Industrial Pollution and Export-oriented Policies in Brazil*

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Summary: 1. Introduction; 2. Export promotion policies and pollution in Brazil; 3. Industrial emission: an input-output model; 4. Conclusion.
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This paper discusses the pollution effects of the export promotion strategy carried out in Brazil during the 1980s. The study is based on the combination of water and air pollutants emission coefficients and the input-output matrix, in a way that emissions in the whole production chain are considered. The main conclusions are: a) the export chain is more emission intensive than the average of the economy, and b) the industry as a whole became more emission intensive between 1980 and 1985. These results indicate that the Brazilian strategy to minimize trade deficits in the 1980s resulted in increasing pollution problems without adequate attention to control and abatement policies and practices.

Este artigo discute os efeitos sobre a poluição causados pela estratégia de promoção de exportações adotada no Brasil na década de 80. O estudo é baseado na combinação de coeficientes de emissão de poluentes da água e do ar e a matriz de insumo-produto, de forma que as emissões em toda cadeia produtiva sejam consideradas. As principais conclusões são: a) a cadeia de exportação é mais intensiva em emissões do que a média da economia, e b) a indústria como um todo tornou-se mais intensiva em emissões entre 1980 e 1985. Esses resultados indicam que a estratégia brasileira para minimizar déficits comerciais nos anos 80 resultou em problemas crescentes de poluição sem a atenção adequada para as políticas e práticas de controle e redução.

1. Introduction

There is a fierce debate over the pollution consequences of structural adjustment policies in developing countries. Critics argue that adjusting countries have more comparative advantages in natural resource based activities,

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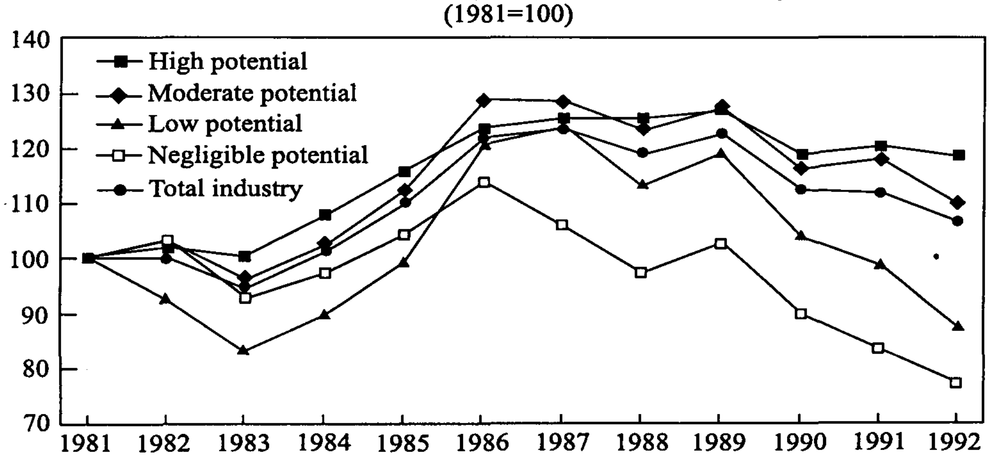
petitiveness, and modern technology tends to be less polluting. These higher efficiency standards may have resulted in better environmental practices which were not captured by the exercise.

Table 1
Evolution of the Brazilian industry according to its pollution potential (1981=100)

Year	High	Moderate	Low	Negligible	Total
1982	101.9	102.9	92.9	103.3	100.0
1983	100.1	96.6	83.4	93.3	94.8
1984	107.9	102.6	89.9	97.2	101.6
1985	115.8	112.5	99.4	104.5	110.2
1986	123.6	129.1	120.8	114.0	122.3
1987	125.5	128.7	123.8	106.3	123.3
1988	125.4	123.7	113.5	97.4	119.3
1989	127.3	127.8	119.5	102.9	122.8
1990	119.1	116.6	104.1	90.1	112.9
1991	120.7	118.3	98.7	83.9	112.3
1992	118.8	110.1	87.8	77.5	107.1

Source: Carvalho & Ferreira (1992).

Evolution of Brazilian industry according to its pollution potential (1981=100)



Source: Carvalho & Ferreira (1992).

