	**56**	**164**	**111**	**65**	**447**

Percentages B/F	**6.8**	**12.7**	**6.0**	**7.2**	**10.4**	**7.4**
3 = IMPORTANT (C)	**221**	**157**	**933**	**337**	**137**	**1,784**
Percentages C/F	**30.6**	**35.6**	**34.1**	**21.9**	**21.8**	**29.4**
4 = VERY IMPORTANT (D)	**201**	**153**	**914**	**599**	**195**	**2,062**
Percentages D/F	**27.8**	**34.7**	**33.4**	**38.9**	**31.0**	**34.0**
5 = CRUCIAL (E)	**69**	**29**	**429**	**341**	**99**	**967**
Percentages E/F	**9.6**	**6.6**	**15.7**	**22.2**	**15.8**	**15.9**
Total of firms (F)	**722**	**441**	**2,737**	**1,539**	**628**	**6,067**
Source: Fundação Sistema Estadual de Análise de Dados - SEADE. Pesquisa da Atividade Econômica Paulista – PAEP 1996.						

The results above confirm that companies investing internally in R&D are more able to generate or adopt innovations, including the ones destined to environmental issues. Companies attributing a higher degree of importance to their R&D departments are the ones with higher positive answers in terms of innovation in processes (carried out to reduce environmental damage), and perception of environmental restrictions as a motivation factor in the innovation process.

Export-Oriented Firms

In the previous section, it was shown that foreign owned firms have a better perception of environmental issues than do those owned by nationals. The objective of this section is to show that a similar trend is also true for export-oriented companies, independently of their capital ownership. In other words, the pressure for better environmental performance is more clearly perceived in the companies that are more exposed to the global economy.

According to table 33, the companies that have declared the environment to be a business opportunity (instead of a restriction) tend to present a higher level of exports. The contrast is more accentuated for domestically owned companies, but the higher perception of the potential for "green" business is found among the foreign owned.

Table 33: Average % of exports over total sales, according to the origin of capital and the consideration of the environment as business opportunity

		Environment as business opportunity		
Origin of capital		**Yes**	**No**	**Average % exports**
Domestic	**Average % exports**	**1,04**	**0,66**	**0,77**

Foreign	**Average % exports**	**9,40**	**8,94**	**9,19**
National and foreign	**Average % exports**	**7,39**	**5,99**	**6,64**
Total Global		**1,32**	**0,76**	**0,93**
Source: SEADE/PAEP				

Table 34 confirms that companies that admit the possibility of market losses because of environmental consequences of their activities are also more export-oriented – the export average of those who answered yes is more than double the average of those who answered no. The results of table 35 also point in the same direction – i.e. the firms that declared that they had costs in activities related to the environment have a higher proportion of exports in their total sales. Considering only the domestically owned companies, the export average of those that answered positively (2.03%) is almost four times the export average of those that declared that they did not have this kind of expenditure (0.55%). This difference is also significant for foreign owned companies.

Table 34: Exports over total sales according to the origin of capital and the effect of losing markets because of the environmental consequences of their activities

		Environmental effects: market losses		
Origin of capital		**Yes**	**No**	**Average % exports**
Domestic	**Average % exports**	**1.47**	**0.74**	**0.77**
Foreign	**Average % exports**	**15.21**	**8.20**	**9.07**
National and foreign	**Average % exports**	**11.35**	**6.20**	**6.69**
Total average % exports		**2.14**	**0.87**	**0.93**
Source: SEADE/PAEP				

Table 35: Exports over total sales according to the origin of capital and the effect of increasing costs because of activities related to the environment

		Higher costs because of environmental activities		
Origin of capital		**Yes**	**No**	**Average % exports**
Domestic	**Average % exports**	**2.03**	**0.55**	**0.77**
Foreign	**Average % exports**	**13.55**	**5.87**	**9.07**

National and foreign	**Average % exports**	**6.72**	**6.67**	**6.69**
Total average % exports		**2.55**	**0.63**	**0.93**
Source: SEADE/PAEP				

Finally, it is important to make some comments on sectoral differences. Table 36 shows, for each industry, the exports average according to selected variables: products and processes perceived as environmentally friendly; costs incurred because of environmental activities; investments in the substitution of contaminating inputs; and investments in process modification in order to reduce environmental stress. The answers are not homogeneous in every sector, but in most sectors the data confirm the relationship between a higher concern with the environment and a greater importance of exports in total sale. Some aspects deserve attention: the questions where differences in the answer patterns refer to costs already incurred for environmental matters in the sectors with higher export profile (footwear; motor vehicles; machinery and equipment, pulp and paper); and the difference between the average export proportion among firms is considerable among firms declaring concern with environmental issues and the ones declaring the opposite. The most important exception to this pattern of answers refers to petroleum refineries and alcohol distilleries.

Table 36: Environmental perception and exports over total sales, by sector

	Environment as business opportunity		Higher costs because of environmental activities		Investment in the substitution of pollutant inputs		Investment in environmentally friendly processes	
Sectors	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Mineral extraction	**0.66**	**0.15**	**0.40**	**0.39**	**0.12**	**0.43**	**0.49**	**0.31**
Refineries & alcohol dist.	**3.40**	**3.80**	**3.05**	**4,.82**	**1.21**	**5.15**	**1.04**	**5.44**
Chemical products	**1.86**	**2.21**	**3.07**	**1.47**	**2.89**	**1.67**	**2.92**	**1.54**
Rubber and plastic products	**0.56**	**0.33**	**0.98**	**0.31**	**0.79**	**0.34**	**0.57**	**0.37**
Non-metallic minerals	**0.57**	**0.81**	**1.53**	**0.59**	**2.46**	**0.53**	**1.88**	**0.52**
Metallurgy (basic)	**1.38**	**0.37**	**1.57**	**0.45**	**1.18**	**0.53**	**0.94**	**0.59**
Metallic products (excl. machinery and equipment)	**0.72**	**0.44**	**1.38**	**0.34**	**1.31**	**0.38**	**1.15**	**0.35**
Pulp and paper	**1.45**	**0.54**	**2.50**	**0.50**	**3.19**	**0.38**	**2.67**	**0.42**
Food and beverages	**1.70**	**0.64**	**2.86**	**0.42**	**3.76**	**0.59**	**2.63**	**0.50**
Textiles	**1.46**	**0..50**	**1..54**	**0.56**	**1.93**	**0.54**	**1.70**	**0.55**

