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INSTITUTO DE ECONOMIA

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nº 383

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Textos para Discussão

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Sumário

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, and the pressure to increase the level of exports represent an incentive to the overexploitation of these assets. Since environmental legislation and control in these countries are less strict than in developed countries, this would favour the expansion of pollution and energy intensive industries. One possible outcome of this process is that, in the long term, adjusting countries would attract investments from pollution intensive industries which have had to 'migrate' from developed countries as a consequence of higher production costs imposed by tighter environmental controls.

At the opposite side, defenders of adjustment programmes argue that reform policies bring more production efficiency to the economy. Higher competition would close down companies operating with old and inefficient equipment. Higher prices for energy are an incentive to reduce energy consumption and, therefore, emissions. Finally, the removal of subsidies to capital intensive industries in developing countries would represent an incentive to labour intensive activities, which are less pollutant.

The objective of this paper is to illustrate this debate in the context of the Brazilian industry in the 1980s. Industry was characterized by the expansion of export-oriented activities as called for by the adjustment principles. More precisely, this paper investigates whether the shift towards an export oriented industrial growth has influenced the pollution problem in Brazil. The methodology is based on the combination of input-output techniques and the use of water and air pollution coefficients, estimated according to actual data for Brazil. The results indicate that during the 1980/85 period, water and air emissions from industrial sources increased despite declining economic activity. This suggests that the structural changes in the Brazilian industry in the early 1980s, associated with the adjustment objective of increasing the trade surplus, encouraged industries which are more intensive sources of pollution.

2 - Export promotion policies and pollution in Brazil

The Brazilian economy has experienced successive policy changes to alleviate the pressure on the balance of payments caused by external debt crisis. In the early 1980s, in order to improve the external accounts situation, many incentives were created to increase exports. Indeed, the expansion of the export sector was a key element in the structural adjustment strategy carried out with the approval of the IMF and the World Bank. This change in the orientation of the industrial policy, so far dedicated to import-substitution, has affected significantly the Brazilian industrial structure. As a consequence, the export oriented industries achieved a much better performance relative to the traditional, domestic market oriented industries.

During the same period, there is evidence that the pollution problem has increased in Brazil. Carvalho and Ferreira (1992) created an index of industrial growth according to four groups of potential pollution impacts: high, mean, low and negligible. The index was built using output data from IBGE's monthly industrial survey, combined with the air and water pollution potential of each product according to the classification adopted by the state of Rio de Janeiro environmental agency (FEEMA). It is important to highlight that FEEMA's classification is based on the

potential hazard of the production of the good to the air or water assuming that no mitigation measures are taken. Therefore this index does not consider the existence of abatement processes which may reduce or even eliminate the pollution impact. In other words, it is an estimate of potential rather than actual industrial pollution.

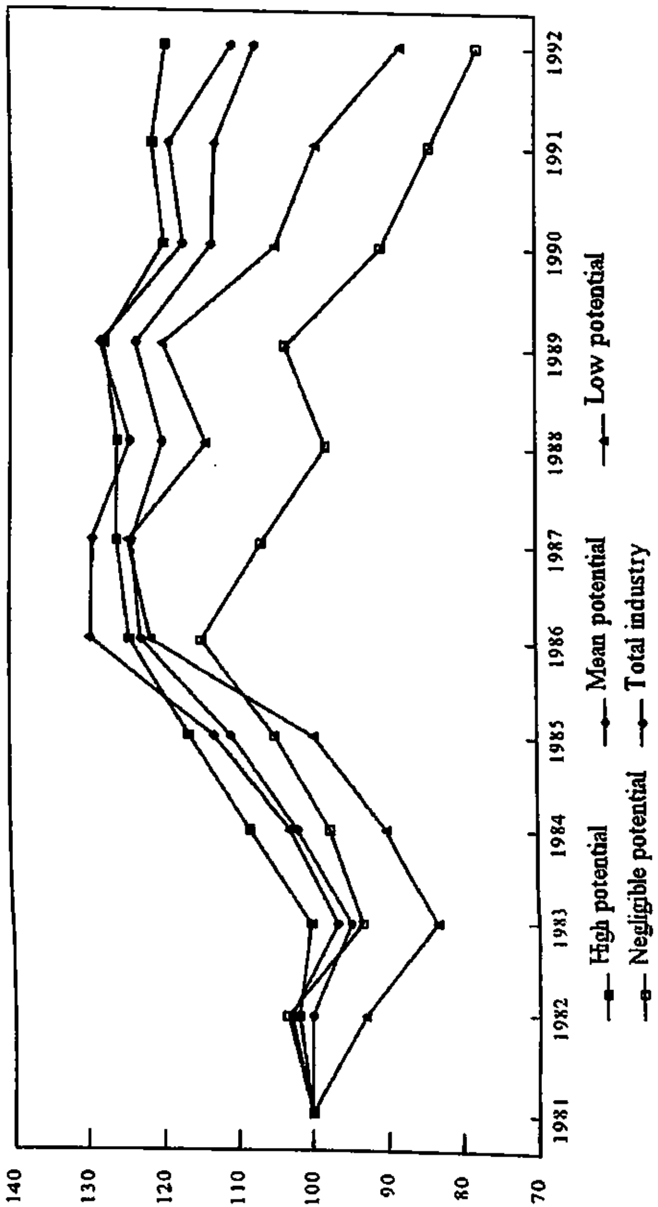
Table 1 and graph 1 present the results obtained by Carvalho and Ferreira (1992). They show that the industries with high and mean pollution potential grew at higher rates than the average of the Brazilian industry. The worst performance refers to the industry with negligible pollution potential. The conclusion of the study was that the dynamics of industrial growth in the Brazilian industry since the 1980s has been positively associated with the level of potential pollution: the higher the growth, the higher the pollution threat, in a way that industrial growth has been diverted towards the potentially polluting industries.

