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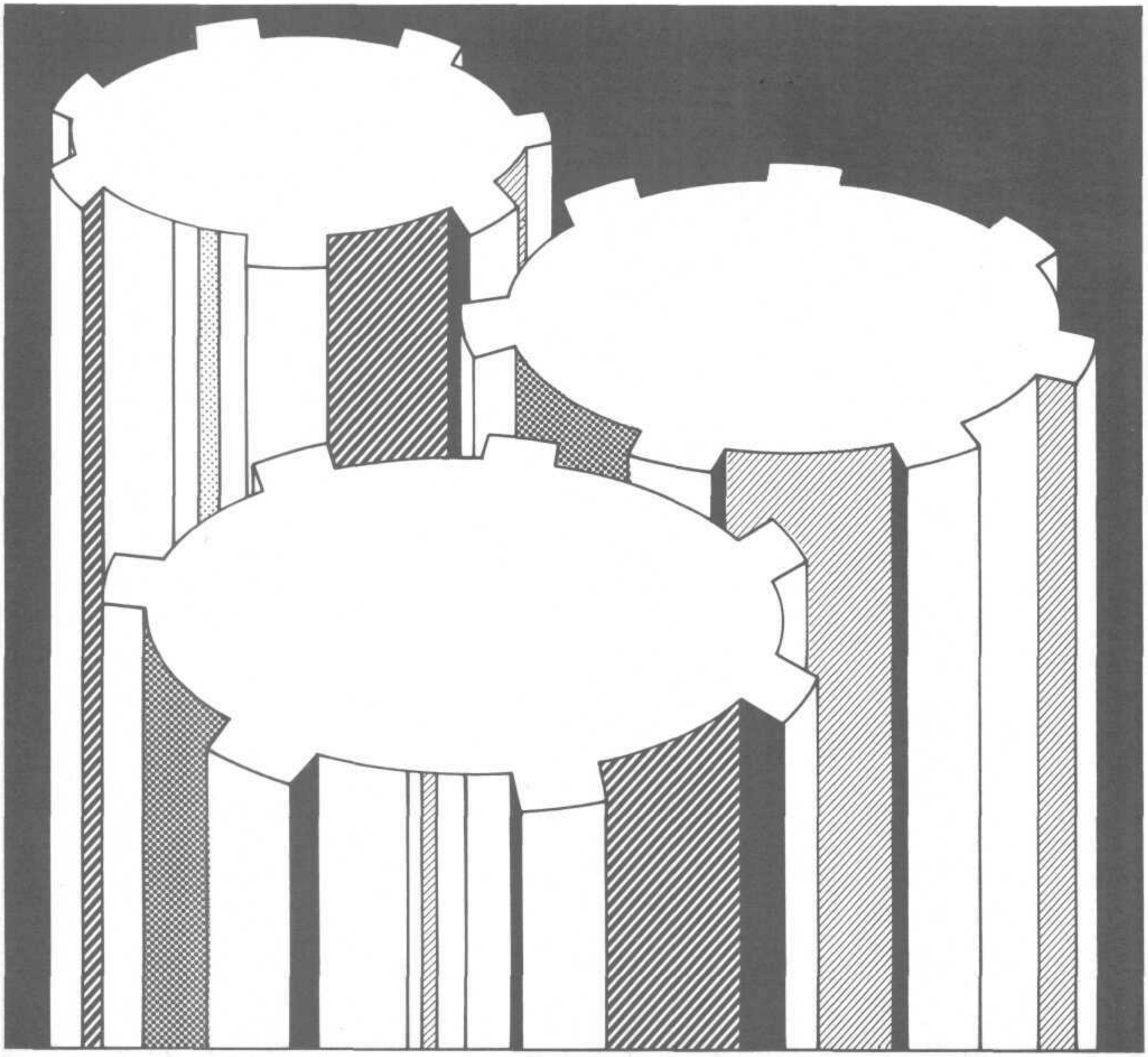
Environmental Regulation and Economic Efficiency



CBO STUDY

ENVIRONMENTAL REGULATION AND ECONOMIC EFFICIENCY

Congress of the United States
Congressional Budget Office

NOTES

Details in the text, tables, and figures of this report may not add to the totals because of rounding.

Unless otherwise noted, all years in this report are calendar years.

PREFACE

Contemporary environmental regulation has been a source of controversy since its advent in 1970. Hundreds of billions of dollars have been invested in pursuit of improved air and water quality and the safer disposal of hazardous and toxic substances. While proponents of these regulatory activities point to gains in the level of environmental amenities, detractors question both the rationality of the existing regulatory regime and whether regulation has handicapped the competitiveness of U.S. goods and services. This study, prepared at the request of the Senate Committee on Environment and Public Works, examines the effects of environmental regulation on the efficiency of the U.S. economy. In keeping with CBO's mandate to provide objective analysis, the report makes no recommendations.

This report was written by Everett M. Ehrlich, Thomas J. Lutton, and John B. Thomasian. Thomas Lutton performed the econometric simulations found in this report, and John Thomasian conducted the survey of foreign regulatory practices. Marc Chupka made valuable comments throughout the analysis, and Kristin Hughes and Patricia Macias provided research assistance.

The authors are grateful to many reviewers, including Raymond Kopp, Henry Peskin, Paul Portney, and other members of the staff of Resources for the Future; Eric Hanushek and Kenneth Rubin of the Congressional Budget Office; Marvin J. Kosters of the American Enterprise Institute; Paul MacAvoy of the University of Rochester; and James Barth of George Washington University. The study was prepared in CBO's Natural Resources and Commerce Division, under the general supervision of David L. Bodde, Everett M. Ehrlich, and John B. Thomasian. The report was edited by Sherry Snyder, and typed and prepared for publication with style and grace by Deborah L. Dove.

Rudolph G. Penner
Director

March 1985

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SUMMARY

Since the passage of major environmental legislation in the early 1970s, the U.S. private sector has spent hundreds of billions of dollars in efforts to comply with regulations intended to control pollution and maintain and improve the quality of the environment. This investment may improve the welfare of U.S. citizens by incorporating the value of environmental amenities into economic decisionmaking throughout society. That is, by discouraging the production of goods that result in pollution when produced or used, environmental regulation may improve the efficiency of the U.S. economy. But if regulation is poorly devised or administered, it can inhibit unduly economic activity in general, leaving the economy less productive. The balance between these conflicting effects has been a continuing source of controversy.

This study analyzes the effect of these expenditures on the efficiency with which U.S. goods and services are produced, both absolutely and relative to the experience of major U.S. trading partners. Although these effects can be identified, the reader should be cautioned that the observed relationship between regulation and economic activity does not indicate whether environmental regulation has made society "better off." Many benefits of environmental regulation, such as the preservation of pristine areas or species, go unmeasured in marketplaces and are not, therefore, considered "economic activity." Whether or not environmental regulation has ultimately increased societal welfare is a question beyond the reach of this analysis.

To compare the effects of environmental regulation in the United States and abroad, this report examines three issues:

- Are environmental quality standards and attainment strategies comparable in the United States and abroad?

- Have the expenditures made to achieve pollution abatement been similar in the United States and abroad?

- Have the measured effects of these expenditures on output, prices, and productivity been comparable in the United States and abroad?

The results of this analysis indicate that environmental regulation has not been a significant source of productivity losses in the private sector. The output and productivity losses attributable to environmental regulation in the United States have been slightly larger than those experienced in the three other nations studied--Canada, Japan, and the Federal Republic of Germany--but they are nonetheless small in magnitude. Moreover, the economic losses attributable to environmental regulation, in terms of both measured output and productivity, appear to have declined over time. All four countries, with the exception of Canada, appear to sustain their largest cumulative productivity losses related to environmental regulation in the mid-1970s, with the magnitude of these losses declining thereafter. In fact, annual productivity growth appears to have increased after an initial dislocation in the first half of the 1970s.

These shrinking losses can be partially explained by the fact that some of the benefits of regulation (such as lower levels of illness or improved productivity in resource-related industries) take some time to occur, and only became apparent later in the decade. Moreover, expenditures made for pollution control, measured in real terms, were larger in the years immediately following the passage of regulatory statutes, suggesting that initial expenditures were aimed at controlling a "backlog" of pollution sources, and that a smaller "steady state" level of investment might now be needed to comply with environmental regulation.

The decline in losses later in the 1970s might also be explained by the substantial learning that has occurred as both regulators and polluters gain experience in carrying out environmental programs. New technologies have been developed to control pollution, and the regulatory regimes in all four nations have experimented with new strategies for reaching environmental goals. Learning, therefore, can reconcile the effects of regulatory requirements with economic efficiency, through continued innovation and adaptation on the part of U.S. regulators.

SIMILARITIES IN REGULATORY PROCEDURES

One reason that environmental regulation has had comparable effects on the four nations studied is that their approaches to attaining environmental quality have been similar. All four countries establish environmental quality standards in a similar manner. Though not identical, goals for safe air and water quality, as expressed through ambient standards, are comparable among the countries. This is not merely coincidence: it is largely due to the sharing of scientific information formally through such organizations as the World Health Organization and the North Atlantic Treaty Organization, and informally through the international scientific community.

The regulatory approaches used to control pollution in each country also share many characteristics. Standards or guidelines for controlling pollution discharges often originate from a central bureaucracy and are applied to large categories of sources. Most important, they are usually based on state-of-the-art or "best available" control technology, and tend to be stricter in areas having difficulty meeting ambient air and water quality standards. All countries also appear to employ tax and spending subsidies to encourage investment in pollution abatement.

But differences also exist that illustrate both the difficulties encountered in meeting environmental quality goals and the innovative schemes that have been used to address the adverse effects of regulation on the economy. In Japan, for example, pollution occurs within densely populated urban areas, many of which are surrounded by mountainous terrain. This is a natural consequence for a highly industrialized nation with a low proportion of habitable land at its disposal. As a result, Japan spent more (as a proportion of gross domestic product) in the early and mid-1970s than the other countries to achieve similar environmental quality. Canada, with a low population density and vast stretches of flat terrain, reflects the opposite situation, with the United States and West Germany falling somewhere in between.

Recognizing its situation, Japan has instituted a number of strategies aimed at reducing the costs of pollution abatement. First, Japan tends to be somewhat more flexible in accommodating national control requirements to local conditions. Discharge standards set by the central government, though taken quite seriously, can be modified by local governments or prefectural agencies to meet a specific situation. If the standard appears too harsh for a particular plant, it can be relaxed for that plant if it continues to operate in good faith. More often, however, if a standard can be tightened with acceptable economic consequence, the local governments will impose tougher controls. In fact, prefectural governments commonly impose tighter standards for new sources than for older ones. In addition, discharge limits often are applied to a plant as a whole, even if it contains several individual discharge points. This allows the firm to choose the most cost-effective mix of controls at the individual pollution sources to meet its overall limit--a procedure not always permitted in the other countries studied.

Second, Japan supplements this flexible approach with an enforcement attitude that includes rewards as well as penalties. Rewards can take the form of below-market loan rates and hastened permit reviews. Punishments include the denial or delay of permits and general lack of bureaucratic cooperation. Japan attempts to negotiate all environmental requirements, using the courts infrequently and only as a last resort. Certainly, Japan is not the only country that employs innovative strategies; all do to some extent. But these innovations are employed against a backdrop of common regulatory practice.

SIMILARITIES IN POLLUTION CONTROL EXPENDITURES

Pollution control expenditures are here defined as new plant and equipment expenditures made by the private sector to conform to regulatory requirements. Most of these data are from surveys of private firms or from engineering studies that depict the regulatory compliance costs of a "prototypical" plant and then extrapolate these costs to the industry or economy level. Since these estimates are made by numerous agencies using different techniques, international comparisons must be regarded with caution.

This measure of pollution control costs is a limited one. Alternative measures could include the administrative costs of regulatory activities, the operations and maintenance activities related to abatement, or some of the economic dislocations induced by pollution control activities (which can, in a larger sense, be considered "costs" as well, but really measure the effects of these activities). Given the limited nature of the cost measure used in this analysis, the cost estimates presented here are lower than other available measures.

While the expenditures made to control pollution (as defined here) are generally small as a share of gross domestic product (GDP) in all four nations studied, the United States currently spends the largest share (see Summary Table 1). In 1979, the last year for which data exist for all four countries, U.S. expenditures on new plant and equipment dedicated to controlling pollution equaled $7.1 billion, or 0.30 percent of GDP. In the same year, Canada, Japan, and West Germany spent 0.04 percent, 0.13 percent, and 0.15 percent of GDP on the same activity. U.S. expenditures declined to 0.28 percent of GDP in 1982. In general, pollution control expenditures have declined as a percentage of GDP and as a percentage of total private capital expenditures in all four nations since the mid-1970s, with the U.S. ratio remaining the highest. Had 1982 U.S. expenditures declined to the level suggested by Japan's ratio of expenditures to GDP (in 1981, the last year such data are available), they would have fallen from $8.5 billion to $5.2 billion, a savings of $3.3 billion.

SIMILARITIES IN ECONOMIC EFFECTS

The econometric simulations performed for this analysis and for other studies reviewed by CBO are consistent with the view that the aggregate effects of environmental regulation, as measured by pollution control expenditures, have been small in all four countries, and that these effects appear to have taken a parallel course in all four as well. The CBO analysis used an econometric model to compare productivity and gross domestic product (GDP, or output) under two cases; one using observed pollution control expenditures, and a second assuming that none of these expenditures occurred. The results of this comparison estimate the effects of pollution control expenditures on these variables.

Summary Figure 1 depicts the cumulative difference in the level of total factor productivity in the four nations attributable to expenditures made for pollution control. This difference declines in the United States, Japan, and West Germany after peaks in the mid-1970s. Using a 1967 base,

SUMMARY TABLE 1. POLLUTION CONTROL EXPENDITURES IN THE UNITED STATES, CANADA, JAPAN, AND WEST GERMANY, 1973-1982 (In billions of current dollars and as a percentage of gross domestic product)

	United States		Canada		Japan		West Germany	
Year	Billions of Dollars	Percentage of GDP	Billions of Dollars	Percentage of GDP	Billions of Dollars	Percentage of GDP	Billions of Dollars	Percentage of GDP
1973	4.9	0.38	0.13	0.10	1.8	0.45	NA	NA
1974	5.7	0.41	0.14	0.09	3.1	0.69	NA	NA
1975	7.0	0.46	0.14	0.08	3.2	0.64	1.0	0.24
1976	7.2	0.43	0.14	0.06	2.7	0.47	1.0	0.21
1977	7.3	0.38	0.05	0.03	1.7	0.22	1.1	0.18
1978	7.6	0.35	0.06	0.03	1.7	0.16	1.2	0.17
1979	8.4	0.35	0.09	0.04	1.2	0.13	1.2	0.15
1980	9.2	0.36	NA	NA	1.5	0.13	NA	NA
1981	8.9	0.31	NA	NA	2.0	0.17	NA	NA
1982	8.5	0.28	NA	NA	NA	NA	NA	NA

SOURCES: Congressional Budget Office. Exchange rates and GDP data from International Monetary Fund, *International Financial Statistics* (various years). Pollution control expenditure data for United States from Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (June 1981 and June 1983). Data for the other nations obtained from the respective embassies (1983).

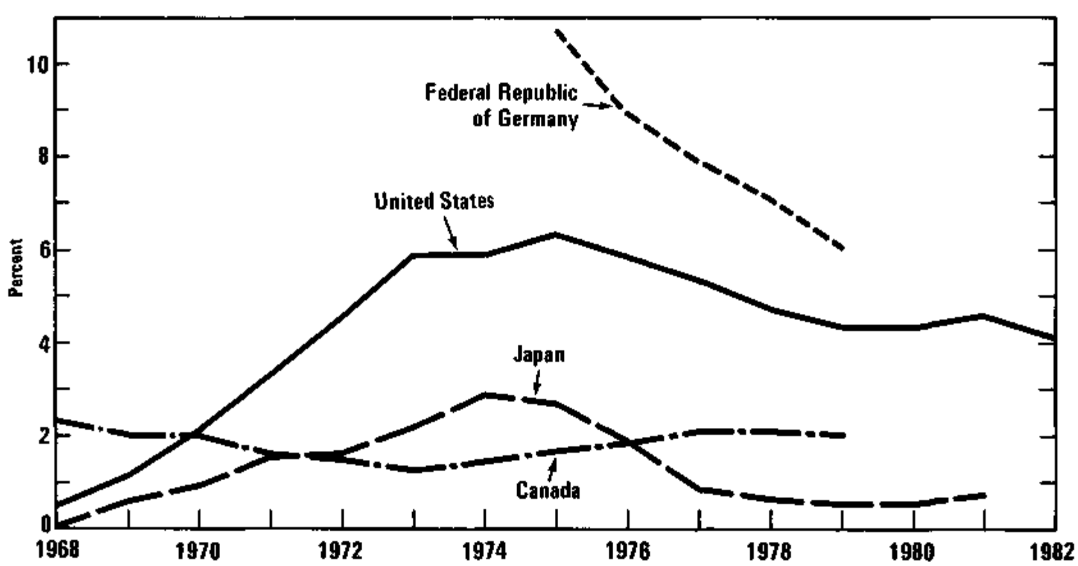
productivity in the United States is 4.3 percent lower by 1982; that is, the annual productivity loss attributable to pollution expenditures over this 16-year period is 0.28 percent, a result slightly higher than estimates of the other studies reviewed by CBO. The magnitude of this loss is small, but it is greater than the comparable annual measured losses experienced in Japan (0.06 percent) and Canada (0.14 percent). The observed annual loss for West Germany is 1.14 percent, but the limited data for West Germany might make this estimate unreliable.