Wearing apparel	**0.04**	**0.13**	**0.15**	**0.11**	**0.09**	**0.11**	**0.05**	**0.12**
Leatherware	**5.53**	**2.23**	**16.40**	**1.64**	**8.22**	**2.25**	**12.81**	**1.86**
Machinery and equipment	**2.54**	**1.97**	**5.00**	**1.72**	**5.13**	**1.53**	**3.49**	**1.81**
Machinery for offices/computers	**0.00**	**0.84**	**10.87**	**0.10**	**4.71**	**0.11**	**6.92**	**0.11**
Electric equipment	**1.14**	**1.05**	**2.52**	**0.91**	**2.61**	**0.79**	**2.04**	**0.86**
Electronic and communications material	**2.62**	**0.90**	**2.92**	**1.26**	**3.04**	**1.13**	**1.92**	**1.36**
Medical equip., optics, industrial automation	**3.12**	**2.59**	**4.83**	**2.56**	**2.60**	**2.78**	**2.79**	**2.75**
Motor vehicles	**3.49**	**1.91**	**6.81**	**1.38**	**4.89**	**1.67**	**4.80**	**1.75**
Other transportation equip.	**1.06**	**2.84**	**6.97**	**1.42**	**4.96**	**1.95**	**2.25**	**2.39**
Other industries	**0.50**	**0.53**	**1.04**	**0.44**	**0.89**	**0.47**	**0.80**	**0.47**
Total	**1.32**	**0.76**	**2.55**	**0.63**	**2.49**	**0.67**	**2.00**	**0.68**
Source: SEADE/PAEP								

The survey confirmed the hypothesis that firms with global interests are the most prone to adopt environmental innovations, even though most of the nationally owned companies or domestic-oriented also consider environmental issues a motivating factor to innovate. This counterbalances the previous sections, in the sense that shows that the process of opening the economy has some environmental advantages, as argued theoretically by many. One specific case study, to be presented in the next section – the timber industry in the Brazilian Amazon – also points to a similar effect: the growing environmental pressure in international markets has positively differentiated producers that export mainly to Western Europe and USA, and eco-labeling has been an important tool for this.

Foreign Trade and Investment in the Brazilian Timber Industry[21]

Background

An important debate is linked to the environmental performance of foreign owned companies in Brazil. This responds to the ongoing debate in the literature over whether FDI is improving or worsening environmental conditions in developing countries.

Defenders of the positive environmental aspects of globalization argue that higher competition would close down companies operating with old and inefficient equipment. A more competitive atmosphere would force them to adopt modern methods of production, which tend to be more efficient in all respects, including environmental respects (in terms of emission avoidance and reduced wastage of raw materials). The reduction of barriers to FDI would favor the import of modern, state-of-the-art equipment. Since this machinery is developed to follow the more rigorous environmental standards of industrialized countries, the acquisition of this equipment would result in an overall improvement of the environmental performance of the importing country. Moreover, according to the theory of comparative advantage, liberal trade and capital policies would favor a shift in developing countries towards labor-intensive activities, which tend to be less polluting. Finally, consumers in developed countries are more aware of the environmental standards of products they buy. This would force a more responsible behavior by multinational companies when operating abroad, either because these companies would be interested in exporting to developed countries or because they fear consumer boycott campaigns and other kinds of pressures in their headquarters.

On the other side of the debate, critics argue that under the existing institutional conditions in countries such as Brazil, globalization may magnify the effects of poor environmental enforcement, increasing the tendencies of overexploitation of natural resources in areas where policies are deficient (the "race to the bottom" hypothesis) or increasing industrial pollution (the "pollution havens" hypothesis). A basic assumption of these arguments is that the enforcement of environmental standards is weaker in countries such as Brazil, stimulating the migration of activities intensive in natural resources. The competitive pressure from the world market would make it impossible to forge the necessary political support at home to upgrade standards and control policies that would deter the environmental degradation.

We start by assessing the debate through an analysis of general production before moving to the specific case of forest production. The results of general theoretical and empirical studies are often contradictory, and there is no definitive answer to the opposing arguments outlined above. Ulph (1998) comments:

> (Our) recent analysis is capable of providing starkly different predictions of environmental policy under liberalised trade regimes from those derived from the traditional literature, but there is a severe problem of non-robustness of results. This is especially problematic when it comes to trying to draw policy conclusions from this new literature, although (this) analysis does not support some of the policy prescription discussed in popular debates (Ulph 1998, p.237-238).

Empirical studies for the Brazilian industry confirm these apparent contradictions. There is a huge gap in reliable data for indicators of environmental impact. In the absence of actual observations on environmental impact, one possible proxy is to use emission coefficients that assume fixed ratios between production output and pollutant emissions for different products. Using these emission coefficients, it was shown that the industrial output of products with high-pollution potential has consistently grown above the average of the industry, and that Brazilian industrial exports present a much higher intensity of potential emissions (i.e. kg of pollutant per unit of output) than the output that is destined to domestic markets (Young, 1998, 2001a; Young and Lustosa, 2001).[22] In other words, Brazilian industrial exports have become more specialized in potentially "dirty" products over time, confirming the pessimistic perspective of more concentration of these activities in the Third World.

However, the use of fixed emission coefficients does not capture the efforts by firms to improve their environmental performance and the resultant technological changes in production. In order to evaluate the importance of environmental reasons in the investment decisions, a series of empirical studies have analysed the survey of economic activities in the State of São Paulo (PAEP), which refers to voluntary answers from 43,900 industrial and commercial firms for the year 1996. Lustosa (2002) and Young and Lustosa (2001) show that foreign owned companies (and also those with higher exports/output ratio) tend to be more concerned with environmental issues, to invest more in "cleaning" their production processes, and to perceive the competitive advantages of environmental innovations. Ferraz and Seroa da Motta (2002) indicate that these differences are statistically significant in a model that estimates the causes of any firms' expenditures in environmental protection. The trend towards higher environmental standards in foreign owned or exporting companies is compatible with the hypothesis that the trade and capital openness process tends to encourage the adoption of environmentally sound practices and products.

