Regulating Industrial Pollution in Developing Countries:
Some Possible Frameworks

Paul R. Portney
(consultant)

December, 1989

The World Bank

Internal Discussion Paper

Latin America and the Caribbean Region

Report No. IDP-0056

Trade, Finance and Industry
Operations Division

Country Department I

Discussion Papers are not formal publications of the World Bank. They present preliminary and unpolished results of country analysis or research that is circulated to encourage discussion and comment; citation and the use of such a paper should take account of its provisional character. The findings, interpretations, and conclusions expressed in this paper are entirely those of the author(s) and should not be attributed in any manner to the World Bank, to its affiliated organizations, or to members of its Board of Executive Directors or the countries they represent.
LAC DISCUSSION PAPER SERIES

<table>
<thead>
<tr>
<th>Report No.</th>
<th>Title, Author and Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDP-3</td>
<td>&quot;An Analysis of the Sources of Earnings Variation Among Brazilian Males&quot; by Marcelo Dabos and George Psacharopoulos, December 1987</td>
</tr>
<tr>
<td>IDP-4</td>
<td>&quot;The Efficiency and Effectiveness of Export Credit and Export Credit Insurance Programs&quot; by Bruce Fitzgerald and Terry Monson (Consultant), December 1987</td>
</tr>
<tr>
<td>IDP-9</td>
<td>&quot;Export Processing Zones: The Economics of Offshore Manufacturing&quot; by Peter G. Warr (Consultant), August 1987</td>
</tr>
<tr>
<td>IDP-10</td>
<td>&quot;Dumping, Anti-dumping and Efficiency&quot; by Bruce Yandle and Elizabeth M. Young (Consultants), August 1987</td>
</tr>
<tr>
<td>IDP-11</td>
<td>&quot;The Regulation of the Quality of Traded Commodities and Services&quot; by Simon Rottenberg and Bruce Yandle (Consultants), June 1987</td>
</tr>
<tr>
<td>IDP-13</td>
<td>&quot;Argentina: Towards the Year 2000&quot; by F. Desmond McCarthy, June 1987</td>
</tr>
<tr>
<td>IDP-14</td>
<td>&quot;Trade Liberalization: The Lessons of Experience&quot;, Papers presented in the conference &quot;Toward a New Trade Policy for Brazil&quot;, Sao Paulo, April 11 and 12, 1988</td>
</tr>
<tr>
<td>IDP-16</td>
<td>&quot;Aspects of Privatization: The Case of Argentina 1978-81&quot; by R. Luders (consultant), April 1988</td>
</tr>
<tr>
<td>IDP-17</td>
<td>&quot;Aspects of Privatization: The Case of Chile 1974-85&quot;, by D. Hachette (consultant), April 1988</td>
</tr>
<tr>
<td>IDP-18</td>
<td>&quot;Privatization in Argentina and Chile: Lessons from a Comparison&quot; D. Hachette and R. Luders (consultants), April 1988</td>
</tr>
<tr>
<td>IDP-19</td>
<td>&quot;Principles of Water Supply Pricing in Developing Countries&quot; by Mohan Munasinghe, June 1988</td>
</tr>
<tr>
<td>IDP-21</td>
<td>&quot;What are the Prospects for Land Reform?&quot; by Hans Binswanger and Miranda Elgin (consultant), August 1988</td>
</tr>
<tr>
<td>IDP-30</td>
<td>&quot;Debt Reduction Schemes and the Management of Chilean Debt&quot;, Felipe Larrain (consultant), March 1989</td>
</tr>
<tr>
<td>IDP-32</td>
<td>&quot;Leading Economic Indicators for Brazil: At Attempt at Forecasting Turning Points&quot;, Antonio Estache, February 1989</td>
</tr>
<tr>
<td>IDP-33</td>
<td>&quot;Recovering Growth with Equity, World Bank Poverty Alleviation Activities in Latin America&quot;, George Psacharopoulos, April 1989</td>
</tr>
<tr>
<td>IDP-34</td>
<td>&quot;Brazil - External Debt Development and Prospects&quot;, Silvina Vatnick, December 1988</td>
</tr>
<tr>
<td>IDP-41</td>
<td>&quot;Growth, External Debt and the Real Exchange Rate in Mexico&quot;, Sweder van Wijnbergen, May 1989</td>
</tr>
<tr>
<td>IDP-49</td>
<td>&quot;Feeding Latin America's Children&quot;, Human Resources Division, Technical Department, October 1989</td>
</tr>
<tr>
<td>IDP-50</td>
<td>&quot;Marginal Effective Tax Rates on Capital Income in Argentina&quot;, Luca Barbone and Michael McKee (Consultant), August 1989</td>
</tr>
<tr>
<td>IDP-53</td>
<td>&quot;A Bibliography on Poverty and Income Distribution in Latin America&quot;, Human Resources Division, Technical Department, November 1989</td>
</tr>
<tr>
<td>IDP-54</td>
<td>&quot;Ecuador: Development Issues and Options for the Amazon Region&quot;, Country Department IV, December, 1989</td>
</tr>
</tbody>
</table>
Economic growth leads inevitably to environmental pollution. As economies grow in size and sophistication, pollution issues become all that more pressing and difficult to solve. The central issue, therefore, is the search for acceptable trade-offs between economic growth and increases in pollution levels. This report provides a framework for the systematic investigation of such trade-offs.

It analyzes the economic consequences and effectiveness of alternative ways of setting, regulating and enforcing levels of pollution with particular emphasis on Brazil. The report draws extensively on the experience of the US and, to a lesser extent, on other developed economies.

* For their helpful comments on a previous draft of this report, I wish to thank Walter Spofford, Samia El Baroudy, Bernard Baratz and Demetris Papageorgiou. None bear responsibility for errors that may remain.

** Paul R. Portney is Vice President of Resources for the Future. This paper was written as part of the preparation of an industrial pollution control project for Brazil.
One of the most difficult problems facing developing countries is the frequent conflict they face between economic growth and environmental quality. On the one hand, these countries are desirous of increasing per capita GDP. This is not merely because of the slavish pursuit of income per se, but because increases in income often make possible substantial improvements in health, literacy, housing, infrastructure and other measures of well-being. Helping these developing countries increase per capita income has been one of the major purposes of international economic assistance, whether conducted unilaterally by donor countries or through major international lending institutions.

On the other hand, if the pursuit of these goals brings with it extreme forms of environmental pollution, economic growth will at the least be less effective than hoped in improving well-being. In the extreme, it could be completely ineffective--this would be the case, say, if pollution problems became so serious and widespread as a result of industrialization that individual health actually suffered on net. While this latter possibility is unlikely, it must be considered seriously by anyone concerned with international development.