The annual loss in U.S. productivity attributable to environmental regulations, as calculated in the CBO analysis, is compared with the losses estimated in other analyses in Summary Table 2. While the CBO estimate of this annual loss is slightly higher than the average of these other studies, the results are generally comparable. Moreover, those studies that break their analyses down into different time periods generally confirm the result found in the CBO analysis--that the losses attributable to environmental regulation have declined over time.

POLICY STRATEGIES

These findings suggest that environmental regulation has not been a major contributor to a loss in the efficiency of the U.S. private economy. But they

Summary Figure 1.
Percentage Differences in Productivity Between WPCE and PCE Simulations, 1968-1982



SOURCE: Congressional Budget Office.

SUMMARY TABLE 2. ESTIMATES OF U.S. PRODUCTIVITY LOSSES ATTRIBUTED TO ENVIRONMENTAL REGULATION

Study	Productivity Measure	Method	Years	Average Annual Decline in Growth Rate of Productivity (In percents)
CBO (1984)	Total factor productivity	Small systems	1973-1982	0.28
Christainsen et al. (1980)	Labor productivity, average of other measures	Survey of other studies	1973-1979	0.25
Crandall (1981)	Industrial output per manhour	Single-equation econometric	1973-1976	1.5
Denison (1979)	Nonresidential business income per employed person	Growth accounting	1969-1973 1973-1976 1975-1978	.05 .22 .08
DRI (1981)	Labor productivity	Large-scale econometric	1974-1979	0.1 to .25
Farber et al.(1984)	Nonfarm output per person	Growth accounting	1972-1982	.09
Kutscher et al. (1977)	Private output per manhour	Growth accounting	1966-1977	0.1
Norsworthy et al. (1979)	Private nonfarm output per manhour	Growth accounting	1973-1978	.09
	Manufacturing output per manhour	Growth accounting	1973-1978	.19
Siegel (1979)	Nonfarm output per manhour	Single-equation econometric	1967-1973 1973-1979	0.1 0
Thurow (1980)	Private output per manhour	Single-equation econometric	1973-1978	0.2

SOURCE: Congressional Budget Office.

also suggest that U.S. firms have spent more in pursuit of environmental goals than have firms in other nations, and that environmental regulation has had a slightly more negative effect on the U.S. economy than on the other three nations. The pattern of economic effects is also consistent with the idea that regulation has benefited, both in the United States and abroad, from the learning that accompanies experience. If this is so, then the process of adapting and improving regulation must be continued if regulation is not to disadvantage the U.S. economy vis a vis its trading partners.

Proposals to achieve this end can be grouped into three policy strategies: changing the basis for environmental standards, changing the attainment strategies used to achieve these standards, and subsidizing the costs of compliance.

Change the Basis for Standards

Viewed from an economic perspective, environmental regulation can contribute to economic efficiency by correctly specifying the societal costs of pollution and the benefits of reducing it. If decisionmakers in a competitive economy are forced to bear these costs, then they will likely adjust their production and consumption of polluting goods and services until the costs and benefits of reducing it are balanced. The statutory basis for most environmental regulation, however, is protection of public health without explicit concern for economic factors, although most analysts believe that these are often implicitly taken into account.

Amending environmental statutes to make explicit the process of setting standards on the basis of costs and benefits would pose both advantages and disadvantages. The benefits would be the potential economic gains to be realized by setting standards that accurately reflect the costs and benefits of pollution. A variety of examples can be cited in which man-hours of exposure to common pollutants might have been overvalued both in terms of health and property protection. The disadvantage is that a cost-benefit approach does not resolve the significant uncertainty that surrounds all of these calculations, including the valuation of human life. Thus it may give a false impression of scientific accuracy. Moreover, a cost-benefit approach would subject the standard-setting process to intense legal scrutiny, allowing opponents of individual standards to delay their imposition through court proceedings. Finally, although U.S. standards are generally less stringent than those of Japan, environmental regulation appears to have had a more dramatic impact on the U.S. economy than in Japan. Thus, the standards set by the regulatory process might be less important than the manner in which they are carried out.

Change the Attainment Strategies

The strategies pursued by regulators to achieve environmental standards can be changed in several ways to allow polluters more latitude when complying with regulation, without relaxing overall pollution abatement goals. Options for changing attainment strategies include emissions trading and emissions taxes.

Emissions trading works on the following principle: A group of polluters is required to meet a common standard, but some sources in the group can reduce pollution at a lower cost than others. If polluters with high costs are allowed to purchase additional reductions from their low-cost counterparts and credit them to their own abatement activities, the total cost of reducing pollution can be lowered while still meeting the overall reduction goal. The group can be defined either as the group of facilities within one plant or a group of plants in one region. Such schemes have already been applied on a limited basis in the United States and more extensively in Japan. In the extreme, a **marketable permit system** would allow any firm to sell reductions in their emissions above the levels required by standards, or to buy an emissions reduction and credit it toward their own compliance. Such a system would give every polluter the incentive to search out opportunities to reduce pollution at least expense.

These trading policies offer the advantage of reducing the cost of realizing any level of environmental quality by providing each polluter with a broader set of compliance alternatives while maintaining a ceiling on total emissions in any area. Models of such systems developed by CBO suggest the potential for significant cost savings under trading policies. On the other hand, they require greater administrative resources, since they increase the monitoring requirements of regulation, and require the administrative agency to produce highly individualized results rather than apply a universal standard. Other difficulties concern the possible "retirement" of polluters involved in emissions trades, the existence of local pollution "hot spots" created by changing the distribution of emissions within a region, and the fact that, in some areas, one polluter might have an effective monopoly on "extra" emissions reductions and might charge too high a price for them.

Rather than set a discharge limit for each polluter or classes of polluter, regulators could impose **emissions taxes** on polluters and then allow firms to control pollution until the cost of doing so was greater than the tax. In this sense, an emissions tax is equivalent to an ambient standard but allows the cost of reducing emissions at each source to be taken into account. The advantage of emissions taxes is that they are completely neutral with respect to firms' compliance activities; they do not favor or disfavor any approach to abatement and therefore lead to a least-cost set of compliance activities. The disadvantages associated with this strategy are the amount of information it requires regulators to have, and its potentially uncertain relationship to pollution levels. In order to anticipate the amount of pollution resulting from any level of emissions tax, regulators must first know each polluter's production process and how its output will respond to the imposition of the tax. In fact, the effect of such a tax on the price firms charge for their goods, and therefore the demand for them, will vary greatly. The alternative to complete information is to set taxes on a trial-and-error basis, an extremely difficult procedure given the long time period between the imposition of a tax and the opportunity to observe how long-term pollution levels have responded. Thus emissions taxes may be less effective at achieving any desired goal for emissions, when compared with a system that dictates a technological response. Moreover, an emissions tax would require substantially greater monitoring capability; for example, only 4 percent of the nation's 13,000 major air polluters were monitored using the "stack tests" that would be necessary to assess emissions taxes.

Subsidize the Costs of Compliance

Each of the four nations studied provides some subsidy to pollution control investments, generally through the depreciation codes found in their tax systems. Throughout the 1970s, pollution-related investments in the United States were given preferential tax treatment when compared with other investments. These distinctions were eliminated, however, by the Economic Recovery Tax Act of 1981.

In general, subsidization of investments for pollution control moves the economy further away from the notion that "the polluter pays," which is central to achieving the beneficial effects of environmental regulation. Subsidizing the costs of pollution control does not reduce them but only reallocates them. Thus, while subsidization may ease the burden on an individual firm or industry, it contributes to larger budget deficits by forgoing tax revenues or increasing expenditures. If larger deficits lead to higher interest rates, then the costs of environmental regulation would still penalize U.S. goods and services.

Pollution control expenditures have been said to have contributed to the shutdown of some U.S. production facilities. It is often alleged that foreign producers, whose costs determine the prices of the goods in question, do not face comparable expenditures. This may be the case in the domestic nonferrous metal industry, in which the costs of complying with environmental regulations have been substantial. One option to address such a situation is to impose a tariff on the imported good equal to the cost of pollution abatement that is not carried out. If pollution control expenditures are seen as an irrevocable aspect of modern production, then the failure to make such expenditures is tantamount to dumping or selling below cost--practices condemned by international trade agreements. But the willingness of foreign producers to export goods at the expense of their own environments might reflect their greater preference for economic growth over environmental amenities; in effect, these nations could be "exporting" their environmental quality to the United States. Prohibiting them from doing so would bear the traditional costs of restrictions on international trade.

CHAPTER I

INTRODUCTION

Since the creation of the Environmental Protection Agency (EPA) in 1970, the Congress has passed a number of bills aimed at restoring and maintaining the quality of the environment. Regulations now cover air quality, water quality, hazardous wastes, toxic substances, and other environmental "media." Proponents of such regulation point to the benefits created by these efforts. Indeed, for many environmental media or individual effluents, deterioration has been reversed or significantly slowed by the imposition of pollution controls.

This progress has not been without criticism, however. Many critics, even while recognizing the benefits, claim that the costs of achieving them have been unduly high. Over the past 10 years, for example, measurable private U.S. plant and equipment expenditures for pollution control (an admittedly limited definition of pollution control costs) have averaged approximately $7 billion a year in current dollars. According to this view, environmental regulation has compromised the economy's efficiency and has lowered economic output and productivity.

This paper examines the effects of environmental regulation on U.S. private-sector efficiency, specifically, whether environmental regulation has lowered the productivity of the U.S. private economy, both absolutely and relative to the nation's major trading partners. In its analysis, the Congressional Budget Office (CBO) has looked at three issues:

- Are environmental regulations more stringent in the United States?

- Has the U.S. private sector spent disproportionately more on pollution abatement?

- Have the economic effects of such expenditures, as revealed through econometric simulations, been more severe in the United States?

Several caveats should be expressed regarding interpretation of the results of this analysis. First, while the paper often discusses the effects of regulation on material economic outcomes, these results cannot be extrapolated to a conclusion regarding the effects of environmental regulation on societal well-being. While many of the benefits and costs of environmental regulation can be measured in monetary terms, others are difficult to measure or are not traded in the marketplace. These include the unmeasured value that people assign to preserving the physical environment for future generations, and the possibility of diminished entrepreneurship in the private economy. The effects of regulation on the production of goods and services certainly will strongly influence its effects on societal well-being, but these effects alone cannot indicate whether society has been made "better off." Such a conclusion involves concepts and measurements beyond the scope of this study.

Second, this report discusses the effects of regulation on the the U.S., Canadian, Japanese, and West German private sectors in the aggregate. It does not address whether different burdens have been placed on any one industry in the United States and abroad, resulting in changed patterns of competitiveness. The focus on the private sector as a whole is appropriate, however, since those industries that appear to bear the greatest share of the costs of pollution control (such as electricity generation, metals, petroleum refining, and chemicals) produce goods that are used in other industries throughout the economy.

Similarly, this paper should not be taken as a "cost-benefit" analysis of either environmental regulation generally, or of specific programs, because of the unmeasured benefits (and perhaps costs) and because of the likelihood that the effects of individual programs are cross-cutting. This analysis will be of value to the Congress in determining whether environmental regulation has handicapped the efficiency of the U.S. private sector in the aggregate. But the Congress may wish to consider the more specific costs and benefits of individual programs as well when considering environmental legislation.

CHAPTER II

THE ECONOMIC EFFECTS OF ENVIRONMENTAL REGULATION

The focus of this paper is on the effect of environmental regulation on the efficiency with which U.S. goods and services are produced. Efficiency is measured here by the growth of productivity in the U.S. economy. This is compared with the growth of productivity in three trading partners of the United States; if productivity grows more rapidly in the United States than abroad, then the relative efficiency of U.S. goods and services increases, raising the U.S. standard of living.

A variety of measures can be used to define productivity, but all are based on some measure of economic output (goods and services) divided by a measure of economic inputs (such as labor, machines, energy, and the like). Given that any economy's endowment of economic inputs is relatively fixed, particularly for short periods of time, changes in productivity are driven by changes in economic output. The effects of environmental regulation on economic efficiency, therefore, depend strongly on how regulation affects output. This chapter describes those effects, dividing them into positive and negative influences.

POSITIVE INFLUENCES

Environmental regulation may improve productivity or increase economic output by incorporating pollution-related costs into economic decisionmaking, thereby improving the economy's efficiency.

Improving Efficiency

Absent government interference or distortions of the competitive system, the decisions that determine which goods and services will be produced in the economy, and how much of each will be produced, are based on profitability. If a good or service is profitable, then firms will be induced to produce it. In a perfectly competitive economy, this profitability guideline can lead to a desirable allocation of resources among different goods and services. If a good or service is profitable, and in the absence of distortions of competition, then its price exceeds the cost of producing it, implying that the value of the good in question (its price) is greater than the value of the resources that went into producing it (its cost). If this is the case, then profitable production increases the value that society derives from its resources and, in turn, enhances societal well-being.

The existence of pollution does not change this guideline but does affect the way in which it is applied. The pollution that ensues from the production of a good or service creates a wide range of costs that occur elsewhere in society--air pollution, for example, can lead to illness requiring medical care. The costs of this care, however, are "external" to the polluting firm: since they occur elsewhere, the firm has no incentive to include them when considering the profitability of production. One interpretation of environmental regulation, therefore, is that it compels the inclusion of these external costs in assessments of the profitability of producing a particular good or service. Only if the external costs of pollution are incorporated into a firm's decisionmaking will the profitability of production again become a valuable guideline for allocating society's resources.

Environmental regulation, therefore, has the potential to improve the efficiency with which the economy produces goods and services. If the external costs of pollution are correctly estimated and assigned to the production of the goods and services that lead to them, then the profitability guideline will lead decisionmakers in a competitive environment to reduce the production of goods and services that generate pollution. Such a response will reduce the societal costs of pollution by reducing the loss of life and the damage to property that pollution causes. These benefits are often tangible. If lower levels of air pollution lead to lower health care costs (or lower dry-cleaning bills, for example), then consumers may be better off monetarily than they were when pollution levels were higher, and will have additional income available to purchase other goods and services.

Other benefits can occur on the production side of the economy. Lower effluent levels in air and water, for example, can lead to greater productivity in such industries as agriculture, fisheries, and forestry, allowing the price of these goods to fall and their production to expand.

All of these outcomes lead to higher levels of economic output using the same level of societal resources. The only difference is that by correctly assigning the costs of pollution, society has used its resources more efficiently and therefore has made them more productive. The potential improvement in economic efficiency realized through regulation, of course, need not be across the board. While society as a whole gains from greater efficiency, some sectors or industries might bear a disproportionate share of the costs of pollution control. This assignment of regulatory compliance costs would be considered reasonable, however, if regulation correctly identifies the social costs of unabated pollution and assigns them correctly to the pollution's source.

This view of regulation is, of course, theoretical. It depends particularly on the ability to measure the costs and benefits associated with pollution, and on the economy's competitive underpinnings. But under the right circumstances, environmental regulation can increase both societal well-being and the productivity of the private sector.

The "Pollution Abatement" Industry

An additional benefit often pointed to in defense of the economic effects of environmental regulation is that it creates a new set of economic activities aimed at preserving the environment--a "pollution abatement" industry. Certainly, regulatory statutes have given rise to the production of goods and services that were not produced before the imposition of regulation--catalytic converters in automobiles, flue gas desulfurizers (scrubbers) in power plants, and wastewater treatment facilities. These activities obviously create output and employment. But the fact of their existence does not necessarily lead to greater overall productivity, nor to higher total output and employment. Pollution control uses valuable resources, and such activities therefore can be considered a net addition to the economy only if the level of environmental amenities is correctly specified and achieved through regulation. The existence of a pollution abatement industry can be part of a misuse of society's resources and therefore can reduce output and productivity, if these conditions are not met.