In spite of methodological limitations, our assessment is that globalization has resulted in a dual movement within the Brazilian economy: the growing specialization in the supply in products based on natural resources (including in this category manufactured goods with higher pollution potential), and increasing environmental awareness by the companies with international interests (foreign owned or exporters). However, regional and sectoral differences are also relevant factors that must be considered in the analysis. For this reason, the following sections focus on the wood-chain activities (logging in native forests, planted forests, pulp and paper, charcoal and furniture).

The Links between the Current Forestry Framework, FDI, and Sustainable Forestry in Brazil

The main pattern of deforestation in the Amazon is the conversion of forest land into pastures or cultivation areas with most deforestation occurring in Pará, Mato Grosso and Rondônia. The extraction of commercially valuable logs is an important co-product of this process. In many cases, revenues from this unsustainable pattern of logging finance the investment in land conversion or pasture restoration, particularly for those without access to credit. Many studies show how logging, ranching and cultivation systems become linked (Veríssimo *et al.*, 1992; Toniolo and Uhl 1992; Ozório de Almeida and Campari 1995; Young 2001b). Three common links include:

- Paths opened to extract the logs are used by farmers to move ahead into forest areas.
- Loggers finance pasture reforms in exchange for timber.
- Many of the farms that have cultivation have also small cattle herds.

The sawmill centers in the Amazon follow a mobile frontier with few official or social controls, and this mobility discourages investment in improved technology and the capacity for sustainable management. Given the low capital intensity of this dispersed mobile production there is little need or incentive for FDI in these situations.

In terms of FDI, one perception is that foreign firms are complicit in unsustainable practices, a view reinforced by news headlines about the apprehension of foreign firms' illegal loads of mahogany destined to foreign markets such as the United States. However, a glance at the magnitude of the internal market (table 37) suggests that unsustainable forest use is much more likely to be linked to Brazilian-owned companies whose production is destined for domestic markets.

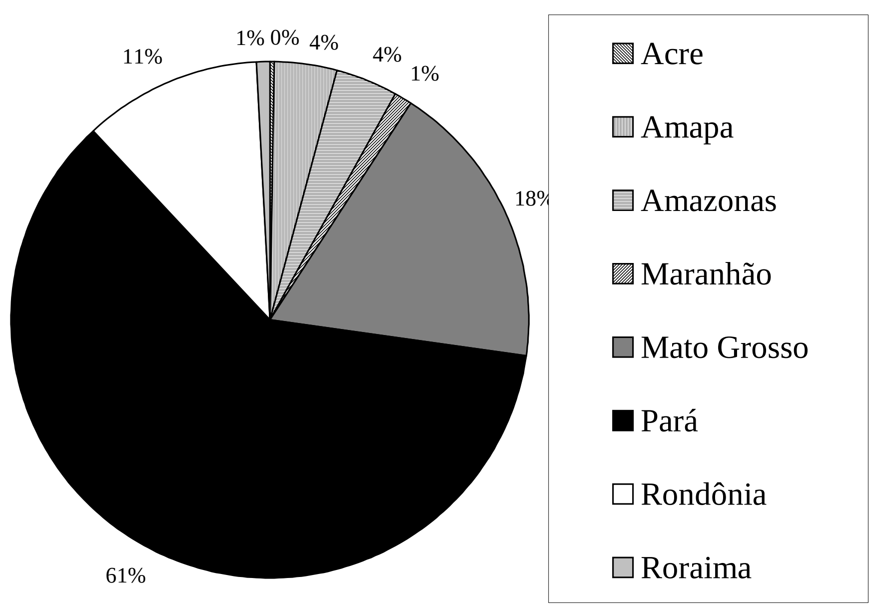
Table 37: Consumption of Brazilian Amazon timber, 1997

Destination	Foreign markets	Brazilian Amazon	State of São Paulo	Rest of Brazil
Millions of m^3	4.0	2.7	5.6	14.0
% of total	14%	10%	20%	56%
Source: Smeraldi and Verissimo (1999)				

In assessing the patterns of FDI it is useful to look in more depth at the pattern of exports from Brazil (although it is worth noting that there is no *a priori* reason why FDI should lead to exports, nor that Brazilian firms are not equally involved in exports). There is a distinct division between states that are linked to Southern Brazilian markets by road transport and those that are not. The most important exporter states in the Amazon in absolute terms are Pará, Mato Grosso, and Rondônia (all linked to Southern markets by road), (figure 1 and table 38). These three states are dominated by the domestic market and by timber from land clearance due to settlement.

The state of Pará is the single largest exporting state in Brazil, although the domestic market still greatly exceeds the export market. The main international markets from Pará are the United States, Western Europe (mostly France, Spain, the Netherlands and Portugal) and, more recently, China. In spite of the presence of relatively large foreign-owned companies (see table 38), most of the production is controlled by Brazilian capital.