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

Year	High	Mean	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 and Ferreira (1992)

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



Source: Carvalho and Ferreira (1992)

According to the adjustment debate, the simultaneity of the expansion of the export oriented industrial sector and the increase in the levels of pollution may suggest that developing countries under adjustment programmes, such as Brazil, tend to specialize in polluting industries due to their lower regulatory costs (compared with the costs in developed countries). On this view, the expansion of the potential levels of pollution is not a coincidence but a consequence of the boom in export oriented activities.

However, since the exercise carried out by Carvalho and Ferreira (1992) is based on potential rather than actual data, it is not possible to refute the opposite proposition, i.e. the change in the structure of the industry was environmentally beneficial. One possible explanation is that export oriented industries need to be more efficient in order achieve international competitiveness, 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.

The difference between potential and actual (i.e. after abatement measures) pollution 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 al.*, 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 pollution in Brazil, based on indicators of water and air quality for 13 states where systematic monitoring is undertaken.[2] 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 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 pollution, and particulate matter, sulphur dioxide (SO_2), nitrogen oxides (NO_x), hydrocarbons (HC) and carbon monoxide (CO) for air 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 World Health Organization, 1982). The potential pollution 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 pollution 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 pollution were then divided by the value added of the respective industrial sectors, at the state level, in order to produce the pollution intensity coefficients. Tables 2 and 3 presents the average value for the 13 states.

These indicators show the average amount of emission required for a unit of value added in each sector, and this is a crucial information for the analysis carried out in this paper. However, it is important to bear in mind the many limitations involved. Among them, three are particularly important. First, the pollution estimates were not obtained directly from observations of the quality of water and air at the emission points but indirectly, by the specifications of the industrial plants surveyed. However, the environmental impact of a specific pollutant is affected by many other variables which were not considered in the exercise.[3] 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 which 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 pollutant establishments are responsible for a considerable amount of the total pollution. Given these limitations imposed by the lack of consistent data on industrial pollution in Brazil, the results from the exercise carried out in the next sections should be considered as a preliminary attempt to assess the contribution of export oriented activities to the air and water pollution problems in Brazil.

Table 2
Water pollution: potential and actual pollution intensity coefficients, by industrial sector (g/US$ of value added), Brazil, 1988

Industrial sector	Biochem. Oxygen Demand		Heavy Metals	
	Potential	Actual	Potential	Actual
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
Cosmestics & 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 3

Air pollution: potential and actual pollution intensity coefficients), by industrial sector (g/US$ of value added), Brazil, 1988