This simple observation suggests that it is impossible to divorce an interest in economic development from a concern about environmental pollution and the approaches that might be taken to control it. The
primary focus of this report is the latter. That is, the purpose here is to identify the fundamental questions that must be asked and answered in designing and operating a program of pollution control in developing countries. While the "right" approach will vary from country to country, sometimes dramatically so, the set of possible alternatives in general will not. One purpose here, then, is to identify the approaches that a country might use in controlling environmental pollution and to discuss the strengths and weakness of these approaches.

The focus here is narrower than the preceding paragraph might suggest, in two respects. First, the report will only be concerned with industrial pollution. It will not deal with the environmental problems posed by agricultural production, forestry, natural resource extraction, urban runoff, or similar forms of economic activity. Having said this, however, it will be clear that many of the conclusions drawn in this report concerning the regulation of industrial pollution will have straightforward application to or implications for these other forms of pollution.

There is a second narrowing of the focus, also. While much of the discussion in the report will be generic, dealing with alternative approaches to pollution control in a variety of developing countries, it is illustrated wherever possible with examples drawn from and illustrative of the Brazilian experience.

The plan of this report is as follows. Section I briefly discusses the growth of the Brazilian economy and the nature of the industrial pollution problems that have resulted. While these will differ in some respects with the problems and experiences of other countries, there is much that will be common to them.
Section II identifies several types of alternatives to the more traditional regulation of industrial pollution, including state operation of industrial facilities, use of the legal system to address pollution problems, state purchase of pollution control equipment, and what is often called "moral suasion." Following that, the basic decisions that must be made if the direct regulatory approach is to be taken are discussed. These include: identifying the appropriate roles for different levels of government; deciding how ambient environmental standards are to be set; translating ambient standards into controls on individual industrial polluters (if command-and-control regulation is the preferred approach); or ascertaining the levels at which effluent charges will be set, or determining the appropriate quantities of marketable discharge permits (if an economic incentive approach to environmental policy is preferred). In Section III, implications are drawn for pollution control regulation in Brazil.

I. Economic Growth and Industrial Pollution in Brazil

There is little question that Brazil has grown economically. According to data from the World Bank, per capita GDP there stood at $270 (US) in 1965, $710 in 1973, and by 1986 had grown to $1,840. However, the rate of growth in per capita GDP was much faster in the 1970s (7.7 percent from 1970-1975, for example) than in the 1980s (1.6 percent from 1981-1987). During the period 1970-1987, industry's share of total GDP remained about constant at a little more than a third. Agriculture's share declined from about 14 percent of total GDP to 10 percent, a drop which was picked up by the service sector which increased from about 50 percent to 55 percent.
This increase in GDP per capita was accompanied by increases in life expectancy at birth (from 57 years in 1965 to 65 years in 1986), a decline in the infant mortality rate (from 104 to 67 per thousand live births), and an increase in the percentage of homes served by electricity (from 56 percent in 1973 to 67 percent in 1986). Not all social indicators measure such improvements, though. For example, the percentage of the population with access to safe water fell from 77 percent in 1973 to 71 percent in 1986. And even along those dimensions where improvements have been registered, there is considerable room for improvement. To take but one example, the infant mortality rate in industrial market economies stood at but 9 per thousand live births in 1986, less than one-seventh the Brazilian rate.

As suggested above, economic growth is often accompanied by industrial pollution and the Brazilian experience is no exception. The extent of industrial pollution varies geographically throughout the country with the southern states of Rio Grande do Sul, Santa Catarina, Parana, Sao Paulo, Rio de Janeiro, Espirito Santo, and Minas Gerais being the most industrialized. Of these, Sao Paulo is home to the most industrial activity (an estimated 60 percent of the nation's industrial production). The Brazilian states of Goias, Pernambuco, Ceara, Maranhao, Para, and Bahia have industrial pollution problems significant enough to warrant further investigation.

While the nature of industrial production and its associated pollution varies from state to state, Brazilian industry includes substantial production in iron and steel; wood, cellulose, and paper; rubber; petroleum production and refining; petrochemicals; pesticides and fertilizers; cement; coffee; cotton and textiles; pharmaceuticals and cosmetics; sugar
and alcohol; food and beverages; electronics; leather and associated products; and nonferrous metals.

As one might expect from this list of industries, a variety of environmental problems can and do result. These include air and water pollution, the disposal of solid and hazardous chemical wastes, and so on. The most pronounced air pollution problems are those associated with particulate matter and sulfur dioxide, although there are also considerable emissions of volatile organic hydrocarbons, carbon monoxide, and oxides of nitrogen. Particulate matter concentrations have been especially high in the Greater Sao Paulo Metropolitan Area and in the Cubatao-Vila Parisi air basin. In the former, between 1983-1985 ambient concentrations of total suspended particulate matter averaged 130 ug/m$^3$, with the highest concentrations sometimes reaching 400 ug/m$^3$.

By contrast, of the major cities included in a recent U.N./W.R.O. survey of urban air pollution worldwide, only Calcutta and Tehran registered such high average and extreme readings for particulate matter. To make the relevant comparison with the U.S., the average concentration of total suspended particulate matter for a sample of large cities was about 50 ug/m$^3$ during the same period. In addition to these problems with particulates, a variety of less ubiquitous but still harmful air pollutants are discharged from Brazilian industrial facilities. These include such carcinogenic substances as benzene, formaldehyde, and acrylonitrile as well as fluorides, ammonia and other substances.

A variety of water pollutants is also associated with these industrial facilities. These include dissolved solids, biochemical oxygen demand (or BOD), heavy metals, and organic and inorganic chemicals; in combination with the bacteria from treated and untreated wastes, as well as the water
pollutants that result from so-called non-point sources (agricultural fields, urban streets, parking lots, and storm sewers, for instance), water quality can be a serious concern in many Brazilian states. One should not discount the problems caused by non-industrial sources, however. For instance, of the 14.5 million persons in the Greater Sao Paulo Metropolitan Area, only half are served by the sewer system. Industrial pollution accounts for about 30 percent of BOD discharges, with households and other non-industrial sources accounting for the rest.

Less is known about hazardous wastes in Brazil, a situation one generally finds even in the more developed industrial countries. Even in Sao Paulo, home to Brazil's most sophisticated pollution control agency (CETESB), only a small fraction of the known hazardous wastes are disposed of in an acceptable fashion and no approved public hazardous waste disposal site exists.

Even this brief and selective description makes clear why the choice of a pollution control strategy is important in Brazil, as it is in any developed country. We turn now to a review of the kinds of approaches one might take to regulate industrial pollution in Brazil or in other developing countries, and to the respective strengths and weaknesses of these approaches.