Figure 1: Timber exports by source, 2001



Source: Own elaboration, using SECEX data

Table 38: Evolution of timber exports by origin, 1990/2001 (US$ 1000)

	Acre	Amapá	Amazonas	Maranhão	Mato Grosso	Pará	Rondônia	Roraima	Tocantins	Subtotal Amazon	Other states	Brazil
1989	1664	4322	10883	434	6462	126041	12320	0	0	162125	247411	409536
1990	2168	2893	12126	1110	6850	138612	7755	0	0	171513	254478	425991
1991	1993	475	11185	1567	10486	141205	12094	20	0	179024	262972	441995
1992	1784	656	18730	2610	8619	172069	12516	298	101	217383	349711	567094
1993	3444	9639	32129	4253	14651	259705	19163	962	21	343968	495944	839911
1994	3964	18685	37429	6158	24906	324538	19275	743	84	435781	611325	1047107
1995	5134	15509	37157	7114	22757	346632	25346	421	0	460070	671328	1131398
1996	2381	56940	28312	4119	30678	300860	22670	865	64	446891	658860	1105751
1997	109	27265	38217	2250	37270	330775	28938	682	164	465670	747969	1213639
1998	262	37863	26101	1768	29016	255041	29448	1098	20	380618	739363	1119981
1999	899	26499	22849	2933	58148	277630	43122	1520	0	433600	950454	1384054
2000	949	21501	19078	4142	77628	309031	55226	2281	0	489837	984425	1474261
2001	1103	18117	18015	5810	84308	286265	52426	3487	0	469530	1017558	1487088

Source: Own elaboration, using SECEX data

Mato Grosso is the second largest exporter, although its exports are less than one-third of those of Pará, even though extraction in both states is of about the same magnitude. However, there is a recent trend of exports expansion in Mato Grosso, concentrated in plywood, veneered panels and similar laminated wood (around 70% of the total), and sawn wood (around 25%) linked to graded taxation for added value processing. The most important markets are Europe (60%) NAFTA (20%) and Mercosur, although the latter market is losing ground to Japan and other Asian countries. The expansion of Asian demand shows that there remains space for expanding non-certified timber exports to markets that are not as environmentally conscious, as argued by those who believe that there would be a spontaneous greening of tropical timber markets. The situation in the state of Rondônia is very similar to the one in Mato Grosso, with limited exports and strong domestic demand.

Amazonas is only the fifth largest exporter, but in this case exports can be considered the main source of demand. This is primarily related to the state’s natural isolation, with no perennial roads connecting to the southern markets. There is also a lower density of commercial species in the state's forests and a low level of agricultural settlement due to low population. Under these conditions, there has been much less domestic interest in timber activities, explaining the relatively high proportion of export-oriented companies. This also explains the higher proportion of foreign-owned firms and a more concentrated industrial profile than in the neighboring states. The main destination markets are the United States and Western Europe.

Within the state of Amazonas, the main production center is in Itacoatiara, 250 km from the state capital Manaos. The most important companies are foreign-owned – Gethal (owned by US investors), Carolina (Asian investors), Mil (Swiss investors) and Braspor (Portuguese investors) – and their production is almost completely directed towards foreign markets. Indeed, these four companies were responsible in 1997 for 67% of the total value in wood exports from Amazonas and more than 13% of the total state exports.

Another difference in Amazonas is that property rights are better defined, thus allowing the logging companies to buy land and to ensure reliable sources for their forest management plans. As a consequence, in spite of localized problems, corruption is much less a problem in the Amazonas sawmill industry than in the rest of the region. Altogether, it can be said that export-driven logging activities in Amazonas represent a lower threat to forest preservation than in other parts of the region, where the activity is much more domestically oriented.

It is clear, therefore, that contrary to some domestic opinion, FDI and international trade in wood products is not, *per se*, a more important cause of deforestation than domestic ownership and trade. However, for specific areas or tree species (mainly mahogany), one cannot rule out its potential negative impacts.

Changing Patterns of Industrial Structure Linked to FDI

The industrial structure of the Brazilian forest sector is made up primarily of numerous non-integrated firms (table 39, from May and da Vinha, 2003). It can be seen 81.1% of all firms have nine or fewer employees, and that many of these smaller firms pay lower salaries and use informal labor (May and da Vinha, 2003). The few larger firms in forestry operations, processing industries, and furniture manufacture tend to pay higher salaries and use officially registered staff.

Table 39: Firms, employees and salaries in wood products industries in Brazil - 2000

Classification of activities by number of total employees	Number of firms		Total personnel		Salaried (officially registered) personnel		Average salary per employee R$/yr
Forestry industries	**4.653**	**100%**	**63.571**	**100%**	**57.006**	**89.7%**	**3497**
to 4	3.301	70.9%	5.120	8.1%	982	19.2%	1254
5 to 9	474	10.2%	3.147	5.0%	2.176	69.1%	2658
10 to 29	510	11.0%	8.552	13.5%	7.698	90.0%	2843
30 to 49	162	3.5%	6.237	9.8%	5.957	95.5%	3078
50 to 99	122	2.6%	8.398	13.2%	8.188	97.5%	3631
100 to 499	70	1.5%	13.682	21.5%	13.575	99.2%	4457
500 and over	14	0.3%	18.435	29.0%	18.430	100.0%	3935
Processing industries	**28.069**	**100%**	**255.849**	**100%**	**214.226**	**83.7%**	**3762**
0 to 4	19.058	67.9%	31.923	12.5%	7.294	22.8%	1154

5 to 9	3.772	13.4%	24.949	9.8%	18.131	72.7%	2560
10 to 29	3.664	13.1%	58.926	23.0%	52.010	88.3%	3106
30 to 49	748	2.7%	28.029	11.0%	26.584	94.8%	3555
50 to 99	533	1.9%	36.254	14.2%	35.135	96.9%	3849
100 to 499	270	1.0%	52.795	20.6%	52.142	98.8%	5284
500 and over	24	0.1%	22.973	9.0%	22.930	99.8%	6996
Fabrication of furniture	**27.656**	**100%**	**242.574**	**100%**	**200.877**	**82.8%**	**4654**
0 to 4	19.015	68.8%	33.405	13.8%	8.018	24.0%	1284
5 to 9	3.958	14.3%	25.925	10.7%	18.821	72.6%	2721
10 to 29	3.252	11.8%	52.830	21.8%	46.676	88.4%	3621
30 to 49	685	2.5%	26.073	10.7%	24.730	94.8%	4252
50 to 99	452	1.6%	31.122	12.8%	30.173	97.0%	4941
100 to 499	270	1.0%	52.966	21.8%	52.271	98.7%	6822
500 and over	24	0.1%	20.253	8.3%	20.188	99.7%	9785
Source May and Vinha, 2003 from IBGE online database, 2003.							