NEGATIVE INFLUENCES

Environmental regulation also has the potential to reduce both output and productivity. It can do so by:

- o Misspecifying the level of pollution control to be achieved, and
- o Requiring firms to comply with regulations in a manner other than the least-cost one.

Moreover, environmental regulation often gives the appearance of having reduced output and productivity even though such reductions have not occurred. Regulation can do this by:

- o Creating benefits that cannot be measured in terms of economic output, and
- o Creating benefits that will not be realized until the future.

Misspecifying the Level of Control

Incorporating the full social costs of pollution into the decisionmaking of firms increases the efficiency with which economic resources are allocated in the production of goods and services. But this is unlikely to occur if the social benefits of pollution control--and hence the levels of pollution to be abated--are misspecified. If regulatory standards are too stringent, they depict the costs of pollution as being greater than they actually are. In such a circumstance, firms are led to spend too much for abatement, thus raising the prices of goods whose production causes pollution and restricting their production beyond the levels justified by a comparison of pollution's costs and benefits. A hypothetical example of such a standard would be to prohibit all sulfur dioxide emissions from power plants. No technology today can meet that goal, so power plants that burn coal and oil would have to be shut down. The resulting higher electricity prices would lower economic output by far more than the benefits created by the reduction in pollution.

Conversely, standards that are not stringent enough depict the costs of pollution as being lower than they actually are, and force some of these costs to be borne by the victims of pollution rather than by the activities that generated them. In this case, more stringent standards would increase output and improve productivity by eliminating the production of goods and services that are uneconomic when their external pollution-related costs are considered (assuming that all the benefits can be measured).

Impeding the Use of Least-Cost Responses

Regulatory authorities commonly not only stipulate the level of pollution abatement to be achieved but also provide guidance regarding the means by which it will be achieved. In fact, in some environmental statutes, the means of achieving abatement (sometimes called the "attainment strategy") is explictly specified.

Ideally, regulators would provide economic decisionmakers with information on the costs of the pollution they create and require them to incorporate that information in their decisions. For example, manufacturers that burn coal could be told that they must pay a fee (or tax) for each ton of particulates (soot) they emit into the atmosphere. Given this information (and presuming for the moment that such a system could be enforced), coal-burning manufacturers would then deploy their resources as they saw fit to reduce particulate emissions until the cost of eliminating them was equal to the tax. Beyond that point, paying the tax would be preferable to reducing emissions. If the tax were precisely equal to the external costs of particulate pollution, then it would be equivalent to the correct standard for controlling particulate emissions. As a result, output and productivity would increase, in part because manufacturers would be free to reduce their particulate emissions by any means at their disposal, whether by eliminating them from flue gas after combustion or by converting their facilities to burn fuels other than coal. Given the correct signals, the manufacturer would likely employ the least-cost technique for reducing these emissions.

This result occurs, however, only if polluters have universal latitude in selecting their individual strategies for pollution control in response to such a tax. If regulatory statutes limit this latitude, then there is no guarantee that the pollution-controlling activities chosen will be the least-cost ones. And many statutes do limit this latitude, through a variety of mechanisms, two of which are discussed below.

Engineering vs. Performance Standards. Engineering standards specify the use of a particular technical process; performance standards specify only a discharge limitation, leaving the polluter free to decide which process to use. In some instances, environmental regulation can require a particular engineering-based approach to abatement, rather than specify a target for effluent discharges. This approach can raise costs, by limiting the available choices to reduce pollution. For example, the Resource Conservation and Recovery Act (which guides the disposition of hazardous wastes) requires construction of "double-lined" landfills, with runoff collection systems and groundwater monitoring wells. Such specificity obviously limits the choice of compliance strategy and, if a cheaper substitute technology exists, raises the costs of compliance. In other instances, regulations can be written and interpreted in a manner that can be satisfied by only one existing technology. For example, current standards implicitly require "scrubbers" for power plants and catalytic converters for cars, since no other technological possibilities exist.

Rigidity in Standards Application. Standards for pollution control are written to attain an aggregate level of environmental amenities. But regulation can offer varying levels of latitude in meeting these standards. Air quality regulation, for example, sometimes allows a manufacturing facility enough flexibility to exceed its original level of abatement if it can identify and secure an equivalent reduction in pollution elsewhere within its plant (a procedure known as "bubbling") or outside its plant (a procedure known as "offsets"). Under the Clean Water Act, however, individual dischargers must meet their specified limits even if less expensive abatement opportunities (offsets) can be identified and secured. Regulation that is too rigid, therefore, can overlook least-cost opportunities for pollution control that reflect specific local conditions.

These stipulations regarding firms' compliance strategies can compromise the gains in efficiency created by environmental regulation. A specified technological response to pollutant emissions may not anticipate the least-cost solution for each individual polluter. Inevitably, some polluters will be required to spend more than is necessary to achieve a given level of abatement. This added expense reduces the efficiency with which the economy meets its environmental goals and, hence, lowers its productivity.

The distinctions between old and new, large and small, or any other division of polluters also adds to the total cost of providing a given level of environmental amenities. For example, industrial facilities that discharge wastes through a pipe to a body of water must receive permits before they can do so. But polluters whose discharges are carried into water bodies by rain runoff (as occurs on farm acreage treated with chemical fertilizers or pesticides) are generally not controlled. Yet it may be cheaper to control water pollution from these so-called "nonpoint" sources than from the controlled sources. Similarly, older establishments might offer, in some instances, less expensive emissions reductions than newer ones. Sacrificing these opportunities to pursue least-cost pollution reductions compromises the efficiency gains to be realized through environmental regulation.

Are these losses inevitable? To some extent, compromises in the efficiency of environmental regulation resulting from misspecified levels of abatement and circumscribed attainment strategies must be anticipated, since regulators are unlikely to obtain enough information to devise or administer an ideal regulatory scheme. Given these obstacles, regulators might be forced to opt for levels of abatement or for compliance strategies that are less than ideal.

Several examples illustrate this concept. Regulators impose a performance standard on fuel-burning installations (often called "sources") that fall within the bounds of the Clean Air Act. That standard dictates maximum allowable levels of pollutant emissions, which these sources must meet. But the harm done by the same amount of pollution from two sources will differ, according to the characteristics of the airshed receiving the pollution, the existence of other pollutants that interact with the effluent, or the proximity of an affected population or economic activity. If the purpose of regulation is to provide each economic actor with the correct information regarding the external costs of the pollution he or she creates, then regulators ideally would calculate the economic losses attributable to each source's pollution. But such a procedure would be time-consuming and expensive. Moreover, the value of reducing pollution from each source would change if any one of them were to close, or if a new one were to appear, or if the exposed population were to change. Therefore, to provide some measure of regulatory certainty to the polluter and to make the administrative tasks of regulation tractable, "rules of thumb" such as uniform national performance standards are employed.

Other such rules of thumb are used in designing attainment strategies. They are often motivated by the desire to reduce the costs associated with monitoring regulatory compliance. The decision to target air quality regulation at major (in other words, large) fuel-burning installations reflects the judgment that monitoring efforts could best be devoted to the largest polluters. Similarly, one of the arguments put forward in defense of engineering standards over performance standards is that the existence of specified equipment facilitates monitoring, since installed equipment is easier to observe than is the level of discharge.

Rules of thumb are sometimes intended to approximate economic calculations. The Clean Air Act, for example, targets new sources over old ones, in part because of the judgment that building control equipment into the design of a new facility is cheaper than retrofitting it over an existing one, and that the costs of equipping old facilities with control equipment are more likely to result in their eventual shutdown, causing economic dislocation. Pollution from some old sources might be easily controlled, but exempting older sources from more stringent standards could prolong their economic life and hinder attainment, thereby necessitating more stringent controls on newer sources, compounding the problem. Thus, while there may be substantial merit in these rules of thumb, they pose potential losses of efficiency. Certainly, not all of the potential inefficiencies found in environmental regulation can be traced to the desire for administrative simplicity; many stem from the desire to protect particular groups, interests, or industries. But the amount of information and administrative effort required to establish an "ideal" regulatory regime may prove impossible to provide and, therefore, some deviations from such an ideal regime must be anticipated.

On the other hand, these deviations might decline over time. As regulators acquire experience, they become more familiar with the shortcomings of the various rules of thumb they employ. This learning is sometimes reflected in subsequent amendments to environmental statutes or in new rulemaking on the part of regulatory agencies. For example, the Environmental Protection Agency recently ruled to allow groups of facilities or plants to trade off air pollution emissions within an aggregate limit. This acceptance occurred in response to dissatisfaction with the rigidities of new source performance standards as they were first implemented. Similarly, the 1981 amendments to the Clean Water Act allowed a broader range of acceptable municipal wastewater treatment technologies to qualify for federal matching funds. Learning, therefore, makes possible continued improvement in the performance of environmental regulation.

If the number of less expensive, but forsaken, opportunities to control pollution is small, or if the misspecification in the level of environmental amenities to be achieved is small, then environmental regulation still has the potential to increase output and productivity when compared to a "no regulation" case. These minor deviations can be thought of as sacrifices in output and productivity only when compared with the ideal regime. The potential of environmental regulation to detract from productivity and lead to lower total output increases, however, as the limitations on the available opportunities to control pollution grow in number (whether through presupposed technological choices, inflexible application of standards, or a limited subgroup of polluters to be controlled), or as the error in the specification of ambient pollution standards increases.

Unmeasurable Benefits

Environmental regulation frequently creates benefits that are of real value to society but nonetheless cannot be incorporated into such measures as gross national product. Output and productivity appear lower, then, despite the fact that regulation has led to a more efficient allocation of resources and increased societal well-being. The often-cited "scenic vista" problem is a case in point. People might assign a value to a scenic vista that is threatened by pollution, but no market exists within which the vista can be purchased. Since enjoying the vista requires no direct transaction, its value is never expressed in monetary terms. A comparable problem exists for such benefits as the preservation of pristine areas or endangered species.

Deferred Benefits

Certain benefits created by regulation will not be realized until some time after the expenditures required to lower pollution levels have been made. For example, lower levels of exposure to air pollution or carcinogenic substances will reduce the incidence of illness and death--but only after a sustained lower exposure--some time after expenditures for pollution control have been made.

Benefits are also deferred when regulatory activity has an "insurance" value. The regulation of toxic waste sites, for example, may avert the future contamination of groundwater resulting from possible leakage. By some estimates, the costs of cleaning up contaminated groundwater are 10 to 100 times the cost of proper hazardous waste management. 1/ Given the size of these costs and the likelihood that they could occur, it would be possible to calculate the amount that should be spent now to avert future losses, effectively buying insurance against them. Costs incurred to build safer waste disposal sites, therefore, provide a benefit in that they lower the risk of future losses. This benefit, however, is not captured in current measures of output and productivity.

CONCLUSIONS

These conflicting effects of environmental regulation on economic efficiency and, in turn, on output and productivity, make the overall impact of regulation uncertain. Moreover, the effects of environmental regulation on the U.S. private economy will be determined not only by how these conflicting effects sort themselves out domestically but also by the extent to which they occur in the nations that are U.S. trading partners. In order to measure fully the effects of environmental regulation on efficiency in the U.S. private sector, the following questions must be answered:

- o Are environmental quality standards and attainment strategies comparable in the United States and abroad?
- o Have the expenditures made to achieve pollution control been similar in the United States and abroad?
- o Have the measured effects of these expenditures on output, prices, and productivity been comparable in the United States and abroad?

The following chapters address these questions.

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1. Office of Technology Assessment, *Technologies and Management Strategies for Controlling Hazardous Waste* (March 1983).

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CHAPTER III

ENVIRONMENTAL LAWS AND REGULATIONS

How different or similar are the environmental regulatory approaches of the United States and other countries? This chapter examines the approaches used to regulate pollution as practiced in the United States, Japan, Canada, and the Federal Republic of Germany, including the types of programs used, attainment strategies, and government assistance for pollution control. The available information on individual regulatory styles permits only general conclusions but illustrates differences in attitude and, most often, flexibility in applying regulatory standards. These differences can affect the costs of environmental programs.

Two important determinants of regulatory policy are the environmental quality goals and the natural environment of each country. The first involves each country's desired level of environmental quality. The levels of permissible pollution embodied in air and water quality standards can affect the cost of regulations. The second aspect involves inherent differences in the natural environment (geography and topography) and demographics of each country. Because such differences can affect the ease with which environmental quality standards can be achieved, CBO has examined the following three issues, briefly reviewing the first two, but concentrating on the third:

- o How comparable are the environmental quality goals among the countries studied?
- o What effect do natural environment and demographics have on each country's ability to achieve these goals?
- o How comparable are their regulatory approaches?

SIMILARITY OF ENVIRONMENTAL GOALS

If environmental goals differ drastically among the countries examined, then so will the economic costs of achieving them. In theory, each country shares a common goal--the protection of human health. To provide such protection, governments must set standards or guidelines that specify a permissible level of pollution, mainly for air or water. The interpretation of acceptable levels of protection may differ among nations, however, reflecting the varied scientific evidence concerning human exposure to pollutants and the effects on health. Thus, regulators must base decisions on their assessments of acceptable risk, and this judgment may differ among countries.

In practice, these judgments have been fairly consistent. The United States, Canada, and West Germany all seem to have similar notions on what levels of pollution constitute healthful air and water quality for the major recognized pollutants. Japan's standards, however, are often stricter. For example, air quality standards for selected pollutants are roughly comparable among three of the countries, but not Japan (see Table 1). Similar examples exist for water quality standards.

Stricter standards such as those in Japan do not necessarily reflect the goals pursued in practice, however. The most limiting standards often are designed to protect property--such as structures and agriculture--in addition to human health. While they may be codified by the government, they are

TABLE 1. COMPARISON OF AIR QUALITY STANDARDS FOR POLLUTANTS IN FOUR COUNTRIES (Average daily values in micrograms per cubic meter, unless noted)

Country	Sulfur Dioxide	Nitrogen Dioxide	Particulate Matter
United States	365	244	260, 150[a]
Japan	100	38	100
West Germany	400[b]	282[b]	400[b]
Canada	300[b] 150	188	120

SOURCE: Organization for Economic Cooperation and Development, *Environmental Policies in Japan* (Paris, 1977).

a. Lower value is secondary standard designed to protect public welfare (for example, agriculture and property) as well as public health. This is more stringent than the primary standard, which is designed to protect only human health.

b. Short-term standard, that is, less than 24-hour average.

rarely enforced to the degree health standards are and, for this reason, frequently remain only "paper standards." Moreover, when the separate standards of local governing bodies within each country are taken into account, a wide range of goals can be found. If this range of standards is taken to reflect each country's stated goals, then the similarities among countries become more apparent.

One reason for these similarities is the presence of international organizations whose purposes include disseminating information on the health effects of exposure to pollution. These organizations include the World Health Organization (WHO), the Organization for Economic Cooperation and Development (OECD), the United Nations Environment Programme (UNEP), the North Atlantic Treaty Organization (NATO), and the European Community (EC). (In particular, WHO has published many studies on suggested safe exposure levels to common pollutants.) The international scientific community, through independent publications and other forums, also shares information on the health effects of pollution. Such organizations and independent forums have contributed to uniformity worldwide in development of environmental standards.

Stated goals, of course, are only one characteristic of environmental policy. The commitment to reach such goals--manifested in enforcement policies--is another important determinant, though one that is difficult to measure. Each of the countries studied appears to have had some success in environmental management. While the evidence varies and is sometimes contentious, examples are available that show progress has been made in improving air and water quality in some areas (see Tables 2 and 3). While problems still plague many urban and highly industrialized areas, these countries seem to have made a commitment to reach their stated environmental goals. 1/

DIFFERENCES IN NATURAL ENVIRONMENT AND DEMOGRAPHY

A country's topography, geography, and its pattern of development all affect environmental quality. High terrain around industrial centers exacerbates air pollution, and population density determines the number of people exposed. Concentrated industrial development around rivers and other watersheds jeopardizes water quality, often in spite of discharge standards. The

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1. The ability to compare accurately the environmental quality of industrialized countries is very difficult given the state of environmental data and the relatively short period over which it has been collected. One of the better reviews can be obtained from Organization for Economic Cooperation and Development, *The State of the Environment in OECD Member Countries* (Paris, 1979).

use of cars and municipal sewage services---aspects of urban life everywhere--can strain the air and water quality of local environments.