II. Strategies for Pollution Control

Even if one is greatly concerned about industrial pollution, it does not necessarily follow that direct government regulation (of either the command-and-control or the economic incentive type) is required. Indeed, there are a variety of means that might be employed to address the serious social costs that pollution often entails without issuing direct orders to
industrial facilities. These include the private use of a legal system to address serious environmental "nuisances," state ownership and/or operation of large industrial facilities, state purchase of pollution control equipment, and appeals to conscience.¹

Private Legal Action

Consider first the use of legal actions between private parties (sometimes referred to as tort actions), or negotiation between disputing parties. Both depend upon a clear prior definition of property rights. For instance, suppose it was clearly understood that any citizen had an absolute right to be compensated fully for the damages of any kind of pollution. If the smoke from a factory furnace were ruining a laundry business, the owner of the latter could take the offending party to court. If the launderer's damages could be accurately assessed, and if the polluter were indeed held liable for them, the legal approach would create the right economic incentives for industrial polluters.² They would undertake certain pollution control measures if the cost of these measures was less than the damages they would have to pay the laundry. And they would continue to emit some pollution—and pay the laundry for the resulting damage—if it were more expensive to control than it was to compensate the launderer. One could easily envision a similar example involving water pollution from an industrial facility which harms fishermen, contaminates drinking water, and imposes other losses on individuals.


There is an economic appeal to legal solutions like that sketched out above because, in such simple cases, they can minimize the total costs—pollution control expenditures plus residual damages—associated with environmental protection. In many industrialized countries, this is how air and water pollution problems were handled for a long time—under the nuisance and trespass provisions of common law. Even in countries where a regulatory approach has been adopted, private legal actions (or tort liability) continues to provide strong supplementary incentives to control at least some forms of pollution.

Unfortunately, the real world is much more complicated than this simple example would suggest. And the added complexity makes a purely legal approach to environmental protection much less practical. First, it is not perfectly clear where property rights in clean air are, or even ought to be, vested in modern societies. This may seem puzzling since most accept the "right" of the citizenry to be free from pollution. Yet even this apparently sensible proposition seems strained in, say, the case of a laundry that deliberately moves from a clean location to one directly adjacent to a factory and then demands compensation for smoke damage. In other words, rights seem to depend in part on less absolute considerations like who was there first.

Even if property rights were more clearly defined and quite absolute, environmental protection via the legal system or private negotiation would not be without difficulties. For instance, pollution rarely occurs on a one-to-one basis as in the simple example above. As the brief discussion above of Cubatao and the Greater Sao Paulo Metropolitan Area makes clear, there are often many polluters, thus making it difficult or impossible to know which factory, car, or wood stove was responsible for which damages.
Also, there are generally many "pollutees," not just a lone launderer, no one of which may be suffering sufficient damages to merit taking legal action or initiating mediation or negotiation alone. Legal transactions costs may be so high that they inhibit the filing of class action suits, even though aggregate damages across all pollutees may be significant. This too greatly inhibits the use of the legal system as the sole weapon against industrial or other forms of pollution.

Next, some of the damaging effects of pollution may be both more subtle yet more serious than mere dirty laundry. For example, pollution is one of the many causes of cancer and other serious illnesses. Yet, the long latency period between exposure to a pollutant and the manifestation of the illness it may cause, coupled with the possibilities of other causes, will generally make it virtually impossible to assess liability satisfactorily in a courtroom or arbitration chamber. Add to this the difficulty of valuing the pain and suffering from such illnesses, and one can quickly understand the shortcomings of legal action or mediation in lieu of more direct government intervention to deal with pollution.

Finally, because of the pervasiveness of pollution, dealing with it exclusively through private legal actions would keep courts tied up with such matters around the clock. This would make it difficult to pursue other actions in court which are of importance in their own right. This is still another obstacle to the tort approach to environmental pollution. Nevertheless, one should not ignore the added incentive for environmental cleanup which expanded liability can provide.

State Ownership

Still another alternative to more direct regulation is the state ownership and/or operation of entire industries or facilities that are
serious polluters. This is relevant to Brazil because of Petrobras, Electrobras, and other parastatals there, and examples could be drawn from any number of other developing countries, as well. The idea behind this approach is simply that the state-owned facilities can be operated in an environmentally sound way that would require no outside environmental regulations. In fact, some have suggested that state-owned facilities be used as exemplars for their private counterparts in the same industry or in other industries where private ownership is more common. For example, some in the United States have suggested that the Tennessee Valley Authority, which owns and operates a number of electricity generating facilities, be operated as a "model" for other privately owned electric powerplants around the U.S.\(^3\)

In reality, this is unlikely to be a successful approach to controlling environmental pollution. First of all, there are other profoundly important implications of state ownership, going far beyond environmental management, which must be taken into account. These have mainly to do with economic efficiency and the creation of incentives which will promote it. If anything, the trend in the world today seems to be going in the direction of divesting governments of the ownership of important industries, rather than the other way around, and this says something about the attractiveness of state ownership.

More importantly, if one looks to those countries where state ownership is the rule rather than the exception, one generally sees environmental problems far more serious than those in mixed or mostly private economies. The environmental problems in the Eastern European

---

3. During the Carter administration, the TVA was in fact revamped and refocused to heighten environmental sensitivities and set an example for other electric utilities.
bloc, in the Soviet Union, in China, and in other centrally planned economies are sober reminders that state ownership is no panacea. The pressure to earn foreign currency, to keep employment high, and to serve other non-environmental objectives often crowds environmental protection off the agenda of state-owned industrial facilities. While state ownership could certainly be consistent with environmental responsibility, it is neither a necessary nor a sufficient condition for it.

**Government Purchase of Pollution Control Equipment**

Still another alternative worthy of mention is direct government investment in pollution control equipment. The most natural setting in which this might take place is the construction of municipal sewage treatment plants. This surely makes more sense than requiring individual housing units, apartments, and office buildings to install their own sewage treatment equipment. Of course, it is possible to imagine governments paying for the pollution control equipment to be installed at private industrial facilities—electrostatic precipitators and scrubbers on smokestacks, for instance, or end-of-pipe treatment equipment for waterborne effluents.

There are several problems with this approach. First, even governments in the wealthiest countries would probably balk at increasing public expenditures by several billions of dollars each year for pollution control, given the budgetary problems many of them are having (with the U.S. government being a prime example). Depending on the extent of industrialization and its attendant pollution, this could require considerable public expenditures each year by the government.