These recent analyses of the Brazilian forest sector might be thought to provide a rather bleak general picture for potential acquisitions or greenfield investments (although there are some differences by state and many notable exceptions). The mobility of the numerous small timber firms, coupled with outdated machinery, limit much production to low quality sawn wood.

For example, Veríssimo *et al.* (2002) estimate that in the estuarine areas of the Amazonas and Pará rivers in 1998, there were 458 sawmills equipped with circular saws. The direct employment was 2,800 workers (all in the informal labor market), and the output was 128,000 m^3 of sawn wood (from 357,000 m^3 of logs). There was no further processing beyond basic sawing and the industry was undergoing both rapid turnover and rapid decline. Almost half (49%) of the firms had been established in the preceding three years since 1995. The number of sawmills was considerably lower than the estimate made five years earlier by Barros and Uhl (1993) for the same region (at which time there were 1,195 firms consuming 2.1 million m^3 of logs for a production of 780,000 m^3 of processed wood). The causes of declining production were identified to be the accelerated depletion of natural reserves (the sawmills were processing only low quality timber, indicating the exhaustion of more valuable species), more rigid control by the authorities, and competition from low quality timber from other parts of the Amazon (Veríssimo *et al.*, 2002).

This myriad of small scale suppliers is competing mainly on price rather than quality or other non-price characteristics and, given their large number, do not have much market power to influence the price they receive. Intermediaries play an important role and it is believed that they capture much of the forest rent, especially for the export market, which is oligopsonistic (many producers but few buyers). This creates a vicious cycle: with low rents and difficulties accessing credit, these firms have strong limitations to investment and, therefore, have to remain attached to the frontier process.

FDI within such a system might be expected to change little. If foreign investors only engage with the "upper" parts of the timber chain, they strengthen the role of the dealer, usually without much impact on how the wood was harvested. Such investment might be focused only on the most valuable species, with a high dependence on a small number of them, particularly mahogany. Since foreign companies are usually linked to international markets, they would capture most of the rents involved (buying cheap raw material and selling the processed product at much higher prices). There would be no need to invest in costly capital costs associated with forest management. There are certainly examples of this type of behavior.

Contrasting trends can also be found, however, and FDI in the Brazilian timber sector can also be shown to have strong links with stability of tenure and investment in management. Data is scarce, and we base our findings on previous studies on the issue - Greenpeace (2001), Cotton and Romine (1999) and Viana (1998) – complemented with information provided by 15 companies on their web sites.

The total stock of foreign capital in forest exploration and related activities (inclusive of planted forests) was US$ 87.7 million. This number is only 0.1% if compared to the total stock of foreign capital in the Brazilian economy. This means that the impact of foreign investment in native forest activities has been more of a qualitative character than a quantitative one. Nevertheless, foreign owned firms are comparatively large and operate relatively more in downstream activities. So despite only comprising 1% of all firms in the forest products sector according to Cotton and Romine (1999), it was estimated that firms with foreign investment are responsible for 3% of the volume of timber extracted, between 8% and 12% of the volume of semi-processed wood (sawn wood and wood-based panels) and 25% of wood exports.

There is no prevailing country in terms of the origin of FDI. European, North American and Japanese companies have been established in the region for some time. In the mid-1990s, after the collapse of Southeast Asian reserves, there were expectations of a massive wave of Asian companies migrating to the Amazon. Even though some companies did invest, mainly Malaysian and Chinese, the volume of FDI was much lower than originally expected. The destination of the exports of foreign owned firms is quite varied, with a distribution similar to the destination of the industry as whole (table 40).

Table 40: Characteristics of the Brazilian subsidiaries of international timber firms: export destination and origin of investment

Brazilian Subsidiaries	State	Matrix/origin of the investment	Estimated Capacity (logs/year/m^3)	Exports - 1997 (US$)	Main destination markets	Extraction in own land/estimated capacity (%)	Certified (if yes, Certification Program and type)
Amacol	Pará	Larson Wood Products (USA)	90,000-144,000	12,000,000	USA	n.a.	No
Amaplac and WTK Florestal	Amazonas	WTK Group (Malasya)	36,000-51,408	6,351,950	UK; Belgium; USA; Denmark; Germany	64% - 91%	No
Braspor	Amazonas	Portuguese Group	n,a,	n,a,	n.a.	n.a.	Yes (FSC, chain of custody)
Cifec (China International Forestry Corporation)	Amazonas	China State Enterprise	n,a,	n,a,	USA	n.a.	No
Compensa	Amazonas	Tianjin Fortune Timber (Chinese Group)	30,000	8,005,878 / 1,598,000 (2000)	USA	n.a.	No
Eidai	Amazonas and Pará	Eidai Inds Inc USA (Eidai) (Japan)	225,000-321,300	31,683,771	USA, Japan & UK	63% - 90%	No
Eldorado	Pará	French Group	42,000	17,495,806	France, Haiti, Ireland, Spain, USA	n.a.	Yes (FSC, chain of custody)
Gethal	Amazonas	Westag & Getalit AG (Germany)	120,000-171,360	14,752,484	Germany; USA	45%	Yes (FSC, chain of custody and forest managem

							ent)
Janus Brasil	Pará	Janus International Inc (Sara Hallitex) (USA)	48,000-76,800	3,840,000	n.a.	n.a.	No
Jaya Tiasa Carolina Maginco Selvaplac	Amazonas and Pará	Rimbunan Hijau (Malasya)	621,006-886,797	27,022,532	USA, Europe, South Korea	6% - 9%	No
Lawton	Pará	Lawton Lumber Company (USA)	37,500 - 60,000	3,205,575 (1996) / 2,500,000 (1998)	USA	n.a.	No
Mil Madeireira	Amazonas	Precious Woods (Swiss Group)	60,000-70,000	83,717 (1996)	Netherlands	63% - 56%	Yes (FSC, forest management)
Nordisk	Pará	Dahlhoff, Larsen & Horneman AS (Denmark)	n,a,	20,401,105	Argentina, Belgium, Caribbean, Denmark, France, Netherlands, Portugal, UK, USA	n.a.	Yes (FSC, chain of custody)
Robco	Pará	Robinson Lumber Co Inc (USA)	n,a,	7,733,753	USA, Philippines & UK	n.a.	No
Terra Resources (or Equatorial Resources)	Pará	Grupo Nevada Manhattan Inc (USA)	144,000	n,a,	USA, Southern Europe, Australia and the Caribbean	n.a.	No
Sources: Cotton and Romine (1999); www.endgame.org/gtt-timberland.html , 03/26/2003; www.lvrj.com, 03/26/2003; Viana (1998); Greenpeace (2001)							