The four countries studied have similar types of environmental problems. The cities of Los Angeles and Tokyo possess similar topography and

TABLE 2. INDEX OF PROGRESS IN REDUCING ANNUAL MEAN DAILY CONCENTRATIONS OF SULFUR DIOXIDE (SO_2) FOR SELECTED AREAS, 1970-1976

Urban or Industrial Areas	1970	1971	1972	1973	1974	1975	1976
United States [a]							
New England	100	90	78	69	71	75	65
Great Lakes	100	91	89	76	59	69	62
Japan							
Tokyo	100	62	55	64	55	49	47
Osaka	100	75	54	42	34	40	32
Nagoya	--	100	84	63	47	40	35
Canada							
Montreal	100	69	57	38	37	36	29
Toronto	100	69	45	30	30	26	25
West Germany							
Gelsenkirchen	100	76	79	78	76	78	66
Mannheim	100	55	25	25	40	--	--
Frankfurt/Munich	100	125	97	97	96	95	88

SOURCE: Organization for Economic Cooperation and Development, *The State of the Environment in OECD Member Countries* (Paris, 1979).

NOTE: Concentrations of SO_2 are measured in micrograms per unit volume, based on 100 in 1970. Annual changes in the weather pattern can easily mask the effect of a 25 percent change in the emissions.

Data on the actual concentrations of SO_2 for each area are unavailable from the above study. Data from the late 1960s, however, suggest that most industrial areas in the United States, Japan, and West Germany had roughly comparable SO_2 levels, while Canada had somewhat lower levels overall.

a. Sixty sites in six states in the northeastern United States; 160 sites in six states surrounding the Great Lakes.

air pollution. Water quality in both the Ohio and Ruhr river valleys is affected by high concentrations of basic industry located on their shores. The pulp and paper and smelting industries of Canada and the United States operate in comparable environments and produce similar pollutants. But despite these similarities, the degree of the problem differs.

Japan has perhaps the most consistently "unforgiving" natural environment. Most of its terrain is mountainous, and the amount of habitable land is small as a percentage of the total (see Table 4). As a result, Japan is a highly urbanized country (80 percent of the population lives in cities), with high population density (744 persons per square mile) and industrial development within urban centers. Such topography and growth compound the task of achieving acceptable environmental quality in these urban areas.

In contrast, Canada may have the most "forgiving" environment of the countries studied. It is less densely urbanized (69 percent), and almost all (99 percent) of its habitable land remains open for development. Like the

TABLE 3. ANNUAL MEAN LEVELS OF BIOLOGICAL OXYGEN DEMAND (BOD) FOR SELECTED RIVERS, 1965-1975

Country	River	1965	1970	1975
United States [a]	Delaware	--	3.2	2.5
	Platte	--	14.2	11.9
Japan	Tama	6.6	6.8	7.1
	Yodo	3.8[b]	5.2	2.5
	Kiso	4.5[b]	6.0	1.8
West Germany	Rhine	7.2	7.0	7.9

SOURCE: Organization for Economic Cooperation and Development, *The State of the Environment in OECD Member Countries* (Paris, 1979).

NOTE: Annual mean levels measured in parts per million. Data taken at mouth of river or national boundary (downstream).

a. Three-year average figures for periods 1968-1970 and 1974-1976. Data for Platte River were taken downstream of Denver.

b. Reflects 1966 data.

United States, Canada has a varied terrain, but Canada has more land and a lower population density (six persons per square mile). While it possesses mountainous regions, much flat land is available for industry and agriculture. Such an environment suggests a greater capacity to disperse industrial development and avoid pollution problems than may be found in the other countries.

Somewhat more similar to each other are West Germany and the United States. Both are less urbanized than Japan, and both contain a large percentage of habitable land. Here, however, the similarity ends. Germany's development of available land (15 percent) and high population density (631 persons per square mile), second only to Japan, make it more densely industrialized than the United States. Such high land use and concentrated population, like Japan's, complicates the task of cleaning up pollution.

Precisely how these differences affect the cost of regulation cannot be known, but they do suggest that Japan may need to spend the most (relative to GNP) and Canada the least, to achieve comparable environmental quality. These different characteristics should be considered, along with environmental quality standards, when assessing regulatory approaches.

TABLE 4. SELECTED DEMOGRAPHIC STATISTICS OF THE FOUR COUNTRIES STUDIED

Country	Urban Population (As a percentage of total population)	Habitable Land (As a percentage of land surface)	Developed Nonagriculture Land (As a percentage of habitable land)	Population Density in 1970 (Persons per square mile)
United States	71	52	8.06	38
Japan	80	22	24.50	744
Canada	69	22	0.31	6
West Germany	60	62	15.12	631

SOURCES: Adapted from Organization for Economic Cooperation and Development, *The State of the Environment in OECD Member Countries* (Paris, 1979); and *Encyclopedia Britannica* (appropriate volumes, 1976).

ASPECTS OF ENVIRONMENTAL REGULATION

The rest of this chapter examines the various approaches each country employs to reach its environmental quality objectives. The countries are compared using three different aspects of regulatory approach:

- Types of standards and attainment strategies used;
- Enforcement techniques employed; and
- Governmental tax and subsidy programs offered.

Standards and Attainment Strategies

The first aspect of regulation concerns the standards used and the media they cover--air, water, and hazardous waste, for example--as well as the strategies used to achieve the standards. Two types of standards are common among the nations studied--technology-based discharge standards and ambient environmental quality standards.

Discharge standards limit the amount of pollution from specific sources. A technology-based discharge standard sets that limit based on pollution levels that would result from using state-of-the-art control methods, although they do not specifically require use of that particular method. Most control programs, especially those for air and water pollutants, use technology-based discharge standards. Because such standards are originally set without regard to surrounding environmental quality, even pollution sources located in relatively clean areas must meet tough control limits. Discharge standards, of course, need not be technology-based. In many cases, particularly with regard to older industrial plants, pollution limits are set based on the surrounding environment and the plant's ability to control pollution and the costs involved. But for new plants, technology-based standards are common.

A technology-based standard may be expressed as either a performance or engineering standard. A performance standard allows a source to employ any method available to meet the specified discharge limit. Specified engineering practices are a unique expression of technology-based discharge standards, requiring use of a particular technique rather than specifying discharge limitations. Engineering standards are usually employed when discharge limits are not practical, for example, to specify proper hazardous waste disposal techniques.

Quality standards, as opposed to discharge standards, specify the amount of pollution allowed in a particular environmental medium. Standards for ambient air and water quality are examples. Quality standards are important in that they lead regulators to impose tighter discharge standards on pollution sources in highly polluted areas. Quality standards, if enforced, then become the final determinant of discharge limits.

Attainment strategies, in contrast, dictate how standards are to be applied and can be classified as either flexible or rigid, depending on how much latitude they allow polluters in meeting standards. A rigid program requires individual dischargers to meet their prescribed limits in a prescribed fashion, regardless of the situation. A flexible program, while allowing greater latitude, does not necessarily mean simple relaxation of regulations. Rather, it may involve a readjustment of control priorities, or permit greater flexibility in allocating the costs of control.

Two examples of flexible programs are "emissions trading policies" and use of effluent taxes. Emissions trading involves the reordering of prescribed control levels within a single plant or group of plants, sometimes referred to as a "bubble policy." In theory, an imaginary bubble would be placed over a group of dischargers wishing to trade emissions. The sum of emissions released by the group would be the same as under the original regulations, but the group would be allowed to reallocate abatement priorities so that the sources least costly to control would meet tighter limits, and those most expensive, less strict ones. The resulting agreement would save total costs among the group. Some sources (those with low pollution control costs) would spend more on abatement than under the original regulations, but their pollution control would be "purchased" by other sources having higher control costs they wish to forgo.

Effluent taxes can be used to encourage the efficient allocation of control measures. Under this scheme, a fine is applied to discharges above a specified limit, perhaps in conjunction with minimum discharge standards. Effluent charges give sources latitude in developing an abatement program. Where pollution control costs are lower than taxes, abatement will most likely be employed. Discharge taxes have been used in water quality programs in which the tax, in addition to encouraging further control, supplies revenues for constructing sewage treatment plants.

Enforcement

The second criterion--the nature of enforcement--describes how a government ensures compliance. Again, this criterion can be broadly described within a range running from strict to flexible. While such a characterization is somewhat subjective, strict enforcement involves both compliance deadlines and fines for failure to meet standards, with little room for negotiation. A flexible approach might require compliance as soon as practicable instead of by a specified time, or may permit renegotiation if a deadline has not been met but a good-faith effort has been made to meet it. A flexible approach might employ rewards as well as penalties--for example, compliance earlier than expected might entitle the responsible party to a special tax reduction.

Each stance has its drawbacks. Strict enforcement can create a loss of credibility and promote resentment if deadlines prove unreasonable. On the other hand, a flexible approach may not achieve standards within the shortest time. Most countries employ a mix of both approaches, although one is characteristically favored over the other.

Government Subsidies

The third aspect of regulatory approach is subsidy of investments in measures to control pollution. This criterion is important both in the degree to which it stimulates investment in pollution control and in the type of investment it encourages--"end-of-pipe" treatment or in-plant process change. All four governments offer some favorable tax treatment for investment in pollution control, but not all investments are recognized for favorable treatment. The use of end-of-pipe pollution control equipment reduces discharges after they have been generated, but can substitute one type of waste for another (as when a scrubber converts sulfur oxide gaseous emissions into a liquid waste). On the other hand, in-plant process change can reduce the total amount of all waste generated through either a change in production inputs or alteration in production process. Tax laws generally favor end-of-pipe treatment because investment involves a readily identifiable piece of equipment. By favoring one method over another, however, such policies may not encourage the most efficient approach to reducing pollution.

These characteristics of environmental policy for the four countries studied are discussed below. The environmental policies enacted by the central government generally set the tone for regulation. Local governments have jurisdiction or strong influence in many areas of environmental policy, however, and the implications of this influence are discussed where important. The discussion covers the most salient differences but is not comprehensive; such a discussion is beyond the scope of this study. Further information on environmental policies in these countries can be found in the list of selected readings that follows this report.

THE UNITED STATES

The United States faces a full range of environmental concerns. Air pollution from both motor vehicles and stationary sources has exceeded healthful levels in many urban and some rural areas. Progress has been made in reducing localized air pollution--"hot spots" caused by emissions of relatively stable pollutants from one or more nearby sources--but widespread air quality problems from transported pollutants, notably ozone and "acid rain," plague entire regions in both the East and West. An example of the first case is high localized sulfur dioxide and particulate emissions caused by a nearby coal-burning power plant(s); examples of the second are the Los Angeles Basin (for ozone) and the Northeast Corridor (for ozone and acid rain). During this century, water quality has deteriorated in virtually every basin of the United States as a result of urban development, industry, or agriculture. While water pollution from industry has been lessened, nonpoint pollution from urban storm-drainage systems and farmlands remains a problem. Finally, the improper disposal of hazardous waste and the sheer volume of these wastes threaten surface streams and groundwater in many parts of the nation.

Of all the countries examined except Japan, the United States employs the greatest central government control over environmental policy. The United States has established a wide range of programs (see Table 5), most of them starting in the early 1970s. The federal government, through the Environmental Protection Agency (EPA), generally shares responsibility for environmental management with the states. The federal government, however, typically has taken the responsibility for designing and, in many cases, implementing the major environmental laws. It has also established standards that specify the maximum level of pollution allowed, and stipulated an approach to meet them. States may pass their own laws and often do, but state standards cannot be less strict than federal standards. In most cases, states cannot employ a strategy not acceptable to the EPA.

Standards and Attainment Strategies

Both environmental quality standards and discharge limits are used in the United States. The EPA has established national ambient air quality standards for six major pollutants--particulate matter, sulfur dioxide, carbon monoxide, nitrogen oxides, ozone, and lead. For water quality, the states have been charged with developing quality standards subject to EPA approval. Strict uniform discharge limits also are established by the EPA for most major new sources of air pollution and for major new and old sources of water pollution. These discharge limits typically are based on the use of a predefined best technology for each category of pollution, depending on whether the source is old or new, and inside or outside a region meeting ambient quality standards. Regardless of discharge limits, however, ambient air and water quality standards also must be met in all areas of the country, meaning that stricter discharge limits can be and often are applied to sources in areas of high pollution.

For other programs, such as hazardous waste disposal, prescribed engineering practices are usually enacted rather than quality standards or discharge limits. Methods of hazardous waste disposal, however, cannot violate air or water quality standards, where applicable.

The United States might be considered somewhat rigid regarding firms' compliance strategies (see Table 6). Most new facilities are required to meet their minimum prescribed discharge limits regardless of the state of the surrounding environment. Least-cost approaches by a group of dischargers are generally not allowed. The Clean Air Act allows states to employ bubble strategies for older sources not covered by federal limits (allowing modification of state emissions standards) but does not allow new sources to employ trading or bubbling between old sources. 2/ In the water quality program, bubbling between plants is strictly prohibited.

In most environmental control programs, the states are required to execute the federal environmental laws, often with accompanying federal program support and aid (grants). States and local governing bodies generally are given little latitude in standard setting and implementation, except for setting more stringent standards than the EPA. Some federal programs allow states more discretion than others, however. In the Clean Air Act, for example, flexibility is allowed for areas that have not attained the air quality standards; in such cases, a state may choose from a group of permissible strategies to achieve the standards. Even in these instances, however, the EPA typically encourages a particular approach. Only recently have states been given somewhat greater latitude in implementing control strategies, mostly involving limited emissions trading under the Clean Air Act.

Enforcement

The United States enforces standards through the imposition of fines and penalties. Fines are levied on individual sources for failure to meet a particular standard by a specified time, or for failure to be on a compliance

2. This policy was articulated by a Supreme Court ruling on June 26, 1984.

TABLE 5. THE UNITED STATES: MAJOR ENVIRONMENTAL LAWS

Title	Comments
Air Quality	
Clean Air Act (1970, 1977)	Prescribes strategies for attaining and maintaining ambient air quality standards by specified time; contains both stationary and mobile source emissions controls; requires licensing of new facilities.
Water Quality	
Federal Clean Water Act (1972, 1977)	States must establish water quality standards acceptable to EPA; establishes effluent discharge standards for different industrial categories; requires licensing of new facilities; provides subsidies for sewage treatment plants.
Safe Drinking Water Act (1977)	Establishes national drinking water standards.
Solid and Hazardous Waste	
Resource Conservation and Recovery Act (1977)	Establishes requirements for the transportation, storage, and disposal of hazardous waste; requires states to develop solid waste programs.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund)	Authorizes the federal government to respond to emergency hazardous spills; requires remedial cleanup of existing hazardous sites.

(Continued)

TABLE 5. (Continued)

Title	Comments
Toxic Chemicals	
Toxic Substances Control Act (1977)	Requires testing to determine hazards posed by chemicals in production; can limit their production and use.
Federal Insecticide, Fungicide and Rodenticide Act (1977)	Monitors and controls the use of pesticides.
Land Use	
National Environmental Policy Act (1969)	Requires an impact assessment prior to most federal actions; has limited land use implications.
Clean Air Act, Water Pollution Control Act	Have indirect effect on land use within certain regions.
Victims' Compensation	
None	No universal compensation law exists; victims may seek compensation for damage through traditional routes in civil court. For occupational exposures, various compensation policies hold, for example, "black lung" disease payments.

SOURCE: Congressional Budget Office.

TABLE 6. THE UNITED STATES: APPROACHES TO CONTROLLING AIR AND WATER POLLUTION

Approach	Air Quality Program	Water Quality Program
Quality Standards	Yes; ambient air quality standards are set by the EPA and must be met nationwide by specified time. States may set stricter levels.	Yes; set by states but must be approved by the EPA. Goal of law is for all areas to meet standards by certain time, but is not a requirement.
Discharge Standards	Yes; maximum limits are set for both mobile and stationary sources; the EPA sets uniform standards for new sources, but states have discretion in controlling many older sources.	Yes; maximum effluent limits prescribed by the EPA for both new and old facilities. States have little discretion.
Attainment Strategy	Low flexibility; states must ensure compliance with standards; sources must meet specified emissions standards individually, especially if covered by new source performance standards. Opportunities for bubbling are limited but have recently been expanded.	Rigid; individual discharges must meet specified pollution limits. Bubbling between plants not allowed.
Enforcement	Fines and criminal penalties can be assessed; sanctions may be applied to states for failure to implement law.	Fines and criminal penalties can be assessed.
Taxes/ Subsidies	Yes; accelerated depreciation and tax credits available for end-of-pipe processes; tax-exempt (low-interest) financing available. In-plant process change usually not recognized.	Yes; subsidies provided for construction of municipal sewage plants; tax treatment similar to that for air pollution control for private firms.