More importantly, government installation of pollution control equipment, if paid for out of general revenues, violates one of the most
important principles in environmental policy in the world today—the so-called "polluter pays principle," under which industrial and other sources of pollution are deemed responsible for the costs of abating it. This is not just a matter of fairness: requiring polluters to pay for the cleanup equipment forces them to internalize the costs which heretofore have been external to their operation. This in turn means that the costs of production will increase. To the extent that firms can pass along these higher costs in the form of higher prices, consumers of "dirty" products will pay more for these products. This gives consumers the requisite incentives to shift to other products, the production of which is less polluting. Thus, government provision of pollution control equipment fouls up the invaluable signalling function which market prices can play.

**Moral Suasion**

A final non-regulatory approach involves appeals to principle and decency—this is sometimes referred to as the "moral suasion" approach. Under it, the government resorts to asking firms and/or individuals to abate pollution in the name of environmental protection and for the common good. No strictures or other sanctions are imposed; rather, this approach relies on corporate, state, or individual goodwill to accomplish environmental goals. This approach should not be scoffed at altogether. Such exhortations sometimes do work for short periods of time and under extraordinary conditions. Perhaps the best examples of this are voluntary reductions in water use seen in many places during drought conditions. The voluntary reductions in driving in Los Angeles to improve air quality during the 1984 summer Olympics is perhaps another example.

---

4. See Baumol and Oates, Chapter 19.
Nevertheless, it is not being overly cynical to say that such an approach could not possibly produce enough pollution control for prolonged periods of time to adequately safeguard the environment. However responsibly industrial managers want to behave, their job performance will always be evaluated first and foremost on the economic performance of the company, whether privately or publicly owned. This means that a plant manager who spends large sums of money to reduce air or water pollution will operate at a competitive disadvantage if his or her competitors do not do the same. Over the long haul, that manager's company may lose market share and eventually go out of business. For state-owned enterprises, such as Petrobras or Electrobras in Brazil, for example, internal competition may be somewhat less a threat, but there will still be great pressure to keep electricity rates down, to earn foreign currency, and to meet other non-environmental goals. These pressures will make it difficult for plant managers to voluntarily make large expenditures on pollution control.

**Regulatory Approaches**

The non-regulatory measures discussed above to address industrial pollution is unlikely to provide sufficient incentives for environmental protection. This being the case, we must consider more direct governmental measures to address industrial pollution. In the balance of this report, we consider two very different kinds of policy interventions for this purpose. The first we refer to as "command-and-control" regulation. Under this approach, the government generally (although not always) sets ambient environmental standards and follows these up with a series of specific discharge standards for each of the industrial (and other) sources.

---

of the pollutant in question. The object of the specific source discharge standards is to see to it that the ambient environmental standards are everywhere met. Although there are some variations on this basic theme, command-and-control generally follows this basic formula.

The other route to pollution reduction discussed in some detail below is generally referred to as the economic incentive approach. Under this approach, the government merely tries to confront industrial sources with a variety of economic measures which make it in the source's best interest to reduce emissions and effluents below the level which would result in the absence of any government intervention. However, unlike the command-and-control approach, no source is given specific emissions reductions targets in incentive-based systems. Rather, the decision as to how much or how little pollution control to engage in is left up to the source itself.

Before we discuss the intricacies of these competing approaches to regulating industrial pollution, there is one final issue that must be addressed. So far, we have ignored the following question: At what level of government should this regulating take place? While environmental protection is very important, so too are public school quality, police and fire protection, income assistance, criminal justice, and other important governmental functions many of which are left at least in part to levels of government below the federal in developing and developed countries around the world. It is well worth thinking about how much regulation--of whatever kind--should take place at the federal level and how much is best left to lower levels of government.

In principle, at least, if the risks associated with an industrial pollution problem are strictly local, and if the costs are similarly borne exclusively locally, then the decision may best be made at the local level. This assumes, of course, that the requisite information and power to take regulatory action resides in local authorities. (There is no reason why the research necessary to support regulation could not be handled at the federal level and then made available to state or local authorities to set standards or economic incentives for pollution control.)

It should be quickly acknowledged that for many, perhaps most, environmental pollution problems, the costs and risks spill over not only local boundaries, but also across state and even national borders. Acid deposition, carbon dioxide accumulation in the atmosphere, and stratospheric ozone depletion are but three obvious examples of the frequently international dimension of environmental pollution. In these and many other cases, controlling industrial pollution is a national problem, and one which sometimes requires international agreements.

Nevertheless, there are some pollution problems which may lend themselves to more decentralized decisions. For example, since the risks they pose generally fall only upon nearby residents, determining the extent to which abandoned hazardous waste disposal sites should be cleaned up might best be determined at the local or state level. There is no obvious reason why the right level for one jurisdiction will be the same in all others. The same might be true for drinking water standards, which affect only those who drink the water, clearly. No more will be said here about the question of "environmental federalism" but it is an important one to keep in mind. 7

Ambient Standard Setting

Once the decision has been made to intervene at some level of government, the next choice that must be made concerns how much protection to provide. That is, how stringently should air quality or water quality standards be set? How strict should cleanup standards be at waste sites? What should be the maximum permissible concentrations of various contaminants in drinking water? There are a number of frameworks for deciding the answers to these questions, and different countries use different frameworks in establishing levels of protection. Even in one country, the legislated framework will often vary depending upon the problem being addressed.

The Zero-Risk Approach. One way to select the degree of protection might be called the "zero-risk" or "safe-levels" approach. Under this approach, the environmental authority would be directed to set a particular ambient environmental standard at a level that would ensure against all adverse health (or other kind of) effects. This approach is not uncommon. It characterizes the establishment of air pollution standards in many countries around the world, as well as the standards which are set for bacterial and other contaminants in surface waters.

On its face, the zero-risk approach seems perfectly reasonable. After all, why would one want a standard to be set at a level that poses some recognizable threat to health? This would hardly seem to be a defensible

---


position for a government to take in response to citizens' concerns about health or ecological protection. The obvious attraction of this approach, then, is the assurance it seems to give members of society about the environmental risks they are bearing. To the extent that margins of safety are built into ambient environmental standards, the public feels it is being protected against carcinogenic and other health risks.

Science and economics suggest that the "zero-risk" approach is much less attractive in practice than it might seem, however. Accumulated research in physiology, toxicology, and other health sciences suggests that for a number of environmental pollutants, particularly carcinogens, there may be no threshold concentrations below which exposures are safe. That is, even very low concentrations of some pollutants may pose real risks to at least some members of the exposed populations. This implies that if the zero-risk approach is to be taken literally, ambient standards for these pollutants must be set at zero concentrations if the populace really is to be protected against all risks.

Even for individual pollutants for which a threshold exists, it is probably physically impossible to eliminate all traces of the pollutant without at the same time shutting down all industrial and other economic activity. This is an outcome which few are willing to abide, particularly in developing countries where it is important to increase standards of living across the board. (Even if all such industrial activity were to cease, primitive heating and cooking fires would still result in air pollution problems; and even if these could be prevented, natural sources contribute background pollution that could never be eliminated.) Yet this

is where the zero-risk framework often appears to lead if interpreted literally.