Even though the foreign owned companies tend to be larger than the domestic ones, the level of concentration is not high if compared to other industrial sectors in Brazil. Using data from the

Inventory of Companies of the Brazilian Institute of Geography and Statistics (IBGE), Herfindahl indexes of industrial concentration were estimated for the wood-based sectors and the economy as a whole. Table 41 shows that the concentration in the forestry sector is only slightly higher than the Brazilian average, but considerably smaller than in the pulp and paper sector.

Table 41: Herfindahl Indexes for the Main Forest Activities in Brazil, 2000

Economic activities	Herfindahl index
Forestry operations	1849.0
Processing industries (minus pulp and paper)	1688.1
Pulp production, paper and paper products	2562.8
Furniture production and diverse industries	1643.1
Brazil (all activities)	1813.0
Source: Cadastro de Empresas research, IBGE	

A considerable part of extraction is done on the companies' own land, indicating that investment in land purchasing is an important cost element. This is a way to assure long term supply and, for those interested in certification, to guarantee that the chain of custody is carried out without environmental problems – a very difficult thing with third party suppliers. In that sense, there is no expectation of a "race to the bottom" fueled by foreign capital.

Most of the FDI in the sector comes through acquisition of already existing companies. Greenfield investment usually comes through joint-ventures, in many cases including Brazilian owned companies. Table 42 presents a short description of the history of FDI in a selected number of companies.

Table 42: FDI history for selected companies

Amaplac and WTK Florestal	The Malasyan group WTK is the oldest of the "big five" Sarawak timber giants. Its operation in Brazil began in 1997, when it bought the Brazilian firm Amaplac for US $7 million. A large area of 300 thousand hectares in eastern Amazonia was also purchased by WTK for the approximate price of US $2.4 million.
Cifec	In the beginning of the 1990s, the China state enterprise China International Forestry Corporation acquired a traditional Brazilian logger company named Cifec Compensados da Amazonia Ltda. Afterwards, in 1994, they also bought another Brazilian firm (Compensados Manasa).
Compensa	Compensa was founded in 1958 by a Brazilian entrepreneur and in 1996 it was acquired by the Chinese group Tiajin Fortune Timber, which controls 90% of its shares.
Eidai	Founded in 1972 as a joint venture between the Japanese firms Mitsubishi Corporation and Eidai Corporation. The later acquired total control of Eidai in 1997.
Eldorado	Founded in 1985 as an Brazilian firm and acquired in 1990 by the French group of construction materials Menuiseries Lapeyre SA
Gethal Amazonas	Gethal Amazonas was founded in 1948 in the South of Brazil. It moved its operations to the Amazon region in 1972, as wood had become scarce in the South region. In 1996, a German group bought a 25% participation in the shares of Gethal Amazonas S/A. After other changes, an American fund, GMO Renewable Resources, bought the majority of the shares (85%). The remaining shares are property of the Nilorey Group.
Janus Brasil	Janus Brasil SA is the result of a joint venture between the group Janus International and Jonasa

	Navegação do Brasil, the largest navigation company in the Amazon. It was founded in 1998.
Jaya Tiasa	Jaya Tiasa, a subsidiary of the group Rimbunan Hijau (another of the Sarawak timber giants) bought two Brazilian timber companies, Maginco Compensados S.A and Selvaplac Indústria Madereira do Pará Ltda. These companies were reorganized and renamed respectively as Maginco Verde S.A. and Selvaplac Verde S.A. Jaya Tiasa also bought the Brazilian timber company Carolina Indústria Ltda.
Mil Madeireira	Precious Woods Group, a private Swiss firm, acquired in 1994 the timber company Mil Madeireira Itacoatiara Ltda, which has been operating since the 1970s.
Nordisk	The Nordisk Group from Denmark began operation in Brazil through its Brazilian affiliate in 1982.
Robco	This very traditional American timber company was founded in the end of the XIX century. It operates in Brazil through two affiliates in the Amazon area and other large firm in the South region of Brazil
Terra Resources	Equatorial Resources was a joint venture among the American groups Nevada Manhattan Mining Inc and Equatorial Resources, and the Brazilian groups Jonasa, Ignatius Theodorou Madeiras and UAR. It was founded in 1997. After that, the Nevada Manhattan Mining Inc. group acquired all the shares of the company, and the name of the affiliate was changed to Terra Resources.

The feared "Asian invasion" did not materialize in the Amazon because of very different ecological, institutional and economic conditions compared with those in Southeast Asia. The most important distinctions include:

- Technical issues, including the diversity of species in the Amazon and low densities of high value trees.
- Visibility issues associated with international media attention on the Amazon.
- Political issues, in that despite problems of illegality, the democratization process in Brazil has created stronger mechanisms for investigating abuses and avoiding corruption.

There is no evidence for the relative impact of these regional differences. Economic issues relating to the Southeast Asian financial crisis are also likely to have played a significant role.

Conclusions

Young (2003) and Young and Prochink (2003) have shown that both international trade and FDI are expanding in the Brazilian Amazon but they constitute as yet only a tiny potion of the total investment - and certainly could not be equated with a 'foreign takeover' of the Amazon region. Most of the wood-based industries are small- and medium-scale Brazilian-owned enterprises. In contrast, FDI is associated with larger firms, and while some negative examples remain, the general impression is that FDI is connected to the consolidation of a "modern" logging sector in the region, which could be more sensitive to environmental concerns expressed mostly in foreign markets.

Another reason for expecting a different behavior from larger companies in the Brazilian logging industry – including exporters and multinationals – is related to higher fixed costs, which prevent them from migrating towards new frontier areas, as more traditional, small companies do. This encourages forest management practices, in order to maintain forest reserves to continue their activities in the future.