SOURCE: Congressional Budget Office.

schedule. Enforcement is an important tool in U.S. law since many standards are to be met by mandated deadlines. Negotiation is widespread, but the latitude allowed is limited because the accompanying legislation gives the EPA and the states little discretion in enforcing standards. In the past, pollution sources have sometimes chosen to pay fines rather than meet standards. In some cases, the deadlines were unreasonable, but in others the fines simply were too low or not imposed often enough. States have sometimes been the offending party. Entire areas have remained out of compliance with clean air laws because the states failed to develop plans or enforce standards. In general, polluters and regulators often are at odds, and many new EPA regulations are litigated. This provides the incentive to delay compliance in case the regulations are overturned.

The federal government can also impose penalties on individual states if they fail to carry out the law. For example, federal highway funds might be withheld for failure to implement portions of the Clean Air Act. But such sanctions have been imposed rarely and reluctantly. Cooperation is the rule rather than the exception, and the EPA usually recognizes when good-faith efforts are being made.

Subsidy and Taxation Policy

Several different taxation and subsidy schemes affect equipment and facilities used for pollution control. 3/ Most notably, the Federal Water Pollution Control Act provides direct subsidies to municipalities for construction of sewage treatment works (the government will provide up to 55 percent of construction costs, down from 75 percent in the past). This is the only direct subsidy provided for pollution abatement by the government. The grants are funded from general tax revenues and passed to the municipalities through the EPA.

Several indirect incentives arise from the tax system. Rapid amortization is provided for facilities added to plants in operation before 1976, although the Economic Recovery Tax Act of 1981 has eliminated most distinctions between pollution control and the investments for depreciation purposes. An investment tax credit of up to 10 percent also is allowed for most pollution control hardware. Tax-exempt financing (at lower interest rates) is generally available for construction of pollution control equipment, through the use of pollution control bonds.

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3. This study does not examine grants and other aid given to local governing bodies for the administration of pollution control programs.

Until 1981, tax policies in the United States favored use of end-of-pipe treatment rather than process change. For example, the EPA did not recognize as a pollution control device a process that involves an in-plant change to reduce the generation of wastes but does not in itself remove or dispose of wastes. This distinction favored investment choices that did not necessarily result in the reduction of waste production, nor employ the most efficient approach. The Economic Recovery Tax Act of 1981, however, eliminated this bias.

JAPAN

Japan is a nation of high urban density, rapid industrial growth, and rugged mountainous terrain. The high industrial and urban density, and absence of flat land for development, have contributed to problems with air quality in most cities. The maintenance of water quality also is a concern. Although most water bodies originate in pristine mountainous areas, industrial and municipal wastes have contributed to several major pollution problems inland and on the seacoast. The famous mercury-poisoning epidemic of Minamata Bay is an example. To address these problems, Japan has developed comprehensive laws to control air and water pollution, including the broadest and most detailed victims' compensation policies of all the countries examined (see Table 7).

The central government in Japan--the legislature (Diet), prime minister, and executive cabinet--plays a dominant role in determining environmental policy. The Environment Agency has jurisdiction over basic policy planning and promotion, general coordination of governmental activities for pollution control, and budget planning for regulatory development, implementation, and research. Several other agencies--including the Ministry of Trade and Industry (MITI), the instrument of public-private sector dialogue on industrial development in Japan--also have jurisdiction over various aspects of pollution control.

Local governments (composed of 47 prefectures and subordinate municipal governments) execute the national policies and develop additional measures to meet local needs. The Basic Law for Environmental Pollution Control requires prefectural governors to develop comprehensive control programs for areas where concentrated industrial activity and population create excessive pollution (such areas with substandard environmental quality are termed "designated" areas). These control programs, though locally determined, must be in harmony with applicable policies of the central government.

Standards and Attainment Strategies

Japan employs both ambient quality standards and technology-based discharge limits (see Table 8). The air quality objectives and emissions standards in Japan tend to be the most ambitious of any country examined. Ambient air and water quality standards are enacted at both the central and prefectural government levels. These standards are not binding (that is, the law does not require compliance by a specified time), as are U.S. laws, but serve as objectives. They are taken quite seriously, however, and discharge standards typically are adjusted by local governments at the encouragement of the central government to ensure compliance with ambient standards.

Similar to U.S. law, discharge standards for sources of air and water pollution are set at the national level and administered locally. National discharge standards tend to apply to broad categories of sources and specify minimum acceptable levels of control. For areas of high pollution, sulfur dioxide emissions must be further reduced according to a formula established by the central government. Prefectural governors modify discharge standards to ensure that quality standards are achieved in their area. Unlike the United States, in Japan local governments typically have been the party responsible for imposing stricter controls on newer sources.

For hazardous waste, disposal facilities must be licensed by the central government and must practice acceptable disposal methods. Private enterprises are usually responsible for controlling industrial wastes but, in some cases, municipalities have assumed responsibility.

As often emphasized in its comprehensive plans, Japan is flexible in carrying out environmental law. Strategies such as bubbling are explicitly employed, and discharge limits are often tailored to fit the individual source and needs of the area. Government-set discharge limits therefore commonly serve as guidelines rather than strict requirements. This is not to say they are routinely relaxed; rather, for any one plant or for a single set of emissions, guidelines are proposed. The individual sources within the plant or area can meet the control level best suited to it. Some sources will meet strict limits, while others will meet relaxed ones to achieve the level of abatement expressed in the guidelines. In the case of sulfur dioxide, emissions taxes are used to encourage control and raise revenue for victims' compensation payments.

A distinguishing aspect of environmental management in Japan is the responsibility given to local governments for establishing comprehensive plans for controlling pollution and guiding development. Comprehensive

TABLE 7. JAPAN: MAJOR ENVIRONMENTAL LAWS

Title	Comments
	General
Basic Law for Environmental Pollution Control (1967)	Establishes fundamental pollution control policies for all media. Establishes government responsibilities and jurisdictions. Requires comprehensive planning.
	Air Quality
Air Pollution Control Law (1970)	Establishes ambient air quality objectives; establishes emissions limits for mobile and stationary sources.
	Water Quality
Water Pollution Control Law (1971)	Establishes ambient quality standards and discharge limits.
Sewage Law (1958)	Prescribes standards for sewage treatment plants and pretreatment standards.
Marine Pollution Prevention Law (1976)	Regulates spills; governs tankers and other vessels.
	Solid and Hazardous Waste
Waste Management Law (1970)	Establishes guidelines for local solid and liquid waste disposal practices.
Agricultural Land Soil Pollution Prevention Law (1970)	Regulates disposal of cadmium and other toxic chemicals.

(Continued)

TABLE 7. (Continued)

Title	Comments
Toxic Substances	
Chemical Substances Control Law (1974)	Requires notification and testing of new chemicals in production; can regulate production.
Land Use	
Factory Location Law (1974)	Restricts development of industry in highly populated areas.
Victims' Compensation	
Pollution-Related Health Damage Compensation Law (1973)	Provides compensation to victims of certain diseases related to air or water pollution in designated areas.

SOURCE: Congressional Budget Office.

control programs for areas threatened by extensive pollution are a basic strategy and responsibility of prefectural governors. These areawide plans consider such factors as urban planning, industrial siting, and capital expenditures for public works (such as sewage treatment plants). Such plans even include schemes that promote the transfer of factories from high-density industrial areas to less-developed ones. The prime minister determines the fundamental policy objectives and the areas to be covered; the governors then devise the plans to meet the objectives. None of the other countries studied use such comprehensive planning. In other nations, the objectives of each law are separately issued without regard to mutual or conflicting requirements. Moreover, land-use planning is seldom so explicitly incorporated.

Finally, the most unique aspect of Japanese environmental policy is the concept of victims' compensation. Under the Pollution-Related Health

TABLE 8. JAPAN: APPROACHES TO CONTROLLING AIR AND WATER POLLUTION

Approach	Air Quality Program	Water Quality Program
Quality Standards	Yes; they serve as nonbinding objectives, but are taken quite seriously. Standards set by central government apply nationwide, but prefectures can set lower ones.	Yes; similar to air quality program in approach.
Discharge Standards	Yes; nationwide emissions standards are set by central government for large sources and motor vehicles. Prefectural governments can set lower levels, usually for new plants. Standards prescribe emissions limits according to mathematical formula for each source. Standards for SO_2 can vary by location and air quality.	Yes; but same standards apply to wide range of sources. Local governments can set stricter effluent standards.
Attainment Strategy	Somewhat flexible; ambient standards are to be met through emissions limits, but local governments are given wide latitude to assign limits between sources to reduce "loadings"; for instance, bubbling is permitted. Victims' compensation for air quality-related diseases is funded by emissions tax on SO_2 and car registration fees.	Flexible. Effluent standards are primary focus. Ambient standards used as guideline to judge progress. Modification of receiving stream practiced in some cases.
Enforcement	Persuasion is typical approach. Tax and subsidy treatment is used to encourage compliance. Penalties are not a common tool, and courts are seldom involved.	Similar to air quality program.
Taxes/ Subsidies	Accelerated depreciation is allowed. Automobiles that are considered to be lower-polluting are taxed at a reduced rate. Subsidies are given for desulfurization. Low-interest loans available from Japan Development Bank and other sources for in-plant process change and control hardware.	Subsidies provided for construction of sewage treatment plants. Other tax and loan treatment same as air quality program.

SOURCE: Congressional Budget Office.

Damage Compensation Law, people who have lived in designated areas may be compensated for certain diseases related to air and water pollution. Prefectural governors or mayors of designated cities certify those people entitled to compensation. As of March 1976, roughly 36,000 people had been designated as victims entitled to receive compensation. 4/ Most cases (about 95 percent) involved air pollution, and almost all were located in large industrial cities such as Osaka, Tokyo, Amagasaki, Nagoya, and Kawasaki. Payments are typically made on a monthly basis, covering such items as medical expenses and disability. In 1975, the average monthly payment was about 32,000 yen or about $185 a month in 1983 dollars.

Funding for compensation payments is provided by a tax on sources contributing to air and water pollution throughout Japan. Responsibility is divided between stationary sources (80 percent) and mobile sources (through a pollution-based registration tax). The tax for stationary sources is based on the volume of sulfur oxides released during the preceding year. The tax rates are calculated each year and vary by location; they are nine times higher in the areas designated for victims' compensation than elsewhere. Thus, as mentioned, such taxes encourage additional control where it is necessary.

Japanese compensation law is interesting because it implicitly recognizes that while pollution should be controlled, compensation of victims can serve as a partial substitute for hard-to-achieve environmental quality. It also recognizes that some problems are relatively intractable over the short term. Rather than impose unreasonable costs on controlling pollution, such as stopping industry, it instead compensates the victim. 5/

Enforcement

The flexibility that characterizes the Japanese approach to setting standards extends to their enforcement. At times, when standards have proved too strict to be met within a specified time, they have been temporarily suspended and replaced by less strict ones. Such suspensions can occur through executive order without involving litigation. 6/

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4. Organization for Economic Cooperation and Development, *Environmental Policies in Japan* (Paris, 1977).

5. In contrast, compensation for pollution damage in the United States rarely is obtained through civil court, although a few landmark settlements have been awarded.

6. Organization for Economic Cooperation and Development, *Environmental Policies in Japan* (Paris, 1977).

More important, discharge standards tend to be enforced by persuasion rather than coercion. Compliance by industry is often obtained by balancing rewards and punishment. To promote compliance, administrative agencies can be more or less responsive to industry's needs for tax treatment, funding, procurements, permits, and similar instruments. In general, methods of pollution abatement are part of a total package negotiated between the industry and government. In Japan, unlike other countries, responsibility for pollution control is shared between government agencies, some of which also are responsible for industrial development. Thus, development goals and environmental quality tend to be more in harmony.

Subsidy and Taxation Policy

Japan has subsidy, tax, and financing policies that encourage the use of pollution control equipment. The national government aids control activities through special organizations and financial institutions. For example, the Environmental Pollution Service Corporation provides assistance for land development, construction of public facilities for pollution prevention, and loans for pollution control equipment. The interest rates granted by such institutions for 10-year loans for control equipment typically are about two to three points below market rates.

Tax policy also is used to stimulate spending for pollution control at the national and regional government levels. Accelerated depreciation under various schemes is available for all pollution control equipment and waste-recycling processes. In addition, the tax on fixed assets may be reduced by 60 percent in the third year for control hardware. Additional deductions from income are permitted for companies with large expenditures for pollution control. The Japan Development Bank makes loans at a preferential rate for conversion to nonpolluting systems (including in-plant process change), pollution control equipment, and improved conditions for factory workers. Such policies tend to encourage reduction of waste generated as well as waste discharged.

CANADA

Canada's pollution concerns are similar to those of the United States--air pollution from motor vehicles, utilities, and industry; water pollution from industry, agriculture, and municipalities; and solid and hazardous waste pollution from cities and industry. The pulp and paper industry is generally considered to be the major polluter in Canada, but several other industries--including the chemical, petroleum, electric power, nonferrous metals, and food-processing industries--also produce significant waste.

To date, Canada's policy has been to concentrate on managing air and water pollution; it has not yet seriously addressed land-use issues and hazardous waste management (see Table 9). To a large extent, these problems are just beginning to surface in Canada. Canada's environmental problems are generally more manageable than those of the United States, and it has focused on issues presenting immediate concerns.

Responsibility for environmental protection in Canada is shared by the federal, provincial, and municipal governments. Unlike the states in the U.S. federal system, however, the 10 provinces of Canada are relatively autonomous. The national government has jurisdiction over major air pollution that endangers public health and is responsible for protecting the seacoast and inland fishery resources. Outside these areas, however, most federal law is enacted as guidelines, which provinces are encouraged but not forced to adopt. Nevertheless, cooperation between federal and provincial governments in managing the environment remains strong, although provincial autonomy suggests that environmental policy in Canada may be less uniform than in the United States or Japan, where strong control is exerted by the central government.

Standards and Attainment Strategies

Objectives for ambient air quality developed by the federal government are the only quality standards enacted at the national level (see Table 10). Provinces may adopt these objectives (most have) as a measure by which to gauge progress in improving air quality. Meeting the air quality standards is a desired goal, but compliance is nonbinding. The ambient levels established by the government to protect human health, however, rarely have been exceeded. 7/

Technology-based discharge standards are the cornerstone for control of air and water pollution in Canada. For the air quality program, such standards are based on "best practicable control," and do not take into account surrounding environmental quality (similar to comparable standards in the United States and Japan). The federal government has proposed discharge standards or guidelines for many sources of air and water pollution, and provinces are encouraged to adopt them. Provincial adoption of federal standards is critical for attaining a uniform national policy. Except for air pollutants that arise from motor vehicles, flow across international borders, originate from federal facilities, or endanger public health, the national government may not intervene in provincial matters.

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7. Craig E. Reese, *Deregulation and Environmental Quality* (Westport, Connecticut: Quorum Books, 1983).

TABLE 9. CANADA: MAJOR ENVIRONMENTAL LAWS

Title	Comments
Air Quality	
Clean Air Act (1971)	Provides for development of air quality objectives and national emissions guidelines, which may be adopted by provinces.
Motor Vehicle Safety Act (1970)	Establishes emissions standards for motor vehicles.
Water Quality	
Fisheries Act (Amended 1971)	Requires federal government to develop effluent guidelines, which may be adopted by provinces. No national ambient water quality objectives have been developed.
Canada Water Act (1970)	Sets guidelines for federal/provincial consultations and agreements.
Ocean Dumping Control Act	Regulates dumping of certain substances from ships.
Arctic Water Pollution Prevention Act	Sets stringent antipollution regulations for ships in Canadian Arctic region.
Solid and Hazardous Waste	
None	No comprehensive law exists. Provinces are responsible for solid waste management.

(Continued)

TABLE 9. (Continued)

Title	Comments
Toxic Substances	
Environment Contaminants Act	Requires testing of hazardous chemicals. The national government, with the provinces, may limit or ban usage.
Pest Control Products Act	Controls use of pesticides.
Land Use	
None	No explicit land-use laws exist at federal level.
Victims' Compensation	
None	Civil actions possible through courts.

SOURCE: Congressional Budget Office.