To put the matter differently, those who object to the zero-risk approach do so not because they prefer to bear risks associated with industrial pollution, but because they feel that some degree of risk is inevitable in life. Therefore, this counterargument goes, the task for society is to determine just how much of the various kinds of risks we ought to be bearing and in what forms.

The Benefit-Cost Approach. A very different way to make this determination about appropriate ambient environmental standards is through the use of benefit-cost analysis. Under this approach, ambient standards are directed to be set at levels which equate, at the margin, the damage that additional pollution might do with the added cost of pollution control. In its "purest" form, these favorable and unfavorable effects—benefits and costs as they are known—are expressed in dollars, cruzados, or other currencies.

The logic behind the benefit-cost approach is straightforward: it does not seem to make sense for society to spend two dollars to address a pollution problem that is doing one dollar of damage. By equating benefits and costs of additional pollution control at the margin, one insures that net benefits—the difference between total benefits and total costs—are maximized. To the extent that all benefits and costs are captured in the analysis, and to the extent that they can be expressed in monetary terms, the benefit-cost test brings the same kind of efficiency in public sector analysis that competitive forces are capable of bringing to private market

transactions. This in turn would mean that additional resources would be available to address housing, health, educational or other problems faced by society. While the motivation for the use of benefit-cost analysis, then, is often couched in terms of economic efficiency, the real concern is with helping society make the best possible use of what are always scarce resources.

It should go without saying that, when used to set ambient environmental standards, benefit-cost analysis comes up against a number of very difficult problems. It is definitely not without its shortcomings, and this accounts for the limited role it has played in ambient standard-setting in most countries.

First of all, ascertaining benefits requires one to know the effects of changes in air or water quality on human health, the resilience of the ecosystem, and so on. In other words, improved environmental quality must first be translated into subsequent improvements in human health and other forms of well-being. This requires knowledge of the many pathways through which pollutants can damage human health and the environment, and this knowledge is hard to come by, to say the very least. Often we can only guess at what effect a reduction in air or water pollution will have on health and the environment. Thus, even before the valuation problem arises, benefit estimation comes up against a sometimes quite intractable problem.

Another obvious problem in benefit-cost analysis is the difficulty of expressing in monetary form many of the benefits associated with environmental protection. To take but a few obvious examples, how does

---

12. For a non-technical discussion of benefit estimation, see Allen V. Kneese, Measuring the Benefits of Clean Air and Water (Washington: Resources for the Future, 1984). For a more technical discussion, see Footnote 12 continued on next page
one assign values to the reduced risk of contracting respiratory diseases as a result of air pollution control? To improved visibility? To the enhanced productivity of aquatic ecosystems resulting from industrial water pollution control? To the preservation of species whose existence might be imperiled by pollution? Other examples easily come to mind. While there are answers to at least some of these questions, they are unconvincing answers to many.

For the non-specialist, benefits are measured in modern applied welfare economics by willingness to pay. That is, the benefits I derive from a particular environmental regulation, say, can be approximated by the maximum amount I would be willing to pay for the environmental improvements that would follow—clean air, less polluted drinking water, the removal of a hazardous waste site, etc.

Some of the benefits of environmental regulation can be valued fairly straightforwardly, a point which critics often overlook. For instance, suppose air pollution control increases the soybean yield on my farm by three bushels per year. How much would I be willing to pay for this increase? Since soybeans trade in well-organized competitive markets, a market price is easy to ascertain; when multiplied by the three bushel increase, it is easy to determine the most I would be willing to pay for this particular benefit. Similarly, if air pollution forces me to paint my house or replace my awnings more often than I would otherwise have to do, the savings I would incur from cleaner air provide a good measure of the value of that benefit.

Footnote 12 continued from previous page
However, clean air will also reduce my chances of contracting respiratory disease. Since I can not buy and sell such risk reductions the same way soybeans are bought and sold, it is much more difficult to determine how much I would be willing to pay for this type of benefit.13

For non-marketed effects like this, it is common to look at the medical expenses that would be saved if the incidence of illness is reduced as a lower bound on willingness to pay (lower bound because illness carries with it considerable disutility that does not manifest itself in out-of-pocket costs).14

This problem of assigning values is even more intractable when the prices for products or services which do trade in markets are not reliable indicators of their opportunity cost. For instance, tariffs which leave some wage rates or other input prices artificially high can result in overestimates of costs in benefit-cost analyses. Similarly, subsidized input prices can result in underestimates of true social opportunity costs.15

Nor is this valuation problem the only difficulty one encounters in applying benefit-cost analysis to environmental problems. For instance, environmental regulatory programs often result in benefits which are spread

13. Note, however, that by purchasing or renting a dwelling in an unpolluted neighborhood, one can reduce his or her exposure to pollution and, therefore, to the risk of respiratory illness. This recognition has led economists to look to housing markets for at least some information about the values that individuals may place on reduced risk. See Freeman, op cit, especially Chapter 6.


out over a long period of time. Costs may also accrue for many years. This means that making present value calculations of benefits and costs requires the choice of an appropriate discount rate. Not only is this a contentious issue in modern public economics, there is also a more disturbing implication. For very, very long-lived programs, any positive discount rate, however small, may mean that benefits and costs accruing in very distant periods get almost no weight at all in present decisionmaking. This, too, has become a sticking point in the application of benefit-cost analysis to environmental standard setting.

Still another problem with the benefit-cost approach concerns the distribution of the favorable and unfavorable effects of a policy change. Specifically, there is no guarantee that just because aggregate benefits exceed aggregate costs, every citizen will enjoy positive net benefits as a result of a project. In other words, even though the gains to the winners exceed the losses to the losers, some individuals inevitably lose as a result of any government action. If these "losers" are politically influential, or if they are already among the economically disadvantaged in society, it may be difficult to implement the policy in question. In the first case, the potential losers may use their power to block the proposed policy. In the second case, society may be reluctant to pursue an efficient policy if the harm that will occur will fall on the poor or some other disadvantaged income, racial or geographic group. In either case, it is important to look for ways in which some of the potential gains from the policy can be used to compensate the potential losers--for truly efficient policies, it is always the case that, in theory, the gains are large enough

to do so and still leave some individuals better off as a result of pursuing the policy change.

Although these problems are troubling, there are two important reasons why one cannot automatically dismiss the benefit-cost approach to setting ambient environmental standards. First, note that every environmental decision carries with it implicit valuations. For instance, suppose that a pollution control authority makes a decision not to tighten an existing air quality standard. Even if benefit-cost analysis is explicitly rejected in the decisionmaking process, that decision carries with it the implicit judgement that the disadvantages (costs) associated with tightening the standard in some sense outweigh the added protection (benefits) the stricter standard would provide. Conversely, a decision to approve the more stringent standard implicitly signals that the benefits of added protection outweigh the costs.