A good indication of this is the very low degree of deforestation in Amazonas, the state where FDI, timber trade, and industrial concentration are among the highest in the region. In contrast, in the states with the lowest ratios of exports/output and FDI (Mato Grosso and Rondônia), deforestation trends are much larger. The state of Pará, the biggest producer, is in an intermediate situation in terms of FDI and export/output ratio, but has the smallest degree of export concentration. One cannot, therefore, reliably associate export flows or FDI with deforestation trends or unsustainable management. If there is a connection, it is certainly much more complex and much less significant than the domestically oriented industry as the main driver of unsustainable logging.

The picture is, of course, heterogeneous. The fact that certification is more common among foreign owned companies that export most of their output does not mean that the expansion in FDI and timber exports will necessarily respect good environmental practices. In the group of multinational companies analyzed, there remains a large number of non-certified firms. The expansion of exports from Rondônia and Mato Grosso – states where forest management remains incipient – shows that there remain consumers willing to buy timber without much questioning of its origin.

Conclusions and Policy Recommendations

The debate about the environmental consequences of trade openness cannot be summarized by simplistic positions such as that trade-oriented policies are good (or bad) for the environment. The links between competitiveness and the environment are complex, and the exercises above showed that there are empirically sound arguments for both positions.

In an input-output perspective, using constant coefficients for industrial emissions, it was observed that the production chain associated with Brazilian industrial exports is more emission intensive than the production chains oriented towards domestic markets. This trend was observed for most of the pollution parameters analyzed, showing that the Brazilian industry has been relatively specialized in the supply of potentially polluting goods to international markets. This result is, thus, compatible with the hypothesis that developing countries tend to concentrate "dirty" industries that become less competitive in developed countries because of tighter environmental controls.

This process was, nevertheless, counterbalanced by the emissions "savings" created by the fast expansion of imports in the 1990s. Because they are produced abroad, there is the avoidance of emissions associated with the import goods. Note, however, that this counterbalancing effect was much attenuated by the composition of the import goods basket, compared to the exports: the growth in industrial imports was concentrated in relatively clean activities, particularly those with higher intensity in technology (electronics, for example), while the structure of industrial exports remained associated with more emission intensive sectors. Therefore, the overall reduction in the (potential) emission of pollutants in the Brazilian industry caused by imports growth was smaller than it could have been if these imports were concentrated in "dirtier" activities (intermediate goods, for example).

Another important result was that the direct costs of introducing environmental control strategies are relatively low, considering the industry as a whole. The exercises carried out in section 6 showed that the estimated loss of exports induced by higher production costs caused by the control of water pollutants (BOD and heavy metals) would remain between 1% and 2% of the total value of Brazilian exports. In other words, the comparative advantage of being “dirty” are not as high as argued by those against more effective environmental controls. But the impacts of introducing pollution abatement measures may be very different in different sectors and destination markets. The sectors facing the highest risks of losing markets are footwear, non-ferrous metallurgic and other metallurgic goods. Another important factor is potential losses in specific markets where buyers become more environmentally conscious. In the analysis carried out, the exports destined to the NAFTA region are the ones that would require more expenditure on environmental control.

It is also important to refer to the role of innovation, which systematically changes the effective relationship between production and environmental control costs. The static nature of input-output exercises does not allow capturing the so-called technological effect, which is essentially dynamic and very difficult to measure and model. It was shown in section 4 that, based on the answers from the PAEP survey obtained from industries in the state of São Paulo, firms with international insertion tend to be more concerned about environmental issues and to invest the most in “cleaning” their production processes. Data showed that export-oriented and/or foreign capital companies tend to consider the competitive advantages of environmental innovations more seriously than inward-oriented and/or domestic capital firms do. This is associated with higher environmental standards and pressures in international markets, thus being compatible with the hypothesis that the trade and capital openness process tends to encourage the adoption of environmentally sound practices and products.

These results have important implications for policy making. First of all, it is clear that the relatively high concentration of Brazilian industrial exports in pollution-intensive activities makes these exports very sensitive to the issue of environmental barriers to trade. If there is a change in the institutional framework regulating international trade towards the acceptance of environmental criteria for imports control, as advocated by many environmentalist organizations in developed countries, there could be important losses to Brazilian industrial exports. There are two possible strategies to deal with this problem:

a) to adopt an aggressive position against the proposed changes in trade regulations, maintaining the *status quo* of no/very restricted environmental barriers in the international trade agreements; and/or

b) to enhance the environmental performance of Brazilian industries, either improving local emission standards or changing the composition of industrial exports, becoming less dependent on exports associated with “dirty” production chains.

Even though these strategies are not contradictory, they reflect different perspectives. The (a) option reflects a view that the claims for environmental restrictions in trade (and capital) flows are a short-term pressure that will not be approved in the future. However, one possible problem that may emerge in the forthcoming years is that, with the deepening of regional trade agreements such as Mercosul and possibly the Free Trade Agreement of the Americas, Brazilian producers could face competition from the exports from neighbor countries which are subject to much less environmental control – bear in mind that Brazil is a leader in Latin America in terms of environmental controls. This would be a reversal of the present situation, and in that case the

Brazilian producers could be the losers if no standardization of environmental controls is adopted.

Therefore, the second strategy seems to be a better way to deal with the problem in the long term. There is a smooth but consistent change in the perception of Brazilian policymakers towards the adoption of economic instruments in environmental management, based on the user/polluter-pays principle, and as a consequence some sectors may see short-term losses in their competitiveness. But the good news that the results above show are that this overall cost increase may be considerably less than usually thought (with the exception of some specific sectors, which could receive special compensation policies during the transition to cleaner production), and that many firms are already searching voluntarily for better environmental procedures. This is another important feature of international trade that counterbalances the original problem of specialization in emission intensive activities: the pressures of consumers in developed countries are “reaching their target,” in the sense that export-oriented and/or foreign-owned firms tend to see the potential gains from adopting environmental innovations in a different way than firms that are not exposed to these pressures.