The difference between potential and actual (i.e., after abatement measures) emission may be considerable. This is a conclusion of a series of empirical studies carried out by the Environmental Economics Research Division at Ipea (Serôa da Motta *et alii*, 1993; Mendes, 1994; Serôa da Motta, 1993a, 1993b, 1995). These studies estimated the effectiveness of abatement policy and the status of current water and air industrial emissions in Brazil, based on indicators of water and air quality for 13 states where systematic monitoring is undertaken.[1] This database was built using pollutant emission and abatement estimates for the year 1988 according to a World Bank funded project denominated Pronacop (Brazilian National Programme 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 emissions, and particulate matter, sulphur dioxide (SO_2), nitrogen oxides (NO_X) and hydrocarbons (HC).

It is important to highlight that changes in emissions do not necessarily result in more or less pollution. Topographical, climatic and other conditions are very important to determine the assimilative capacity of the environment. For example, the same amount of discharges in a large river will present different impacts than in a small pond. The same is valid for air pollution: the problem of air quality refers basically to the concentration of pollutants, which is affected by a large number of factors other than emissions. Nevertheless, it is assumed in this work that there is a positive relationship between emissions and pollution, in the sense that an increase in the level of emissions increases the probability of more pollution.

The estimates of potential emissions were obtained by multiplying the potential output of every industrial establishment registered at the states' environmental agencies by emission parameters obtained from the technical literature (most of them taken from the World Health Organization). The potential pollutant emissions estimated this way were considered as a measure of the level of pollutant emitted by the industrial establishment without any treatment.

Data on actual emissions proved to be scarce and, in some cases, available but not reliable (Mendes, 1994). Therefore, the level of actual emissions was estimated by an abatement indicator which considered the potential for emission treatment at the source point (i.e., every industrial establishment registered in the database). The indicators of potential and actual emissions were then divided by the value added of the respective industrial sectors, at

[1] *The states are: Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Rio de Janeiro, Minas Gerais, Espírito Santo, Goiás, Bahia, Pernambuco, Ceará, Maranhão and Pará. These states combined were responsible for 96% of the Brazilian manufacturing industrial output according to the 1985 industrial census.*

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:

$$x_i = \sum_{j=1}^{n} x_{ij} + C_i + I_i + G_i + Ei - Mi \tag{1}$$

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:

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

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:

$$x = Ax + d \tag{3}$$

where x is a $n \times 1$ vector with the total product of each sector, d is a $n \times 1$ vector with sectoral final demand, and A is a $n \times n$ matrix with the technical coefficients of production.

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

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

where $(I - A)^{-1}$ is the $n \times n$ 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:

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

where x_f is the $n \times 1$ vector containing the total production per sector necessary to obtain the $n \times 1$ 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.

3.2 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 Forsund, 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):

$$ef_{hi} = \frac{em_{hi}}{x_i} \tag{6}$$

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:

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

where z_{hf} is the $n \times 1$ vector containing the total emission of pollutant h per sector associated to the f-category of final demand, and $diag(ef_h)$ is the $n \times n$ matrix cointaining in its principal diagonal the emission factors of pollutant h for each sector, and zeroes elsewhere (Pedersen, 1993).

Table 6

Total (actual) emissions caused by final demand (%), Brazil, 1985

Parameters	Exports	Investment	Public administration	Private consumption	Total
Water emissions					
BOD	18.6	11.8	3.1	66.4	100
Heavy metals	29.4	34.4	1.7	34.5	100
Air emissions					
Partic. matter	19.5	42.0	2.3	36.1	100
SO_2	23.1	24.4	2.8	49.6	100
NO_X	22.7	21.9	4.0	51.4	100
HC	24.8	24.3	3.2	47.6	100

Source: Own estimate (see text). Investment includes changes in stocks.

Table 7

Emission intensity per unit of output (g/US$), Brazil, 1985

Parameters	Exports	Investment	Public administration	Private consumption	Total
Water emissions					
BOD	2.608	0.666	0.581	1.841	1.507
Heavy metals	0.074	0.035	0.006	0.017	0.027
Air emissions					
Partic. matter	13.188	11.414	2.096	4.837	7.274
SO_2	11.346	4.828	1.839	4.825	5.286
NO_X	5.629	2.179	1.304	2.524	2.667
HC	1.947	0.766	0.336	0.740	0.844

Source: Own estimate (see text). Investment includes changes in stocks.

The same problem is reflected in the intensity coefficients: for each pollutant, the amount of emission required to produce one unit of export related output exceeds the average of the economy. Indeed, the intensity of emission is higher in export related activities than in any other group for the two water emission parameters and for three of the four air emission parameters (SO_2, NO_X, and HC).

In sectoral terms, it is clear that a few sectors account for most industrial water and air emission. Most of these "dirty" industries are related directly or indirectly to export oriented activities, such as metallurgy (input for the motor car industry and other industrial export goods), paper and cellulose and footwear (leather products). The most important pollutant 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.