Industrial sectors	Partic. matter		SO_2		NO_x		HC		CO	
	Potent.	Actual	Potent.	Actual	Potent.	Actual	Potent.	Actual	Potent.	Actual
Non-metallic minerals	689.1	261.4	51.2	51.0	10.9	10.9	0.2	0.2	3.7	3.7
Metallurgy	247.0	111.4	50.7	50.7	17.2	17.2	6.2	6.2	1303.4	1214.9
Mechanics	5.8	1.1	1.3	1.3	0.1	0.1	2.0	2.0	0.2	0.2
Electric materials	0.4	0.1	0.2	0.2	0.0	0.0	2.2	1.6	0.0	0.0
Transport equip.	0.4	0.1	0.2	0.1	0.0	0.0	0.6	0.5	1.7	1.7
Wood products	42.2	42.1	2.5	2.5	9.7	9.7	2.9	2.9	90.3	90.3
Paper & cellulose	133.8	28.2	16.0	15.8	32.5	32.5	0.7	0.7	37.9	37.9
Rubber products	0.4	0.4	3.3	3.3	0.5	0.5	0.1	0.1	0.6	0.6
Chemicals	41.4	18.3	61.4	59.9	45.7	45.6	38.8	18.4	17.0	17.0
Drugs & medicine	0.4	0.4	2.0	1.9	5.5	5.5	0.1	0.1	1.7	1.7
Comestics & soap	8.8	4.5	32.3	32.3	2.9	2.9	0.1	0.1	0.7	0.7
Textiles	26.4	24.3	13.8	13.4	11.2	11.2	0.4	0.3	3.8	3.8
Leather & footwear	1.0	0.9	5.5	5.5	0.7	0.7	0.7	0.7	1.2	1.2
Food products	27.5	21.8	72.5	72.5	8.8	8.8	0.2	0.2	26.0	3.5
Beverages	68.1	58.2	35.7	35.7	17.4	17.4	0.4	0.4	12.7	12.7

Source: Serôa da Motta *et al.* (1993)

3 - Industrial pollution: an input-output model

3.1 The input-output model

The objective of the input-output model is to describe the sectoral 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:

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

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:

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

where x is a nx1 vector with the total product of each sector, d is a nx1 vector with sectoral 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:

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

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:

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

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.

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 obtained by dividing the total emission of a sector (em_i) by the total output of the same sector (x_i):

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

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:

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

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 cointaining in its principal diagonal the emission factors of pollutant h for each sector, and zeroes elsewhere (Pedersen, 1993).

3.3 Application to Brazil

This section describes the procedures used to calculate equation 7 for the Brazilian industry, combining the 1985 input-output table (43x43 activities) prepared by IBGE (IBGE, 1995) and the emission coefficients estimated by the IPEA research group (Serôa da Motta *et al.* 1993 a, b; Mendes, 1994, Serôa da Motta, 1995). The basic assumption is that the emission coefficients (average emission per unit of product), estimated using data collected around 1988, can be applied in nominal terms to the year 1985. The pollutants studied are the same ones included in the IPEA studies: biochemical organic demanding (BOD) and heavy metals for water pollution, and particulate matter, sulphur dioxide (SO_2), nitrogen oxide and dioxide (NO_x), hydrocarbons (HC) and carbon monoxide (CO) for air pollution. These emission parameters were applied to all activities considered in the input-output table which belong to the same industrial sector. For example, the parameter for the metallurgy sector was applied to the activities metallurgy of iron and steel, metallurgy of non-iron products, and production of other metallurgic goods.

One adaptation was required because the IPEA's emission coefficients were based on the value added (VA) in each industrial sector. However, equation 7 refers to the total value of production (VP), including the intermediate consumption required. 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 which could be applied to the direct and indirect effects of each category of final demand.

The aggregate contribution of each category of final demand to the value of production, according to the IBGE tables, is presented in table 4. Table 5 presents the estimated emission of pollutants required in the production chain resulting from each category of final demand, according to equation 7. Table 6 shows the results as a proportion of the total emission of each pollutant. Finally, table 7 presents the pollution intensity in the total production resulting from each category of final demand, i.e. the ratio between the total emission and the value of production of each category of final demand.