However, this transition towards a more environmentally sound economy cannot rely on a *laissez-faire* belief that the simple exposition of Brazilian firms to the market will move towards the desired situation. One important step is the push for economic instruments for environmental management already referred to, allowing flexible but efficient measures to improve environmental standards. This must be combined with industrial policies aiming at the spread of win-win environmental innovations (energy and other inputs savings; better access to markets, particularly in developed countries; higher quality and efficiency standards associated with changes in processes associated with environmentally-friendly measures; etc.). Some examples of these policies are:

1. Support for the technological capacity-building of firms in environmentally related technologies;

2. Better dissemination of new technologies in the productive sector;

3. Improvement of educational and technical skills of the labor force;

4. Improvement in the quantity and quality of research centers, bringing them closer to the productive sector interests;

5. Specific programs aiming for the reduction of regional differences in environmental performance;

6. Incentives for certification programs, including through the process of public procurement; and

7. Improvement of the domestic consumer’s perception of the benefits of environmentally sound products and processes, creating a domestic market for “green” products.

Finally, it must be highlighted that the results presented in this report have important limitations concerning the methodology and hypotheses used, and that data quality is far from desirable. The improvement of data generation and the production of environmental indicators are an important need to improve our understanding about the relationship between trade and competitiveness issues and the environment. Therefore, another policy recommendation is the implementation of an effective system of environmental information connected to the already existing economic indicators.

Notes

[1] Some other arguments widely used in favor of liberalization include the fact that outward-oriented economies are better able to cope with adverse external shocks and that market-based economic system are less prone to wasteful rent-seeking activities. See Rodrik (1995).

[2] See Siebert (1977)

[3] See Low (1992) for a general discussion of trade and environment and Birdsall and Wheeler (1992) for a discussion on this issue for Latin America.

[4] See Jaffe et al. (1995) for a study on the effects of environmental regulation on the US manufacturing sector's competitiveness.

[5] Again the original name given to the colony expresses a valuable natural resource that quickly became exhausted: madeira means wood in Portuguese.

[6] There is extensive literature on the subject. A brief summary of thoughts is provided in Prebisch (1984). See Bielschowsky (1988) for a summary of the development debate in Brazil.

[7] In the mid-1980s, 320 sources (related to 116 industrial units) were emitting around 400,000 tons of pollutants annually in Cubatão. The consequences to human health were dramatic: Cubatão had the highest rate of child mortality in the state of São Paulo (72/1000) despite generating more than 3% of the country's GDP, and 18% of the local population was suffering from respiratory diseases. Vila Parisi, the village around the industrial complex, was nicknamed "the Death's Valley." However, it was the very high level of fetus malformation and other problems for newborns ("the children of pollution") that caught more attention from the public (Almeida 1997).

[8] This is easily shown if one uses the argument of the "idealized" world according to a theoretical model different from the proposed free market. For example, in an idealized world according to the Marxist-Leninist theory, any improvement towards more socialism (against almost all pro-market proposals) will unambiguously lead to rising welfare.

[9] These 13 states combined were responsible for 96% of the Brazilian manufacturing industrial output according to the 1985 Industrial Census.

[10] One adaptation was required because the above emission coefficients were based on the value added (VA) for each industrial sector. However, equation (6) refers to the total value of production (VP), including intermediate consumption. Therefore, the VA-based emission coefficients were multiplied by the VP/VA ratio for each industrial sector, in order to provide VP-based emission coefficients that could be applied to the direct and indirect effects of each category of final demand.

[11] The primary data on water emissions were scanned in the work by Mendes (1994); however the data on air emissions were not. This represents another potential difficulty for the exercise, even though the most significant problem identified in the primary data concerned the leather and footwear sector, which is not a main source of air emissions.

[12] For more detail on the construction of the IPPS database see Hettige *et al*. (1994).

[13] The IPPS also provides aggregate estimates of toxicity; however, since the interpretation of these aggregates is not an easy task, they were not considered in this analysis.

[14] On the other hand, the other option (interquartile coefficients), which consider the emissions of industries in the second and third quartiles, presents even more complicated problems, including the lack of sufficient data for some sectors, and that it is not possible to see if the coefficient has an underestimation or an overestimation bias.

[15] A similar exercise was carried out using emission control costs available in the IPPS; nevertheless, in this case, they refer to the average current costs of the US industry in emission control for the year 1994. Hence, the results were considerably smaller than those obtained using the Mendes (1994) coefficients. In order to avoid further confusion (and because the underestimation was much more significant than in the case of emission estimates and these values more precarious), these results were left out of this report.

[16] The result that cost increases are not very large is similar to the estimates of Pasurka (1984) and other studies for the United States (such as Repetto *et al*. 1994).

[17] Comptes Harmonisés sur les Échanges et l'Économie Mondiale – database on international trade organized by the Centre D'Études Prospectives et d'Informations Internationales (CEPII), Paris, France.

[18] IPEA is currently working on estimating these sector elasticities, but there were no results available at the time of concluding this report. The use of these elasticities in the future will considerably improve the quality of these estimates.

[19] This section is heavily based on Lustosa and Young (2000). Maria Cecícila Lustosa is a PhD candidate at the Institute of Economics, UFRJ, under supervision of Dr. Young. The Lustosa and Young paper is part of a number of articles that were produced "around" this study at the Research Group in Environmental Economics and Sustainable Development (GEMA) of the Institute of Economics, UFRJ. Even though not formally considered in the Terms of Reference, the inclusion of this chapter in this report is because it complements the previous analysis since it discusses the issue of the technological effect that cannot be captured in the input-output analysis carried out previously.

[20] In the PAEP/SEADE survey, companies with global interests were considered as the ones with capital ownership classified as foreign (100% of the capital is owned by foreigners) and national and foreign (at least one of the controllers is a foreigner).

[21] This section is a summary of the main findings in Young (2003) and Young and Prochnik (2003).

[22] Young and Lustosa (2002) show that this trend of increasing participation of products with higher toxicity potential in the exports basket was also perceived for Latin America.