3.5 Comparison with the 1980 input-output table

The results presented in the previous subsection suggest that the export oriented approach adopted since the early 1980s has also resulted in higher levels of emission. In order to consider the structural changes occurred during the first half of the 1980s, the exercise was repeated but now applying the emission coefficients to the 1980 input-output table (IBGE, 1989), inflated to 1985 prices.

At that time the domestic oriented pattern inherited from the import substitution industrialization process was still prevailing. This can be seen in table 8, which shows the contribution of each category of final demand to the total output in 1980: in comparison to the 1985 results, export related activities represented a smaller share of the total output (10.8%, against the 14.2% in 1985).

Table 8
Total output directly or indirectly related to the categories of final demand, Brazil, 1980

Category	1985 (US$ millions)	% of total output
Exports	42,553	10.8
Investment	105,642	26.8
Public administration	32,101	8.1
Private consumption	214,601	54.3
Total	394,897	100.0

Source: IBGE (1989). Investment includes changes in stocks.

Even though the total output was larger than in 1985, total emissions were smaller for all the pollutants studied (see table 9).

Table 9

Total (actual) emissions caused by final demand, t, Brazil, 1980

Parameters	Exports	Investment	Public adminis-tration	Private consump-tion	Total
Water emissions					
BOD	80,275	77,026	11,128	397,110	565,540
Heavy metals	1,818	4,528	102	3,689	10,137
Air emissions					
Partic. matter	363,192	1,509,435	41,910	1,088,592	3,003,129
SO_2	308,988	601,448	33,264	1,026,394	1,970,094
NO_X	140,601	274,809	23,924	528,175	967,509
HC	44,397	97,759	5,453	149,248	296,858

Source: Own estimate (see text). Investment includes changes in stocks.

As in 1985, the contribution of export oriented activities to the total output was smaller than the share of total emission in 1980 for every pollutant studied (table 10). The two parameters in which the emission intensiveness of export oriented activities is more accentuated are heavy metals and SO_2.

Table 10

Total (actual) emissions caused by final demand (%), Brazil, 1980

Parameters	Exports	Investment	Public adminis-tration	Private consump-tion	Total
Water emissions					
BOD	14.2	13.6	2.0	70.2	100
Heavy metals	17.9	44.7	1.0	36.4	100
Air emissions					
Partic. matter	12.1	50.3	1.4	36.2	100
SO_2	15.7	30.5	1.7	52.1	100
NO_X	14.5	28.4	2.5	54.6	100
HC	15.0	32.9	1.8	50.3	100

Source: Own estimate (see text). Investment includes changes in stocks.

The consequence is that the emission intensity (emission per unit of output) was higher in export oriented activities than in the rest of the economy all parameters (see table 11).

Table 11
Emission intensity per unit of output (g/US$), Brazil 1980

Parameters	Exports	Investment	Public adminis-tration	Private consump-tion	Total	Average change 1985-80 (%)
Water emissions						
BOD	1.886	0.729	0.347	1.850	1.432	5.2
Heavy metals	0.043	0.043	0.003	0.017	0.026	6.0
Air emissions						
Partic. matter	8.535	14.288	1.306	5.073	7.605	-4.4
SO_2	7.261	5.693	1.036	4.783	4.989	6.0
NO_X	3.304	2.601	0.745	2.461	2.450	8.9
HC	1.043	0.925	0.170	0.695	0.752	12.3

Source: Own estimate (see text). Investment includes changes in stocks.

More important, the emission intensity coefficients were, on average, smaller in 1980 than in 1985 for all parameters, with the exception of particulate matter. This is a strong indication that the structural changes occurred during the 1980s towards an export oriented industry can be associated, in the Brazilian experience, with an increase in the levels of water and air emissions.

Two elements seem to be crucial to explain this phenomena. First, the completion of the II PND industrial projects, carried out as a long term answer to the balance of payment constraints caused by the oil price crisis, changed the industrial character of the economy. The programme emphasized the production of intermediate inputs which are particularly intensive in emissions, such as metallurgy, chemicals and oil extraction. The second factor has to do with the incentives created in the 1980s to export oriented sectors which are also direct and indirect sources of emissions. Paper and cellulose, footwear (related to the leather and tanning activities) and the motor car industries are examples of sectors which successfully increased their exports but are at the top of pollution intensive production chains.