It is simply impossible to submerge these tradeoffs; this being so, proponents of the benefit-cost approach argue, it is better to make these tradeoffs and valuations out in the open. At the very least, use of the benefit-cost approach makes it possible to be consistent when making decisions on a sequence or variety of regulatory problems.

Another defense of the benefit-cost approach is that it need not require monetary valuations of every single regulatory effect, favorable or unfavorable. For example, if certain benefits or costs associated with a proposed regulatory standard were deemed incapable of being expressed in monetary terms, they could simply be listed as additional considerations on the appropriate side of the "balance sheet." This runs the risk of their being ignored relative to those effects which can be expressed in dollar terms, but with some discipline they can be included in decisionmaking.
Controlling Industrial Sources

Having established the environmental goals that drive pollution control programs, environmental authorities must turn to another perhaps more important task. That is translating the desire to meet ambient environmental goals into specific pollution control regulations on individual sources. There are a variety of ways this can be done.

Technology-Based Standards. One of the most common approaches to regulating industrial polluters is the imposition of what are known as technology-based standards. Under this approach, the sources that must be regulated so as to meet the ambient environmental standards are required to install specific types of control equipment, often referred to (in the U.S., at least) as "best available technology" or "best practicable technology." This implies that all steel mills, cement plants, petroleum refiners, electric powerplants, chemical plants, or other sources must be directed to put in place the state-of-the-art in pollution control equipment, or at least that control equipment that is already in use and demonstrated to be working.

There are several attractive features to this approach. First, it asks industrial polluters to come up to some predetermined and generally demonstrably effective technological standard. It has the appearance, then, of asking all regulated sources to do the best that is now being done elsewhere. A second attractive feature of the technology-based approach is that it lends itself to implementation and enforcement, at least in the initial stages. This is because under the technology-based approach, inspectors have only to visit plants to ascertain whether or not these
industrial facilities have, in fact, installed the equipment they were required to. This makes it attractive to regulatory authorities.\textsuperscript{17}

There are a number of drawbacks to the technology-based standard approach, however. Perhaps the most troubling one is that it can enshrine pollution control technologies that may soon become out-of-date. This is because it is unlikely that a pollution control authority will go back to an industrial source that was asked to install a particular technology last year and require that it install a new technology this year simply because the state-of-the-art has advanced. Rather, once installed, pollution control equipment is likely to be left in place for the balance of its useful life, or even for the life of the plant. This has given experts cause for concern about this approach, particularly during periods of rapid advancement in the development of pollution control technologies.

Another drawback to the technology-based approach is that it automatically implies that the control that results from the installation and correct operation of the equipment is necessarily worth the costs to society. That is, if all sources are required to install a particular piece of equipment, this implies that the pollution control that will result is worth more than the cost of the equipment.

In developing countries where little has been done in the way of pollution control in the past, this may be a quite reasonable assumption: the first increments of pollution control are often the least expensive, and can also be those that do the most good. In economists' parlance, these are the controls for which marginal benefits are great and marginal

costs relatively low. However, at successively higher levels of treatment, marginal costs can rise rapidly and marginal benefits can decline. This means that the technology-based approach looks less and less attractive at higher and higher removal levels and must be scrutinized carefully.

Another difficulty presents itself under the technology-based regime. It is that those enforcing the standards can become fixated on the installation of the technology *per se*, rather than on its correct operation. Yet it is the correct operation of the pollution control technology that improves the environment—not the mere presence of the equipment at the industrial facility. It is essential for environmental improvements that enforcement officials get beyond what is called initial compliance with technology-based standards; their eventual goal must be what Russell called continuing compliance, and this implies a real concern with the correct operation of the control equipment.¹⁸

A final problem with technology-based standards is that they can be more difficult to promulgate than one might think. To set such standards, it is first necessary to determine which types of facilities or industrial processes will be grouped together. Will petroleum refineries be treated as one single source, or will the individual processes at one refinery be treated as a source category? Will newer plants be required to meet the same standards as older plants? Will a source in a remote region be treated the same as one located in a densely populated area?

These questions may seem innocuous, but they can slow down the establishment of technology-based standards greatly. In the United States, for example, the Environmental Protection Agency was directed by the 1970 Clean Air Act to set emissions standards for all new sources of

---

¹⁸. See Russell, *op cit.*
conventional air pollutants. By late 1989, however, there were still some types of industrial sources for which standards had not been set, owing in large part to the very protracted legalistic disputes about what constituted a source of pollution, what best technology was, and so on. While there is no reason to believe that this experience would have to be repeated elsewhere, it is a sobering reminder that such standard-setting can be slow.

**Other Centralized Approaches.** How else might centralized command-and-control regulation work to meet ambient standards? That is, suppose the regulatory authority was willing to forego requiring specific kinds of pollution control equipment, but wished only instead to require pollution reductions from all the sources in an area sufficient to ensure that the ambient standards were being met. How would the authority go about determining how big a reduction to require at each source of the pollutant in question? There are several ways this might be done, and it is important to understand the differences between them.

For example, if aggregate emissions must be reduced by 25 percent to meet the environmental standard, each source could be required to cut back its own emissions by 25 percent—this is sometimes referred to as the "uniform rollback" approach. This equiproportional rule has the very attractive feature of appearing fair, because everyone is assigned the same percentage reduction.

In actuality it is not fair. This is because of the very great diversity of sources for many environmental contaminants, ranging from neighborhood drycleaners or car-repair shops to complex steel mills or large chemical plants. These differing characteristics and technological circumstances mean that one source may be able to reduce its emissions by
25 percent quite inexpensively, perhaps by switching to a less polluting fuel or altering slightly its manufacturing technique. Yet another source might find that it can meet its 25 percent reduction only through the installation of expensive control technology. Thus, a requirement for equal percentage reductions may mean very unequal financial burdens. This inequity would be more pronounced if some sources had already been required to reduce their discharges, since the marginal costs of pollution control generally increase at an increasing rate.

Under another approach, the emissions reductions needed to meet ambient standards might be apportioned on the basis of "affordability"—that is, the largest cut-backs might be required of those in the best financial shape. This, too, has some obvious appeal. Indeed, under individual income tax system in many countries, those in higher income brackets are required to pay a higher percentage of their income in taxes, and the affordability criterion would seem to extend that principle to pollution control.

On closer inspection, however, assigning emissions reductions on the basis of affordability also has serious drawbacks. First, it would penalize successful, well-managed firms and reward poorly operated and inefficient ones that may be responsible for their own poor financial state. In this sense, then, it gives exactly the wrong set of signals to firms and slows the replacement of failing enterprises with newer, more efficient ones.