The federal government has somewhat greater authority over general policies for controlling water pollution. While management of water quality is the responsibility of the provinces, protection of fishery resources through effluent controls is the responsibility of the national government. Both effluent regulations and guidelines have been issued for major categories of industrial facilities, based on best practicable controls. New plants must meet standards immediately, while existing plants must comply as soon as is reasonably possible. Effluent taxes are permitted under Canadian law but are rarely used.

Canada currently has no comprehensive law for hazardous waste. The existing set of municipal, provincial, and federal laws have dealt effectively with solid and hazardous wastes by ensuring that proper disposal techniques are being used. The prevention of surface-water pollution has been the greatest immediate threat; concern over potential groundwater contamination in urban areas from leaking toxic dump sites has been increasing.

TABLE 10. CANADA: APPROACHES TO CONTROLLING AIR AND WATER POLLUTION

Approach	Air Quality Program	Water Quality Program
Quality Standards	Yes; but serve only as nonbinding objectives. Provinces encouraged to adopt these or more stringent standards, but not required to do so.	No; but some provinces have set objectives.
Discharge Standards	Yes; but only as guidelines issued by the federal government. Provinces may adopt them for use as binding standards. Motor vehicle emissions standards set at the federal level; less strict than comparable U.S. standards.	Yes; effluent guidelines issued by the federal government. These must be met if they flow into fishable water body.
Attainment Strategy	Nonuniform, depending on approach of individual province. Technological emissions standards are basis of strategy. Complying with ambient standards encouraged. Additional emissions reductions may be considered if air quality objectives are not met. Bubbling typically is not employed.	Same approach as air quality program, except water quality objectives do not exist. Bubbling typically not employed.
Enforcement	Enforcement carried out at provincial level with no federal involvement except in certain cases. Penalties and stop orders are common approaches.	Same approach as air quality control program.
Taxes/ Subsidies	Little federal support in terms of direct grants or low-interest loans. Accelerated depreciation allowed for most investments, including process change to reduce discharges. Some provinces provide low-interest loans for pollution control hardware.	Same tax treatment as air quality control program. The federal government will also subsidize construction of sewage treatment plants.

SOURCE: Congressional Budget Office.

About 200 dump sites in Ontario were being investigated starting in 1983 to determine their hazardous waste content.

In general, attainment strategies in Canada are molded by the provincial governments. This has made uniformity in approach somewhat elusive, and control strategies are often developed on a case-by-case basis. Agreements with some of the largest polluters have been worked out in the past by the provinces in cooperation with the national government. In any case, environmental quality in Canada has not been substantially stressed by development, and standards necessary to attain it remain generally less strict than in the other nations examined.

Enforcement

Enforcement of Canada's environmental laws appears similar to that of the United States. Fines and penalties may be levied on polluters who fail to comply with pollution control legislation. Orders to stop production also may be issued by the federal government when air pollution threatens human health; in most other matters, the provincial governments have such jurisdiction. Since the individual provinces are charged with enforcing most regulations, however, enforcement might be less uniformly carried out than in the United States or Japan, where central governments have a greater hand in regulatory development and enforcement.

Subsidy and Taxation Policy

Canada's tax and subsidy policy also is similar to that of the United States, although much of it is carried out by the provinces. The federal government provides little support in the form of direct grants and low-interest loans. The one exception is construction of sewage treatment plants, for which direct federal subsidies are made. Beyond that, financial assistance is much less uniform. Several provinces provide low-interest loans for pollution control hardware, although it varies considerably by region.

Tax treatment is similar to that in the United States and Japan; accelerated depreciation is allowed for most pollution control hardware. Unlike the United States, however, Canada has always permitted process changes that reduce the amount of pollution generated (as compared with end-of-pipe treatment).

THE FEDERAL REPUBLIC OF GERMANY

Like much of Europe, West Germany has experienced rapid industrial growth since World War II and faces significant problems with air and water pollution. Air pollution from industrial plants, electric utilities, residential fuel combustion, and motor vehicles plague the large industrial centers located in the Ruhr and the major cities such as Berlin, Hamburg, Munich, Cologne, and Frankfurt. Water quality has been degraded in several areas by effluents from the chemical industry--the largest water polluter in Germany--and by the iron and steel industry and domestic sewage. By the early 1970s, the Rhine had become severely contaminated, and several of its tributaries were biologically dead. Pollution from solid and hazardous waste is continually rising and its potential danger grows, aided by poorly coordinated or nonexistent laws for waste disposal. To meet some of these problems, Germany has been enacting major environmental laws since the late 1960s (see Table 11).

West Germany carries out environmental laws in much the same way as the United States, with some key exceptions. It is a federation consisting of 11 states (Lander) having equal status with the national government (Bund). The federal government has concurrent jurisdiction with the 11 states in most areas of environmental protection, including air pollution, noise pollution, poisonous substances, and waste. 8/ The states may pass more restrictive standards in these areas but cannot relax applicable federal ones, much like in the United States or Japan. In other areas such as water quality and land use, the federal government can pass only broad "framework" laws. The states must then carry out these laws by passing their own detailed regulations.

Standards and Attainment Strategies

The national government has greatest jurisdiction over air quality, which is regulated much as it is under U.S. law (see Table 12). Standards for ambient air quality have been issued for such pollutants as suspended particulate matter, sulfur dioxide, nitrogen dioxide, and carbon monoxide. The federal government is also empowered to regulate motor vehicle emissions, and it recently established rules to achieve U.S.-equivalent standards by 1989.

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8. West Germany also is a member of the European Community, which helps coordinate environmental research, monitoring, and corrective actions throughout Europe. While having no direct authority over individual governments, the European Community Environment Action Programme develops directives and policies for the member countries to follow.

Technology-based emissions standards also have been established for most major categories of new and old stationary sources. Similar to U.S. and Japanese laws, further emissions control may be required in areas not meeting ambient standards.

On the other hand, West Germany does not have uniform national standards for water quality. Water quality is the primary responsibility of the states, although the federal government has established effluent standards for new sources (old sources are regulated by the state). Through legislation, states can transfer their responsibility and management of water quality to a water association. The function of such associations is to execute and finance water management policy. One region (containing several water associations) also enacted an effluent tax system based on output and employment. Revenues from these taxes are used to finance sewage treatment works and administrative costs of water management programs. But, to some extent, the federal government has been frustrated in its desire to improve water quality. The development of effluent standards by the federal government for new plants is, in some sense, a response to this. 9/

Waste treatment and disposal sites also are jointly regulated by the federal and state governments. Licensing is required for the storage, processing, and disposal of hazardous waste, and federal rules are used to set up regional programs. Waste disposal takes place primarily on land and is handled by industry, although the federal government runs the only radioactive dump site.

Attainment strategies in Germany generally are flexible, at least with regard to management of air quality. As in the United States, most laws stipulate the use of specific discharge limits and generally do not permit trading or bubbling. Management of water quality is somewhat more flexible--or lax--depending on one's point of view. Some states have been reluctant to impose strict standards for improving water quality. The costs of regulation in these areas have been lower because standards are less stringent. The law also allows states to establish water management regions with other states, and some of these regional groups have focused concern on maintaining water quality. One region in the Ruhr Valley, through cooperation with the federal government, has imposed a control strategy that includes limits and effluent taxes to improve water quality. This system allows polluters to seek least-cost control levels and provides revenue for other needs of water quality management, such as construction of sewage plants.

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9. A national effluent tax system was recently (1984) enacted, giving the federal government greater control over management of water quality. It is too early to report on effects of the new tax laws.

TABLE 11. WEST GERMANY: MAJOR ENVIRONMENTAL LAWS

Title	Comments
Air Quality	
Federal Air Quality Control and Noise Abatement Act	Provides framework for most German air pollution control laws. Empowers the federal government to set ambient air quality standards and technology-based emissions limits.
Water Quality	
Federal Water Act (1976)	Prescribes national maximum discharge limits and directs states to prepare water use plans.
Waste Water Law	Sets fee for discharges based on estimated output.
Solid and Hazardous Waste	
Law on the Disposal of Wastes (1972)	Prohibits disposal of wastes in manner that may endanger human health; municipalities responsible for establishing disposal guidelines and implementing their own programs.
Waste Oil Law (1968)	Regulates disposal of waste oil and oil residues.
Toxic Substances	
Plant Protection Law (1975)	Regulates use of pesticides.
The Law on Traffic in Foodstuffs, Tobacco Products, Cosmetics, and Other Consumer Goods (1974)	Regulates the use of chemicals in consumer and luxury goods.

(Continued)

TABLE 11. (Continued)

Title	Comments
Land Use	
None	No comprehensive law exists, but states often develop land-use plans as part of environmental controls.
Victims' Compensation	
None	No program exists; compensation possible through civil court on case-by-case basis.

SOURCE: Congressional Budget Office.

Enforcement

Enforcement relies heavily on industry self-regulation, and intensive self-monitoring is usually required. The hiring of an emissions officer or a water protection agent is mandated when a license is requested. Their duties consist of ensuring compliance with emissions regulations, but they are responsible to the employer and not the government. Legal devices open to the regulating agencies are plant inspections, continuous monitoring, fines, orders to stop production (stop orders), or revocation of operating permits. In this respect, it is similar to U.S. law.

Subsidy and Taxation Policy

West Germany's subsidy and tax treatment of pollution control equipment appears similar to that of the United States. Construction of sewage treatment plants is subsidized, partly from general revenues and partly from effluent taxes. Loans may be granted at favorable interest rates through state organizations for investment in pollution control equipment, but in-plant process changes that reduce waste generation are not recognized. Accelerated depreciation of equipment for controlling air and solid waste pollution also is available. Each of these tax incentives is directed at end-of-pipe treatment techniques.

TABLE 12. WEST GERMANY: APPROACHES TO CONTROLLING AIR AND WATER POLLUTION

Approach	Air Quality Program	Water Quality Program
Quality Standards	Yes; ambient air quality standards are set by the federal government. No specific compliance deadlines are enacted, but areas that exceed standards must develop a plan for compliance.	No; national standards do not exist. Individual states have primary jurisdiction over water quality, but rarely set quality standards.
Discharge Standards	Yes; emissions standards are set by the federal government and based on state-of-the-art control technology. Large plants and motor vehicle emissions are regulated.	Yes; effluent standards are established by the federal government, but apply only to new sources.
Attainment Strategy	Emissions standards are the basis of strategy; tighter standards may be imposed if air quality standards are not met. Bubbling or trading is not generally allowed.	Federal government has little control; primary jurisdiction resides with states. In most cases, control is based on effluent standards that may or may not reflect best control. In some areas, effluent taxes are imposed to encourage control.
Enforcement	Fines and stop orders can be used. Industry is required to self-monitor.	Irregular; primary jurisdiction resides with the states.
Taxes/ Subsidies	No direct subsidies available. Loans may be granted at low-interest rates by some state and other programs. Accelerated depreciation is allowed on investment in control equipment. In-plant process change is not recognized.	Tax and fiscal assistance is the same as under air quality program. Direct grants from the federal government may be made for construction of sewage treatment plants. These are partially funded by effluent charges.

SOURCE: Congressional Budget Office.

CONCLUSIONS

Both major common elements and differences characterize the four countries studied (see Table 13). The common elements include how ambient standards are treated, how discharge limits are set, and the use of tax policies. All countries employ national ambient standards or goals for air and water quality (except West Germany, which only has national air quality standards). All countries also employ national technology-based discharge standards in either their air or water quality programs, or both. No country provides significant latitude to its polluters, although the Japanese system appears somewhat more flexible than the others. Finally, all countries seem to employ some spending and credit policies to stimulate pollution control.

Several important differences also exist. First, pollution problems exacerbated by geography and demography are most common in Japan, least common in Canada. Second, only Japan and the United States have uniform national programs for air and water quality, as well as for other media; the other countries have less central control, delegating more discretion to local authorities. Third, only two countries employ discharge taxes: Germany, on water pollutant effluents, and Japan, on sulfur dioxide emissions. In each case, the primary use of the tax is to raise revenue; an important but secondary purpose is to discourage pollution. Finally, only the United States and Germany have ignored in-plant process change under their fiscal and tax policies.

How do these differences affect the costs of control? The answer may be more of a guess than fact, but the comparison suggests the following:

- o The comprehensiveness of Japanese law, its tough standards (despite its flexible approach), its relatively unforgiving environment, and high population density suggest that Japanese industry might have the greatest relative costs for pollution control of all four countries.
- o In contrast, the absence of uniform national strategies for pollution control for portions of each major program, the availability of sparsely populated areas for industrial activity, and low population density suggest that Canadian industry might bear the lowest relative cost for pollution control.
- o The relative costs of pollution control for West German and U.S. industry should be similar, although the United States' comprehensive water and hazardous waste laws--in addition to the effluent standards that both countries employ--produce a somewhat higher burden for U.S. industry.

TABLE 13. CROSS-COUNTRY COMPARISON OF ENVIRONMENTAL CONTROL STRATEGIES

Approach	United States	Japan
Quality Standards	Air quality standards are nationally set; water quality standards are set by each state, but must conform to EPA guidelines.	Both air and water quality standards are nationally set. They serve as objectives, but are taken seriously.
Discharge Standards	Technology-based national standards set by the federal government for new air pollution and new and old water pollution sources. States set standards for old air pollution sources at their discretion.	Technology-based national standards are set by the central government for most air and water pollution sources. Discharge standards may be stricter for highly polluted areas. Prefectural governments may set stricter standards.
Attainment Strategy	Both discharge and ambient standards must be met. Bubbling generally not allowed except for older sources covered by state air emissions standards.	Both discharge and ambient standards must be met. Greater flexibility than in other countries exists regarding discharge limits. Emissions trading is explicitly allowed in some cases. Local agencies can change discharge .limits (strengthen or relax) to meet capability of source. Emissions taxes used to encourage further the control of SO_2.
Enforcement	Sources are monitored and subject to inspection. Penalties may be imposed for noncompliance. Negotiation limited.	Negotiation is more common than coercion. Penalties are rarely used. Awards (such as hastening permit approval) are sometimes used.
Taxes/ Subsidies	Sewage treatment plants are partly subsidized by the government. Accelerated depreciation and tax credits are available for large sources through bond markets. End-of-pipe treatment is encouraged.	Subsidies given to sewage treatment plants and some desulfurization technology. Loans available at low interest rates. Accelerated depreciation is allowed. Both process change and end-of-pipe treatment are encouraged. Victims' compensation is paid through revenues from SO_2 taxes.

(Continued)

TABLE 13. (Continued)

Approach	Canada	West Germany
Quality Standards	Ambient air quality objectives proposed at the federal level and adopted by most provinces. They serve as objectives and, unless adopted, are nonbinding.	National enforceable standards exist for air quality, but not for water quality. Individual states have jurisdiction over water quality and usually do not set standards.
Discharge Standards	Technology-based national discharge standards are set for water pollution, and similar guidelines are set for air pollution.	National technology-based standards are set for air pollution sources, but are set only for some new sources of water pollution.
Attainment Strategy	Nonuniform, depending on provincial law. However, preferred approach is for sources to meet discharge limits and not violate quality standards.	In air programs, both ambient standards and emissions limits must be met. Water programs are primarily the responsibility of the states. In the Ruhr area, effluent taxes are imposed; were levied nationally in 1984.
Enforcement	Based on provincial law. Penalties and stop orders can be employed. Compliance of large sources negotiated with the federal government.	For air programs, fines and stop orders can be used. For water programs, states run enforcement with inconsistent results.
Taxes/ Subsidies	Little direct support by the federal government, except for subsidy of sewage treatment plants. Accelerated depreciation is allowed, and some provinces provide low-interest loans. Both end-of-pipe equipment and process change are encouraged.	National subsidies for sewage plants are given (partly funded by effluent charges). Low-interest loans are given by some programs and states. Accelerated depreciation is allowed. End-of-pipe treatment is encouraged.

SOURCE: Congressional Budget Office.

CHAPTER IV

EXPENDITURES FOR POLLUTION CONTROL

Numerous problems arise in attempts to determine the costs of complying with environmental regulation and the effects of those costs on economic efficiency. These problems occur whether the analysis is focused on one country or whether a cross-country comparison is being made. Data on pollution control expenditures have not been collected systematically until recently, and analysis of existing data is further complicated by lack of comparability both in the definition of "pollution control expenditures" and the manner in which the data were collected and estimated.

PROBLEMS OF DEFINITION AND MEASUREMENT

What Are Pollution Control Expenditures?

The costs of complying with environmental regulations can be defined at two levels: broadly, as the economywide costs of environmental regulation; or narrowly, as the expenditures made by individual firms to achieve compliance.