Table 4
Total output directly or indirectly related to the categories of final demand, Brazil, 1985

Category	1985 US$ Millions	% of total output
Exports	54,774	14.2%
Investment	90,502	23.4%
Public administration	42,216	10.9%
Private consumption	199,423	51.5%
Total	386,916	100.0%

Source: IBGE (1995). Investment includes changes in stocks

Table 5
Total (actual) emissions caused by final demand, 1,000 t, Brazil, 1985

Parameters	Exports	Investment	Public administration	Private consumption	Total
Water emissions (1000 t)					
BOD	110,964	70,376	18,645	395,096	595,080
Heavy metals	3,162	3,692	185	3,704	10,743
Air emissions (1000 t)					
Partic. matter	561,212	1,205,839	67,282	1,037,977	2,872,311
SO_2	482,826	510,080	59,034	1,035,496	2,087,436
NO_x	239,529	230,225	41,850	541,549	1,053,152
HC	82,837	80,893	10,798	158,846	333,375
CO	3,723,917	4,829,227	244,249	3,867,466	12,664,860

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

Table 6
Total (actual) emissions caused by final demand (%), Brazil, 1985

Parameters	Exports	Investment	Public administration	Private consumption	Total
Water emissions (1000 t)					
BOD	18.6%	11.8%	3.1%	66.4%	100.0%
Heavy metals	29.4%	34.4%	1.7%	34.5%	100.0%
Air emissions (1000 t)					
Particulate matter	19.5%	42.0%	2.3%	36.1%	100.0%
SO_2	23.1%	24.4%	2.8%	49.6%	100.0%
NO_x	22.7%	21.9%	4.0%	51.4%	100.0%
HC	24.8%	24.3%	3.2%	47.6%	100.0%
CO	29.4%	38.1%	1.9%	30.5%	100.0%

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

Table 7
Pollution intensity per unit of output (g/US$), Brazil, 1985

Parameters	Exports	Investment	Public administration	Private consumption	Total
Water emissions (1000 t)					
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 (1000 t)					
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
CO	87.512	45.713	7.609	18.022	32.071

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

3.4 Analysis of the results

It can be seen from tables 5 and 7 that the proportional contribution of exports to the total emission of all pollutants exceeded the contribution of exports to the total output (14.2%). In other words, exports are more pollution-intensive than the average of the economy. This problem is particularly important for heavy metals, carbon monoxide and hydrocarbons, where the difference between the contribution to the total emission and the total value of production exceeds 10%.

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 pollution is higher in export related activities than in any other group for the two water pollution parameters and for three of the five air pollution parameters (SO_2, NO_x, and HC).

In sectoral terms, it is clear that a few sectors account for most industrial water and air pollution. 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; chemicals for HC; and metallurgy for CO.

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 pollution. 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 7.8 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, 1,000 t, Brazil, 1980

Parameters	Exports	Investment	Public administration	Private consumption	Total
Water emissions (1000 t)					
BOD	80,275	77,026	11,128	397,110	565,540
Heavy metals	1,818	4,528	102	3,689	10,137
Air emissions (1000 t)					
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
CO	2,158,792	5,864,729	138,335	4,016,704	12,178,561

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 emissions in 1980 for every pollutant studied (table 10). The two parameters in which the pollution intensiveness of export oriented activities is more accentuated are heavy metals and CO.

Table 10
Total (actual) emissions caused by final demand (%), Brazil, 1980

Parameters	Exports	Investment	Public administration	Private consumption	Total
Water emissions (%)					
BOD	14.2%	13.6%	2.0%	70.2%	100.0%
Heavy metals	17.9%	44.7%	1.0%	36.4%	100.0%
Air emissions (%)					
Partic. matter	12.1%	50.3%	1.4%	36.2%	100.0%
SO_2	15.7%	30.5%	1.7%	52.1%	100.0%
NO_x	14.5%	28.4%	2.5%	54.6%	100.0%
HC	15.0%	32.9%	1.8%	50.3%	100.0%
CO	17.7%	48.2%	1.1%	33.0%	100.0%

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

The consequence is that the pollution 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
Pollution intensity per unit of output (g/US$), Brazil 1980

Parameters	Exports	Investment	Public administration	Private consumption	Total	Average Change 1985/80
Water emissions (g/US$)						
BOD	1.886	0.729	0.347	1.850	1.432	5.2%
Heavy metals	0.043	0.043	0.003	0.017	0.026	6.0%
Air emissions (g/US$)						
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%
CO	50.732	55.515	4.309	18.717	30.840	4.0%

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

More important, the pollution 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 pollution.

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 pollution 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 pollution 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, 1993, b).

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, 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 interrelations 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).

Notas

1 I thank Francisco E. Mendes, Ronaldo Serôa da Motta and Giles Atkinson for helpful comments.

2 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.

3 The primary data on water pollution were scanned in the work by Mendes (1994); however the data on air pollution 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 pollution.

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