Second, there may be no relation whatsoever between a source's emissions and its financial condition. Thus, a very profitable firm may have very low emissions (particularly if it has continually modernized) but it would still be forced to spend heavily on further emissions reductions.
under an affordability criterion. Meanwhile, a smoke-belching firm in perilous financial condition would be let off lightly. For these reasons, an affordability criterion is much less attractive than it may at first appear.

Finally, the regulatory authority could try to apportion emissions reductions among sources in such a way that the required aggregate reduction was accomplished at the least total cost to society. In other words, the central regulator could look across all sources and ask where the first ton of emissions might be reduced most inexpensively, then require it to be removed. The second ton of emissions reductions would then be assigned, again to the source that could accomplish it most cheaply. And so on until the aggregate emissions goal had been met. This approach has the advantage of ensuring that society (through the affected sources) gives up as little as possible to get the emissions reductions, an attractive prospect.

But it raises the possibility of another sort of inequity. Suppose that one source, among a large number of polluters in a particular area, was always the lowest-cost abater? This is unlikely to be the case in reality, but it might hold true in certain circumstances. It would hardly seem fair to place the entire burden of emissions control on that source merely because it could reduce pollution more inexpensively than the others. Thus, although the cost-minimization approach has some obvious appeal, it is not ideal.

Another obvious problem with this approach is that it requires a tremendous amount of information on the part of the regulatory authority. After all, if emissions reductions are to be parcelled out so that the total costs of meeting the ambient standard are minimized, the regulatory
authority has to have the marginal cost schedules for all the regulated sources: that is, it must know who can reduce pollution by how much and for what amount of money? This is an incredible information burden for any regulator to bear, and the less sophisticated the authority, the less likely it is that the burden could be met. Many countries have yet to even identify systematically all major sources of pollution. In view of this, it is clear how unlikely it is that the requisite information will be available for a centrally-imposed, least-cost approach.

Incentive-Based Approaches. By far the most common types of regulatory approaches used for environmental protection are those discussed above. That is, requiring the installation of specific types of pollution control technologies or, at the very least, requiring specific reductions in sources' emissions has been the predominant means of environmental regulation in the world today. Nevertheless, there are alternatives, one of the most promising of which involves a decentralized approach to environmental regulation that carries with it a variety of advantageous features.

Perhaps the best-known of the decentralized approaches is the effluent charge or pollution tax. Under this scheme, the regulatory authority imposes a tax or fee on each unit of the environmental contaminant discharged, but does not require any specific amount of pollution reduction from any of the sources.

In its purest form, the tax or charge would be set to reflect the damage done by each unit of emissions. Rather than tell each firm how much to reduce emissions, it would be left to respond to the charge however best it sees fit. Depending on the amount of the charge, some sources would reduce their emissions immediately—those will be the ones that can prevent
pollution at unit costs less than the amount of the charge. By doing so, they save the difference between their per-unit cost of pollution control and the per-unit charge. Thus, it is in their economic interest to economize on their use of the scarce assimilative capacity of the environment, just as they try to economize on the use of the labor, capital, and natural resources that cost them money. Other sources may find it economical to continue discharging the pollutants subject to the tax. The firms continuing to discharge will be those finding it cheaper to pay the effluent tax than to incur the required control costs. 19

This approach to environmental protection has several advantages. First, it ensures that the sources that do elect to take control measures are those with the lowest control costs. In other words, it mimics the least-cost approach discussed above, but does so without requiring the regulatory authority to specify emissions reductions for each and every source. This is of utmost importance in developing countries because it implies that they will not spend more to meet environmental goals than they must.

Perhaps more importantly, the effluent or pollution charge provides a continuing incentive for firms to reduce their costs of pollution control. Since they must continue to pay the per unit charge, it continues to be economical for them to find ways to reduce emissions for less than that charge. Note that this incentive is missing under the centralized approaches discussed above. For example, if the technology-based approach is used, once the firm has installed the required equipment, it has complied with the law and there is no reason for it to attempt to reduce emissions still further. This dynamic incentive for continued pollution

19. See Anderson et al, op cit.
control is one of the most attractive features of the effluent tax approach.

Third, the pollution charge requires something from all sources—either they must reduce pollution to escape the charge, or they must continue to pay it. No one gets off scot-free. The latter can happen under other systems, particularly those which require nothing of firms in precarious financial condition. Thus, the charge approach contains an element of fairness sometimes missing from other approaches.

Fourth, the pollution charge generates revenues which the government may then use to finance environmental programs or for other worthy purposes. Unlike regulatory programs, the effluent charge approach can be seen as a money maker. However, it is important that a system of charges not be imposed merely for revenue creation (as it is in many of the countries that have such a system of charges). For if the effluent charges are set high enough, pollution (and hence revenues) will be significantly reduced.

Finally, the effluent charge or tax approach is attractive because it imposes a significantly smaller information burden on the regulatory authority. Contrast it, for instance with a system in which separate technological standards must be issued for many types of sources with a broad array of industrial categories. Under the charge approach, the regulator must only set the level of the charge and then adjust it upward or downward depending on whether the environmental target is being missed or exceeded. This reduced information burden is critically important in countries where administrative resources for environmental control are thinly spread.
As might be expected, the effluent charge route has shortcomings, which at least some economists have been slow to recognize or acknowledge. First, under the purest of the effluent charge approaches—where the tax is to be set equal to marginal damages—it is very difficult to determine the damage done by each unit of pollution. In practice, this could only be approximated at best. Note also that since the damage done by a steel plant in one area might be very different from that done by a steel plant located in another area, the optimal pollution charge would have to vary between the two sources. This will no doubt appear to be inequitable to the source being assessed the higher charge, and such considerations may mean political difficulties. Thus, spatially differentiated charges may be an impossibility. They may also be impossible on legal grounds in some places, especially if the charge is considered a tax.

In fact, some have suggested that this is such a liability of the charge approach that a modified version be used. Under this variant, the regulatory authority would first select the desired level of environmental quality (the ambient standard discussed above) and would then set the charge at a level sufficient to induce the emissions control that would achieve it. Yet even this would require some trial and error, because the marginal cost schedules of the individual sources would not be known to the environmental management agency. The uncertainty this might create


could make firms reluctant to make their initial emissions control decisions.

This uncertainty about the actual amount likely to be discharged is troubling to some for another reason. Suppose it is important that total emissions of a pollutant be kept below some quantity because greater emissions would overwhelm some natural system. The environmental authority would try to set the charge at a high enough level to ensure that actual emissions fell below that target quantity. But if the marginal costs of control at the individual sources were higher than expected, it is possible that this quantity of emissions could legally be exceeded under the charge approach.