Viewed from the broad perspective of the economy as a whole, regulatory costs would include not only those immediate expenditures made by firms, but also the possible macroeconomic costs of regulatory compliance such as unemployment caused by reductions of output in polluting industries, international trade losses, and other costs related to the economic adjustment inherent in complying with the environmental regulatory regime. This aggregate view could also include the costs of regulatory administration and litigation, project delays, and the possibility of reduced entrepreneurship, efficiency, or innovation in response to regulation or regulatory uncertainty.

The costs of pollution control can also be defined as the expenditures made by individual firms in their efforts to adjust the way they produce output so that they will comply with regulations. This definition is really an accounting measure of pollution control costs that involves adjustments in equipment expenditures; purchases of additional labor, materials, and fuel; and other operational expenditures.

For its analysis, the Congressional Budget Office used the second definition to measure the costs of pollution control--the costs of new plant and equipment borne by individual firms as a consequence of complying with regulations. These more narrowly defined costs are a better measure of the "intensity" of regulation in each of the countries studied, since they concentrate on the direct costs of compliance. Moreover, embracing the broader notion of economywide pollution control costs would group together the immediate costs of regulatory compliance with their macroeconomic effects. This would preclude identifying the macroeconomic effects.

Sources of Data: Problems and Limitations

In 1974, the Organization for Economic Cooperation and Development (OECD) reported that data on pollution control expenditures and costs "are limited in coverage and of uncertain quality." 1/ More data have become available since that time, particularly in the United States, where estimates of pollution abatement expenditures are available from at least five different sources: Bureau of the Census and Bureau of Economic Analysis (BEA), in the U.S. Department of Commerce; Council on Environmental Quality (CEQ), in the Executive Office of the President; Environmental Protection Agency (EPA); and McGraw-Hill Inc. These sources, however, differ both in method of collecting the data and in type of data included. Moreover, in Canada, Japan, and West Germany, data remain limited. As a result, international comparisons of pollution control costs, expenditures, and regulatory intensity are still tenuous.

The difficulty in making such comparisons can be seen by looking at three international studies of regulatory intensity, each of which produced different rankings. These different findings stem from the lack of comparability in definition and assumptions, the uncertain reliability of pollution control data, and the fact that rankings may indeed change over time. The OECD forecast that 0.5 percent, 0.6 percent, and 2.6 percent of the gross national products (GNPs) of the United States, West Germany, and Japan, respectively, would be devoted to pollution control between 1971 and 1975. 2/ Taken as an indicator of regulatory intensity, this ratio suggests that Japan exceeded the United States and Germany in regulatory intensity during this period, with Germany slightly ahead of the United States. The Department of Commerce forecast that these same countries would incur

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1. Organization for Economic Cooperation and Development, *Economic Implications of Pollution Control: A General Assessment* (Paris, 1974).

2. Ibid., p. 30.

"pollution abatement costs" of 0.7 percent, 1.8 percent, and 1.2 percent of their GNP, respectively, for various periods between 1973 and 1982, with Germany leading Japan and the United States in regulatory intensity. 3/ Leontief projected that less than 1 percent of gross domestic product (GDP), and therefore of GNP, would be devoted to "current costs of pollution abatement" in all of North America, Western Europe, and Japan over those years. 4/ Leontief's findings suggest that the North American countries (United States and Canada) and Western Europe (Germany) exceed Japan in regulatory intensity if share of GDP is used as a ranking criterion.

The Choice of an Estimation Technique

Expenditures for pollution control can be estimated by either survey or engineering techniques. Each method has limitations. Moreover, these estimates will differ according to their definitions of pollution control costs.

Survey Estimates. Estimates of pollution control expenditures are usually constructed through a survey of firms. The problems inherent in survey estimates pertain to survey design, sample size, sample unit (a single plant, or establishment, within a firm versus a firm that may consist of many plants), response rate, and perceived potential bias in the response. 5/ Surveys that concentrate on large firms and then extrapolate to the national level may overestimate total costs, since smaller firms are more often exempted from stricter environmental standards. Survey results may also be biased by the desire of respondents to report large expenditures, or by allowing respondents to define relevant costs as they see fit.

The extent of the problem is evidenced by the great variation in estimates of pollution control expenditures in the United States. Portney uses estimates of 1978 expenditures in the U.S. business sector to note that three independent and often-cited sources of data on pollution abatement expenditures differ by 100 percent to 300 percent for certain U.S. industries in 1978. 6/

3. Department of Commerce, "The Effects of Pollution Abatement on International Trade--III," prepared as a report of the Secretary of Commerce to the President and the Congress (April 1975), p. G-6.

4. Wassily Leontief, *The Future of the World Economy: A United Nations Study* (New York: Oxford University Press, 1977), p. 53.

5. Paul Portney, "Macroeconomic Impacts of Environmental Regulations," in Henry Peskin, Paul Portney, and Allen Kneese, eds., *Environmental Regulation and the U.S. Economy* (Baltimore: Johns Hopkins University Press, for Resources for the Future, 1981).

6. Portney, "Macroeconomic Impacts," pp. 26-32.

These differences also appear in more aggregate estimates. The BEA, for example, reports total U.S. expenditures for pollution control in 1978 at $6.9 billion (current U.S. dollars), while McGraw-Hill reports expenditures of $8.0 billion (current U.S. dollars). 7/ This $1.1 billion difference is approximately half of what Leontief projected 1978 pollution control investment to have been in Japan. 8/ Care must also be taken in what is being estimated. If state and local expenditures for pollution control--such as sewer systems and wastewater treatment facilities--and budgets for federal regulatory agencies (such as the EPA) are also included, the BEA 1978 estimate increases from $6.9 billion to $42.3 billion. 9/

Engineering Estimates. Pollution control expenditures can also be estimated using an engineering approach, which defines a "typical" plant in an industry, estimates its compliance costs, and then extrapolates to an industrywide estimate. Using this approach, the CEQ estimates that $45.9 billion was spent in 1978 for pollution control, compared with the $42.3 billion estimate obtained by the BEA through survey data. 10/ Moreover, the differences between these estimates are sometimes inconsistent. A comparison of BEA and CEQ estimates for the period 1973 through 1978 reveals that CEQ estimates fall below BEA estimates for 1973 and 1974, and exceed BEA estimates for 1975, 1977, and 1978. 11/

Estimates of capital costs also differ. The CEQ estimates that incremental private capital costs (excluding expenditures attributable to state and local government regulation, but including depreciation and interest)

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7. Gary Rutledge and Betsey O'Conner, "Capital Expenditures for Pollution Abatement: 1978, 1979, and Planned 1980," in Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (June 1980); and McGraw-Hill Inc., *12th Annual McGraw-Hill Survey of Pollution Control Expenditures* (Washington, D.C.: McGraw-Hill Inc., 1979).

8. Leontief, *Future of the World Economy* (1977), p. 53.

9. Gary Rutledge and Susan Trevathan, "Pollution Abatement and Control Expenditures, 1972-78," in Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (February 1980), pp. 27-33.

10. Council on Environmental Quality, *Environmental Quality* (1979), p. 667.

11. Council on Environmental Quality, *Environmental Quality* (1974), p. 221; (1975), p. 564; (1976), p. 167; (1977), p. 334; (1978), p. 447.

totaled $15.5 billion in 1979. 12/ The BEA estimate for private capital costs for pollution control in 1979 is approximately $19.6 billion. 13/

Such differences are not easily reconciled. While the CEQ estimates are based on the engineering details of actual plants, there are problems with extrapolating such data to the entire business sector. Technologies differ across firms, as do interest costs, depreciation, and so forth. Such differences may lead to an inherent bias in aggregation, particularly if firms differ in the way they balance their demands for equipment and other inputs. In addition, the aggregation of a "typical establishment" across all establishments fails to account for local differences in regulations made by state and municipal authorities. But the direction of these biases is unknown. Thus, both engineering and survey approaches must be viewed with caution. Moreover, problems illustrated by differences in annual estimates of U.S. pollution expenditures are also apparent in data from other countries.

DATA USED IN CBO'S ANALYSIS

The problems inherent in choosing any particular data series to represent the economy's pollution control expenditures cannot be resolved unambiguously. Different definitions of pollution control costs and different estimation techniques offer both advantages and disadvantages, depending on the purpose of the analysis to which they are applied. No "perfect" data series exists. Thus, when one series is chosen, its advantages and disadvantages must be well understood.

Given these considerations, CBO chose to use the most simple pollution control data that are both available and defined consistently for all countries: new capital plant and equipment expenditures made by the private sector for pollution control. These data provide a viable proxy for the intensity of regulation, although they only partially represent the costs of complying with environmental regulation.

12. Council on Environmental Quality, *Eleventh Annual Report* (1980). This estimate represents an annualized capital cost.

13. Kit Farber, Frederick Drieting, and Gary Rutledge, "Pollution Abatement and Control Expenditures, 1972-82," in Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (February 1984). See Table 9, "Capital Costs for Residential Business and Non-Farm Residential Business."

Advantages

The principal advantage of using new plant and equipment expenditures as indicators of environmental regulation across countries and over time is that such data are readily available and easily defined. This makes international comparisons of these data less susceptible to different financial assumptions, tax provisions, and other considerations that occur in formulating annual costs. For example, to estimate the annual cost of pollution abatement, one must determine the depreciation schedules of the capital equipment, assume the proportions of debt and equity financing to calculate capital charges, and determine the existing stock of pollution equipment and how new purchases affect this stock. In addition, such costs must be aggregated over many firms in many industries for each country over time. Meeting these requirements in a consistent fashion is exceedingly difficult; in fact, no current estimates meet these criteria. As a result, the comparatively simple measure of new capital expenditures made for pollution control is preferred for this analysis, particularly if operations and maintenance expenditures remain a relatively fixed proportion of new capital expenditures both over time and across countries--an assumption that appears consistent with the survey of regulatory approaches presented in Chapter III. Moreover, new capital expenditures may be a better measure of the "intensity" of environmental regulation than is the cost of the annual stream of services from environmental capital already in place, which may depend more on the level of economic activity than the nature of current regulation.

Disadvantages

The principal limitations of this type of data are that it is a partial measure of expenditure and not a cost, and that it does not adequately reflect changes in interest rates or the purchase price of equipment. It is likely to lag environmental regulations by some time period and does not account for differences in tax treatments across countries, such as accelerated depreciation schedules, investment tax credits, and so forth.

Private capital expenditures for pollution control represent only one index of the intensity of regulation. Other possible indexes are available. One approach would consist of using the estimated reductions in pollution levels as a proxy for regulation's intensity. But using such an index of pollution reductions involves adding together improvements in air quality, water quality, and other environmental amenities--a highly subjective procedure. Another index could incorporate such measures as the number of pages of regulations found in the Federal Register, or expenditures made to administer regulations or to litigate them. But these measures often reflect the intensity with which regulations are contested rather than the extent to which they force firms to deviate from the production decisions they would make in the absence of regulation. Thus, while private capital expenditures are a somewhat imperfect measure of the intensity with which environmental regulation affects the decisions of firms in the private economy, they appear to provide the best index that is readily available in all of the four countries examined.

The use of private capital expenditures for pollution abatement may also be questioned from another perspective. At issue is whether any individual series is a better measure of regulatory intensity than the others. One way to examine this concern is to observe how the different measures are correlated with each other; if the alternative measures are highly correlated (that is, if the changes in each series appear to move in the same direction from year to year), then no statistical problems are encountered when any one of the series is used as a measure of regulatory intensity. 14/ Table 14 presents a matrix of "correlation coefficients" between each pair of the five measures. A value of 1.0 means that any two measures are identical. A value of 0.0 means that they are uncorrelated, and a value of (-1.0) means that two measures are perfectly inversely correlated (that is, as one goes up, the other must go down). As shown in Table 14, all the measures are correlated between .68 and .99. Moreover, the measure used by CBO is correlated between .86 and .96 with the other four measures. All of the available measures of pollution control expenditures, therefore, appear to capture the same effect, in that they generally move together over time.

CROSS-COUNTRY COMPARISON OF POLLUTION CONTROL EXPENDITURES

Estimates of expenditures for new plant and equipment for pollution control made by the private-business sectors in the four countries studied are shown in Table 15. To facilitate comparison across countries, the data are also presented as a percentage of gross domestic product.

The United States

Nominal investment in pollution control rose fairly steadily in the United States between 1973 and 1982. As a percentage of GDP, however, pollution

14. Were this not true, there would be a danger of misconstruing changes in the expenditure measures as changes in actual regulatory intensity.

control expenditures peak in 1975 at 0.46 percent, declining to 0.28 percent by 1982. Among the four nations, this is the highest proportion of GDP claimed by pollution control expenditures at the end of the sample period (although Japan spent a greater proportion in the early to mid-1970s). If 1982 U.S. expenditures were to fall to the share of GDP observed in Japan (in 1981, the last year for which data exist), they would decline from $8.5 billion to $5.2 billion.

TABLE 14. CORRELATION MATRIX OF ESTIMATES OF POLLUTION CONTROL EXPENDITURES, 1973-1979

	CBO [a]	BEA [b]	Census [c]	CEQ [d]	McGraw-Hill [e]
CBO	1.00				
BEA	.93	1.00			
Census	.86	.68	1.00		
CEQ	.96	.99	.75	1.00	
McGraw-Hill	.90	.86	.83	.87	1.00

SOURCES:

a. Congressional Budget Office. Exchange rates and GDP data from International Monetary Fund, *International Financial Statistics* (various years). Pollution control expenditure data for United States from Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (June 1981 and June 1983). Pollution control expenditure data for the other nations obtained from the respective embassies (1983).

b. Gary Rutledge and Susan Trevathan, "Pollution Abatement and Control Expenditures, 1972-78," in Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (February 1980). Includes expenditures for reducing pollutant emissions and for collection and disposal of solid wastes by means acceptable to federal, state, and local authorities, plus expenditures for regulation and monitoring and for research and development, which lead indirectly to emissions reduction. Excludes expenditures for other aspects of environmental control such as conservation of natural resources or protection of endangered species. Also excludes spending by agricultural business (except feedlot operations); real estate operators; private medical, legal, educational, and cultural services; and nonprofit organizations.

c. Bureau of the Census, *Pollution Abatement Costs and Expenditures* (1974, 1976, 1979, and 1980).

d. Council on Environmental Quality, *Environmental Quality* (1974-1979).

e. McGraw-Hill Inc., *17th Annual McGraw-Hill Survey of Pollution Control Expenditures* (Washington, D.C.: McGraw-Hill Inc., 1984), Table 5, "Total Pollution Control Expenditures." Includes total manufacturing expenditures plus those for mining, railroads, airlines, electric utilities, gas utilities, commercial and other transportation.

Canada

Between 1973 and 1979, Canada spent proportionally less of its GDP on pollution abatement than the United States, Japan, or Germany--that is, between 0.10 percent and 0.03 percent of its GDP (see Table 15). Since 1973, pollution control expenditures as a percentage of GDP steadily decreased until 1979 when they increased by 40 million Canadian dollars (30 million U.S. dollars) over 1978 levels.

Japan

The business sector of Japan spent a higher proportion of its new capital expenditures on pollution abatement relative to GDP than did the United States between 1973 and 1976 (see Table 15). Japanese business spent between 0.45 percent and 0.69 percent of its GDP for new capital expenditures for pollution control, compared to the United States, which spent

TABLE 15. POLLUTION CONTROL EXPENDITURES IN THE UNITED STATES, CANADA, JAPAN, AND WEST GERMANY, 1973-1982 (In billions of current dollars and as a percentage of gross domestic product)

	United States		Canada		Japan		West Germany	
Year	Billions of Dollars	Percentage of GDP	Billions of Dollars	Percentage of GDP	Billions of Dollars	Percentage of GDP	Billions of Dollars	Percentage of GDP
1973	4.9	0.38	0.13	0.10	1.8	0.45	NA	NA
1974	5.7	0.41	0.14	0.09	3.1	0.69	NA	NA
1975	7.0	0.46	0.14	0.08	3.2	0.64	1.0	0.24
1976	7.2	0.43	0.14	0.06	2.7	0.47	1.0	0.21
1977	7.3	0.38	0.05	0.03	1.7	0.22	1.1	0.18
1978	7.6	0.35	0.06	0.03	1.7	0.16	1.2	0.17
1979	8.4	0.35	0.09	0.04	1.2	0.13	1.2	0.15
1980	9.2	0.36	NA	NA	1.5	0.13	NA	NA
1981	8.9	0.31	NA	NA	2.0	0.17	NA	NA
1982	8.5	0.28	NA	NA	NA	NA	NA	NA

SOURCES: Congressional Budget Office. Exchange rates and GDP data from International Monetary Fund, *International Financial Statistics* (various years). Pollution control expenditure data for United States from Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (June 1981 and June 1983). Data for the other nations obtained from the respective embassies (1983).

roughly 0.40 percent of its GDP for the same period. This trend, reversed after 1976, however, to the point where the Japanese business sector spent less than one-quarter of one percent of its capital costs on pollution control expenditures by 1981.