4. Conclusion

Brazil undertook structural changes in its industry during the 1980s. These changes can be related to two different strategies (the II PND in the late 1970s and the export emphasis in the 1980s) that shared the same objective of improving the external accounts situation. The changes resulted in the successful achievement of trade surpluses, thus relieving the pressures generated by the burden of the external debt, through the expansion of industrial exports and the reduction of imported intermediate inputs.

However, many of the benefited sectors were emission intensive, particularly the ones at the bottom of the chain of export oriented activities (metallurgy, chemicals). The final effect was an overall increase of the emission intensity of the industrial output, led by the export sector. Therefore, these results suggest an association between the adjustment policies carried out to improve the balance of payments situation and the deterioration of environmental standards.

The other side of this problem is the weakness of the environmental control institutions. The change of the industrial structure was not followed by a similar improvement in the effective capacity of monitoring and controlling air and water emissions. The legislation on environmental issues is relatively recent and is heavily based on command and control instruments (licenses, fines, compensations and closures). Nevertheless, the implementation of this legislation has suffered from two main problems: the scarcity of financial and human resources, and the weak integration of the different government agencies responsible for environmental issues (Serôa da Motta, 1993a, b).

The scarcity of resources devoted to environmental protection is connected to the budget cutbacks forced by the public finance crisis. A survey carried out by Andreoli and Kurzlop (1987, quoted in Serôa da Motta, 1993b) estimated that staff in environmental protection agencies (EPAs) had increased by only 7.3% in the period 1983-87. Four states had EPAs with less than 10 employees; in ten states the EPAs did not have any boat, and in three of these the EPAs did not have any motor vehicle at all. Finally, air quality analysis could be carried out only in three states, and in six states the EPAs did not have laboratories.

The issue of institutional disarray is related to the fragmentation of the institutional framework responsible for the protection of water and air resources. The 1988 Constitution established that environmental control is mainly a task to be performed by the states' EPAs and, as shown above, it results in very heterogeneous levels of control. The national environmental agency (Ibama) is responsible for the coordination of the federal government activities, but since pollution issues are by law almost entirely under state supervision, its action in this field is considerably smaller than in forestry resource management (Serôa da Motta, 1993b).

The problem of institutional fragmentation is more serious in water issues. There is a strong influence of hydroelectricity state companies over the Water Code which regulates water availability and distribution rights. Issues related to water supply for urban use and sanitation concern other state and municipal agencies (usually water supply and sanitation are managed by different companies). This approach lacked, until recently, a wide environmental dimension of water services, and there is still a need for large improvements:

> "Despite the relative progress obtained by creating environmental consciousness among environmental agencies, Ibama and state EPAs have not succeeded in adjusting other sector policies to theirs. The same integration difficulties are also found between Ibama and EPAs and between EPAs and other state agencies." (Serôa da Motta *et al.*, 1993b, p. 41)

Therefore, the final conclusion is that the Brazilian experience of structural adjustment resulted in the increasing of pollution problems without adequate attention to control and abatement policy and practices. If the changes were inevitable (it is not the objective of this chapter to discuss the appropriateness of the adjustment policies in economic terms) they should have been accompanied by the development of an effective environmental protection system since from the early outset of the adjustment process. In other words, the hypothesis that a shift towards a more export oriented industrialization pattern results in a bias in favour of environmental conservation cannot be accepted in the Brazilian experience concerning water and air pollution, at least in its early stage.

Two additional comments should be considered. The first point is that industrial emissions are not the only source of pollution. According to Mendes (1994), the volume of industrial emissions of BOD are equivalent to 39% of the emissions of organic matter from urban domestic emissions. The use of combustible fuels for domestic transportation (gasoline and sugar cane alcohol) is the main source of air pollution in urban centres (SO_2), and the emission of CO_2 resulting from burning biomass for land clearing is far greater than the emissions derived from energetic sources. Therefore, the problem of air and water pollution is not restricted to the industry, and an integrated approach should consider all potential sources of emission.

The second point refers to the limitations imposed by the database used. The exercises carried out in this section depend heavily on the primary data collected by Pronacop and Cetesb. These data derive from official records sent by the industrial companies to the EPAs in the process of obtaining the operational license, instead of actual measures of emission at the source point. Also, the emission coefficients estimated by Ipea using these data and applied in this chapter refer to one point in time, and significant changes may have happened since then. Finally, the most recent input-output tables available refer to 1985, and it was not possible to estimate the changes in the industrial inter-relations after that. Therefore, the analysis could not incorporate the period after 1985, which may have brought different results (even though the results from Carvalho and Ferreira (1992) suggest that the industry has become even more pollution-intensive since then).

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