Finally, the effluent charge route presents one serious political problem. Under this approach, the emissions which sources are now free to discharge under a command-and-control regulatory system (those that remain after the installation of technology, for instance) would be subject to the charge. Thus, many sources that presently complain about over-regulation would have a new complaint: a major effluent tax liability. It would be possible, of course, to impose an effluent tax only on emissions above some pre-determined quantities. In this case, some "free" pollution would be allowed (as it is under virtually every command-and-control system) and the system would, in actuality, be an excess-emissions tax (or charge).

Effluent charges or taxes are not the only incentive-based approach that can be used. A second variant involves marketable pollution allowances or permits. This approach could work in one of two basic ways. Under one version, the regulatory authority would first decide how much aggregate pollution was consistent with the predetermined environmental goal. It would then print up individual discharge permits, the total
quantity of which added up to the aggregate amount permitted. No one without a permit would be allowed to discharge the regulated pollutants. The permits could be allocated among sources in one of several ways. First, a sale might be held at which all of the permits were auctioned off to the highest bidders. Alternatively, the permits could be distributed free of charge on some predetermined (or even random) basis, perhaps historical levels of pollution. Under either approach the permits would be marketable anytime after the initial distribution.

The incentive effect resulting from a system of marketable permits is not unlike that under the effluent charge approach discussed above. Those sources that currently pollute but which could reduce pollution for less than the cost of a permit would take control measures. Those sources finding it very expensive to reduce pollution would buy discharge permits instead. Thus, as if guided by the same "invisible hand," the emissions reductions would take place at the low-cost sources, thus minimizing the costs associated with a given reduction in emissions. Similarly, those firms buying permits would always have a continuing incentive to reduce their costs of pollution control—as soon as they could do so, they could stop buying permits and save themselves money in the process. Also, the information requirements for the regulatory authority are comparable to that under the charge approach—considerably less than those under the command-and-control approach.

The permit approach has one major advantage when compared to the effluent charge. It is that it looks more like the existing system—which involves the permits issued by most environmental authorities—than does the latter. This may sound strange, but radical change is almost always more difficult to accommodate than gradual change. Since the marketable
permit system is capable of accomplishing most of the same things as the effluent charge approach, and may be easier to put in place, it has been the preferred approach in the U.S. and several other countries. Marketable permits are not without shortcomings, of course. One concern has to do with the possibility that certain sources would buy up all the permits as an anti-competitive tactic. While this ought to be rectifiable through governmental antitrust actions, in practice this might take time. Another question concerns the initial distribution of permits prior to the development of secondary markets. If all the permits are auctioned off, this approach would fall prey to the same political problems that arise under a charge approach--some sources would have to pay for emissions they are granted free under the existing system. Thus, political problems could become formidable. If the initial permits are to be distributed free of charge, how should they be allocated? On the basis of previous emissions? To all citizens equally? To environmental and industry groups? This too is a potentially thorny problem, although not an insurmountable one.

III. Implications for Brazil and Other Developing Countries

It is fair to ask about the implications of the preceding discussion for pollution control policies in Brazil and other countries struggling to harmonize economic growth with environmental protection. At the national level, Brazil has just gone through a significant reorganization of its environmental agencies and many other developing countries are just now

establishing serious environmental programs. Much of the actual business of regulation takes place at the state level. While several of the Brazilian states have large, sophisticated and active pollution control authorities (particularly Sao Paulo State), others have virtually no staff or financial resources. For that reason, it may be useful to draw out the most important conclusions from this discussion and highlight them here for the special circumstances in Brazil. These conclusions should apply in many other countries as well.

First, it is difficult to overstate the importance of the potential cost savings which decentralized, incentive-based approaches can deliver. Studies in the United States and other industrialized countries have consistently indicated that effluent charges or marketable permits can reduce the total costs of meeting predetermined ambient environmental standards by 20–90 percent. For countries which are struggling to develop economically while at the same time protecting their environment, such savings cannot be ignored. In the United States, for example, it is estimated that industrial sources of pollution are spending on the order of $40-50 billion annually to comply with federal environmental laws. These laws are primarily of the command-and-control type which are insensitive to variations in pollution control costs between sources. If even a 20 percent reduction in cost were possible from the use of incentive-based approaches, a savings of $8-10 billion would result. It goes without saying that similar percentage savings would be welcomed in Brazil and other countries.

Another point is worth emphasizing. In the early stages of any country's pollution control program, decisions about where and how much to

23. These studies are summarized nicely in Tietenberg, op cit.
control are easiest to make. That is, the air or water pollution problems are of the grossest type, obvious to the eyes and nose. At this early stage, it is probably most important to get basic pollution control equipment in place and to do so quickly. This may appear to be one of the appeals of the command-and-control, technology-based approach, and it must be admitted that these approaches have produced significant pollution reductions in Brazil and other industrializing countries over the last two decades or so.

Nevertheless, the same kinds of progress could have been made with an incentive-based approach. That is, the application of effluent taxes or marketable permits would probably have led to many of the same kinds of investments in pollution control equipment as has more traditional regulation. Moreover, the existence of the charge (or the cost of the permits) would have acted as an additional incentive to continue to find ways to reduce pollution, an incentive that is often missing under traditional approaches.

More importantly, as environmental regulation matures, the advantages of the incentive-based system become more apparent. This is because as the marginal costs of pollution control begin to increase sharply, the cost savings from concentrating control on the low cost sources grow as well. This suggests that to the extent it is possible to make inroads with incentive-based approaches early on, significant benefits will develop in later stages of the regulatory program.

It is also important to say something about the "enforceability" of incentive-based systems as contrasted with their command-and-control counterparts. Opponents of incentive-based systems often argue that they are more difficult to enforce than are command-and-control rules;
proponents of these approaches claim that the opposite is the case. Neither argument is correct. Under either type of system, it is imperative that sources be monitored regularly to ascertain the quantities of pollution they are discharging. This is essential under command-and-control because actual discharges must be compared to the centrally-assigned standards, and to ensure that the installed equipment is operating properly. It is essential under incentive-based systems because the regulatory authority must know how much is being discharged in order to calculate the effluent charge liability or determine whether the source is operating within the confines of the permits it holds. No regulatory system can be expected to work if there are inadequate resources for monitoring and enforcement. 24

This discussion of enforceability prompts an additional question. Does this not imply that a technology-based approach will mean less monitoring, because the regulatory authority has only to ascertain whether the required technology is in place? No. The existence of control technology per se is not sufficient to ensure pollution reduction. Control equipment must be properly maintained and operated continuously. Thus, the burden of monitoring under technology-based regulation is no different than under other approaches.