West Germany

As a percentage of GDP, the pollution control expenditures in West Germany exceed those in Canada, are less than those in the United States, and are comparable to those in Japan. These expenditures as a percentage of GDP in Germany have declined steadily since 1975, from 0.24 percent in that year to 0.15 percent in 1979. Germany spent approximately $1 billion (in current U.S. dollars) per year on pollution abatement expenditures--about 36 percent less than Japan over this period.

CHAPTER V

AGGREGATE ECONOMIC EFFECTS OF POLLUTION CONTROL EXPENDITURES

This chapter discusses the effects of environmental regulations on economic growth and productivity in the United States, Canada, West Germany, and Japan. For its analysis, CBO performed two sets of econometric model simulations for each country during the period 1968-1982. In the first simulation, pollution control expenditures were assumed to be eliminated for the entire period. The second simulation used historical pollution control expenditures for each country. The results of the two simulations were then compared with each other and with the findings of other similar studies.

CBO's comparative analysis suggests that the aggregate effects of environmental regulation on measured economic growth and productivity have been relatively small during the last decade in each of these countries. More important, there is evidence that the initial adverse economic effects of these regulations have declined since the mid-1970s in all four nations. If that is so, the business sector of the U.S. economy as a whole has not been placed at a disadvantage in comparison to the business sectors of these other countries during this time period. 1/ Although some individual U.S. businesses were probably placed at a disadvantage relative to their counterparts in other countries, the cumulative effects of these disadvantages do not appear in the aggregate comparisons, suggesting that such losses may have been offset by gains elsewhere in the economy.

These results do not "prove" that environmental regulation has not lowered measured productivity significantly in the U.S. economy. Statistical results, in fact, cannot prove any such proposition. But the evidence provided by the CBO simulations, and by the other studies cited in this chapter, is consistent with the proposition that these regulations have not had major economic consequences.

ALTERNATIVE ANALYTIC APPROACHES

Many analyses have attempted to provide empirical evidence of the economic effects of environmental regulation. Table 16 presents a partial list

1. See, for example, Department of Commerce, *U.S. Pollution Control Costs and International Trade Effects: 1979 Status Report* (September 1979).

TABLE 16. THE ECONOMIC EFFECTS OF INCREASED POLLUTION CONTROL EXPENDITURES: A LITERATURE OVERVIEW

Study	Output Prices	Output Quantity	Labor Quantity
Chase Econometric Associates, Inc. [a]	+	-	NA
Christainsen, Gallop, and Haveman [b]	+	+, -	+
Crandall [c]	NA	NA	NA
Data Resources, Inc. [d]	+	-	-
Denison [e]	NA	-	+
Department of Commerce [f]	+	-	+
Farber, Dreiting, and Rutledge [g]	+	-	-
Hartman, Bozdogan, and Nadkaini [h]	+	-	-
Haveman and Christainsen [i]	NA	-	NA
Iden, Phaup, and Russek [j]	NA	NA	NA
Kendrick [k]	NA	-	+
Kopp and Smith [l]	NA	-	NA
Kutscher, Mark, and Norsworthy [m]	+	-	+
Link [n]	NA	NA	NA
Maloney and McCormick [o]	NA	NA	NA
Norsworthy, Harper, and Kunze [p]	+	-	+, -
OECD [q]	+	-	-
Siegel [r]	+	-	-
Thurow [s]	NA	NA	NA

SOURCE: Congressional Budget Office.

NOTES: All studies pertain to the United States only, except the OECD study, which includes Japan, and the Kendrick study, which also covers Canada, Japan, and West Germany.

a. Chase Econometric Associates, Inc., "The Economic Impact of Pollution Control: A Summary of Recent Studies," prepared for the Council on Environmental Quality, Department of Commerce, and Environmental Protection Agency (March 1972).

b. Gregory Christainsen, Frank Gallop, and Robert Haveman, "Environmental and Health/Safety Regulations, Productivity Growth and Economic Performance: An Assessment," prepared for the Joint Economic Committee (January 1980).

c. Robert Crandall, "Pollution Controls and Productivity Growth in Basic Industries," in Thomas Cowing and Rodney Stevenson, eds., *Productivity Measurement in Regulated Industries* (New York: Academic Press, 1981), pp. 347-368.

d. Data Resources, Inc., "Macroeconomic Impact of Federal Pollution Control Programs: 1981 Assessment," submitted to the Environmental Protection Agency (July 1981).

e. Edward Denison, *Accounting for Slower Economic Growth: The United States in the 1970s* (Washington, D.C.: Brookings Institution, 1979).

f. Dept. of Commerce, "The Effects of Pollution Abatement on International Trade--III," prepared as a report of the Secretary of Commerce to the President and the Congress (April 1975).

g. Kit Farber, Frederick Dreiting, and Gary Rutledge, "Pollution Abatement and Control Expenditures, 1972-82," *Survey of Current Business*, vol. 64, no. 2 (February 1984).

h. Raymond Hartman, Kirkor Bozdogan, and Rivindra Nadkaini, "The Economic Impacts of Environmental Regulations on the U.S. Copper Industry," *The Bell Journal of Economics*, vol. 9 (Autumn 1979), pp. 589-618.

i. Robert Haveman and Gregory Christainsen, "Environmental Regulations and Productivity Growth," in Henry Peskin, Paul Portney, and Allen Kneese, eds., *Environmental Regulation and the U.S. Economy* (Baltimore: Johns Hopkins University Press, 1981).

TABLE 16. (Continued)

Capital Quantity	Production Costs	Productivity [t]	Type of Study
NA	NA	-	Descriptive/macroeconomic
-	+	-	Descriptive/macroeconomic
NA	NA	-	Econometric/industry
+	+	-	Econometric/macroeconomic
-	+	-	Growth accounting
-	+	-	Engineering/accounting/industry
-	+	-	Growth accounting
-	+	NA	Econometric/microeconomic
NA	+	-	Descriptive/macroeconomic
NA	NA	-	Descriptive/macroeconomic
+	+	-	Growth accounting
-	+	-	Engineering/econometric/microeconomic
-	+	-	Growth accounting
NA	NA	-	Econometric/industry
NA	NA	-	Econometric/industry
+	+	-	Growth accounting
+	+	+	Input-output/econometric/macroeconomic
+	+	-	Econometric/macroeconomic
NA	NA	-	Econometric/macroeconomic

j. George Iden, Marvin Phaup, and Frank Russek, *The Productivity Problem: Alternatives for Action*, Congressional Budget Office (1981).

k. John Kendrick, *International Comparisons of Recent Productivity Trends* (Washington, D.C.: American Enterprise Institute, 1981), pp. 125-170.

l. Raymond Kopp and V. Smith, "Productivity Measurement and Environmental Regulation: An Engineering-Econometric Analysis," in Thomas Cowing and Rodney Stevenson, eds., *Productivity Measurement in Regulated Industries* (New York: Academic Press, 1981), pp. 249-282.

m. Ronald Kutscher, Jerome Mark, and John Norsworthy, "The Productivity Slowdown and the Outlook to 1985," *Monthly Labor Review*, vol. 100 (May 1977), pp. 3-8.

n. Albert Link, "Productivity Growth, Environmental Regulations, and the Composition of R&D," *The Bell Journal of Economics*, vol. 13 (Autumn 1982), pp. 166-169.

o. Michael Maloney and Robert McCormick, "A Positive Theory of Environmental Quality Regulation," *Journal of Law and Economics*, vol. xxv (April 1982), pp. 99-123.

p. John Norsworthy, Michael Harper, and Kent Kunze, "The Slowdown in Productivity Growth: An Analysis of Some Contributing Factors," *Brookings Papers on Economic Activity*, vol. 2 (1979), pp. 387-421.

q. Organization for Economic Cooperation and Development, *Macroeconomic Evaluation of Environmental Programmes* (Paris, 1978).

r. Robin Siegel, "Why Has Productivity Slowed Down?" *Data Resources U.S. Review* (March 1979), pp. 159-165.

s. Lester C. Thurow, "Feasible and Preferable Long-Term Growth Paths," prepared for the Council on Environmental Quality (1979).

t. Productivity is defined differently in these studies as labor, capital, and/or total factor productivity. It is, however, reported as a measure of efficiency and should be construed as such for this table.

of these studies, which differ widely in scope, method, assumptions, and findings. The economic effects observed in these studies are denoted by either a positive (+) or a negative (-) sign. For example, a positive sign under "output prices" in Table 16 signifies that pollution control expenditures were found to raise prices in that study. Some of these studies provide partial answers to the questions raised, but no one study provides consistent estimates of the aggregate economic effects of environmental regulations across all four countries over time.

Definitional Issues

Although all these studies examine how economic growth and performance change as a result of environmental regulations, the definitions of "economic growth and performance" vary considerably. Productivity, for example, is a measure that relates the flow of output in an economy to the flow of inputs. It can be measured, however, in a variety of ways: as nonresidential business income per employed person (as does Denison); as a total factor productivity measure that relates private-sector output to a weighted average of all inputs (Kendrick or Link); as private nonfarm output per manhour (Siegel); as private output per manhour (Kutscher, Mark, and Norsworthy; Thurow); or as industrial output per manhour (Crandall). These differences in definitions can make cross-study comparisons difficult. 2/

Other definitional issues concern how output, output prices, labor demand, and capital demand are measured. Investigators might measure output in physical quantity units (Kopp and Smith), as real income (Denison), or as deflated value added from manufacturing industries (Data Resources, Inc.; Chase Econometric Associates, Inc.), to mention a few approaches. Output prices can be measured as an overall price level (OECD) or as specific output prices associated with particular products (Maloney and McCormick; Hartman, Bozdogan, and Nadkaini). Similarly, labor demands can be measured as number of employees (Denison) or in manhours (Norsworthy, Harper, and Kunze). Capital demands can be measured as stocks, relatively fixed in a given period (Kendrick), or as capital service flows, as in the CBO analysis. These differences in measurement produce potentially different effects associated with pollution regulations, quite apart from other methodological considerations.

Moreover, all of these studies deal with measured output and productivity. The term "measured" is added to reflect the fact that the statistical

2. Citations of the works mentioned in this chapter can be found in Table 16.

measures used to represent output and productivity are imperfect, and because environmental regulation produces benefits that do not enter directly into these measures. Thus, a society's well-being might increase by more than does measured output, and its resources might be put to better use than measured productivity suggests.

Methodological Issues

Methodological issues are also associated with cross-study comparisons. Numerous empirical approaches have been taken by various authors to quantify the effects of environmental regulations on private-sector economic performance. Five analytic approaches are reviewed below.

Descriptive Statistics. This approach provides a useful basis for casually observing the effects of pollution expenditures and regulations. By themselves, however, descriptive statistics are usually insufficient to quantify the effects of changing pollution expenditures and regulations.

Economic Growth-Accounting Procedures. Such procedures assume that environmental regulations direct capital and labor away from activities that create gross national product (GNP) as the business sector complies. The benefits of pollution control are measured in GNP but are not attributed to the regulations that triggered them. As a result, productivity must decline in response to regulations in these analyses. Thus, these studies might provide an upper limit of the effects of environmental regulation, since they predetermine the direction of those effects by forcing output and productivity to decline. 3/ Studies using growth-accounting techniques to assess environmental regulatory impacts include Farber, Dreiting, and Rutledge; Denison; Norsworthy, Harper, and Kunze; Kutscher, Mark, and Norsworthy.

Sector Analysis. This approach estimates the costs of complying with environmental regulations in an individual sector or industry. Unfortunately, sector analysis can seldom be employed to explore economywide or interindustry effects of regulatory actions. Moreover, this "bottom-up" approach to economywide impact assessment relies on extensive data,

3. Gregory Christainsen, Frank Gallop, and Robert Haveman, "Environmental and Health/Safety Regulations, Productivity Growth and Economic Performance: An Assessment," prepared for the Joint Economic Committee (January 1980), p. 60 (see Table 16). It is not universally agreed, however, that growth accounting provides an upper limit, because the pollution expenditures used with this technique might well understate the compliance costs of pollution control. In addition, the disincentives associated with new plant investment created by the relatively less-restrictive pollution standards for older or existing plants, termed "new source bias" by some economists, might escape measurement in growth-accounting procedures.

including an accurate depiction of the typical firm's technology and management (which must not change over time). Hollenbeck provides an example of such a model. 4/ The study by Kopp and Smith is an industry-specific analysis.

Single-Equation Econometric Procedures. Using aggregate data, these procedures can be employed to estimate the effects of environmental regulations on measured output and productivity. These approaches use various economic factors, including regulation, to predict aggregate output or productivity. This technique, however, is based on statistical assumptions that sometimes may not obtain. For this and other reasons, studies that use this procedure report widely different estimates of regulation impacts. In addition, measuring more than one effect (for example, output, productivity, prices, or input demands) proves difficult with this procedure. Both Siegel and Crandall use the single-equation approach to examine the effect of environmental regulations on productivity.

Large-Scale Macroeconomic Models. A collection of econometric equations, these models can be used to analyze the effects of environmental regulations in any one nation. Although they provide more detail than single-equation studies, they may be less useful for making international comparisons, because the structure and assumptions used in models of each nation often differ. Macroeconomic models of Canada, Japan, West Germany, and the United States differ not only in their characterization of the environmental regulations but in their depiction of a variety of economic relationships. Moreover, differences in the underlying theory of the model can produce varying results. Thus, estimates of the differences in the economic effects of regulation among countries may reflect differences in statistical models, data, or method, rather than (or in addition to) true differences in economic conditions. Macroeconomic models were used in the studies by Data Resources, Inc.; Chase Econometric Associates, Inc.; and OECD.

A final limitation of macroeconomic models is that they cannot reflect certain indirect effects associated with regulations. These effects include disincentives toward new, more productive investments by new plants because they must face relatively stricter regulations than older firms, and the unmeasured benefits associated with pollution control. 5/

4. Kevin Hollenbeck, "The Employment and Earnings Impact of the Regulation of Air Pollution," in *The Journal of Environmental Economics and Management* (1979).

5. For an excellent discussion of the macroeconomic impacts of federal environmental regulation in the United States, see Paul Portney, "The Macroeconomic Impacts of Federal Environmental Regulation," in Henry Peskin, Paul Portney, and Allen Kneese, eds., *Environmental Regulation and the U.S. Economy* (Baltimore: Johns Hopkins University Press, for Resources for the Future, 1981).

CBO's Analytic Method

An alternative to these five approaches is the "small-systems" model approach used in the CBO analysis. A small-systems model is a compromise between the more detailed macroeconomic models and the single-equation models. It has the advantage of being built specifically to address a limited set of questions, such as those asked in this study. It is small enough (in this case, five equations for each country) to be computationally tractable, and allows output, productivity, and other effects to be measured consistently across countries in a relatively straightforward manner.

The CBO model is constructed as follows. In each country, five equations estimate five economic outcomes: the total cost of producing private-sector output, the supply of private-sector output, the demand for capital by the private sector, the demand for labor, and the aggregate demand for the output of the private sector. In the first four estimates, pollution control expenditures enter directly into the estimate. Thus, changes in these expenditures will change the costs of doing business, the supply of privately supplied goods, and the demands for labor and capital. Since the demands for capital and labor are important determinants of the income that consumers have to buy goods, expenditures for pollution control "feed back" and affect the demand for goods through the demands for capital and labor. When the model is solved, it depicts how changes in environmental regulation lead to changes in output, prices, and productivity. See the Appendix for model documentation.

Each country's model can be used to simulate the effects of pollution expenditures on output and productivity. The structure of the models does not require that the net effects of environmental regulations be positively or negatively related to any of these individual effects prior to estimation. Two simulations are performed for each country over the period 1968-1982.

The first simulation--referred to as the "pollution control expenditure" (PCE) case--uses historical data, including expenditures by the private sector for pollution control, to estimate the expected output and productivity levels in each year for each country. 6/ Thus, simulations in the PCE case yield a solution that statistically approximates the actual course of all four economies over the time period studied. The second simulation--the "without pollution control expenditures" (WPCE) case--sets the values of pollution control expenditures to equal zero in all years. The models are then solved for the same variables, including output and productivity, for each year in each country. Comparing the PCE and WPCE cases for each

6. The model also predicts output prices, input demands, and gross domestic product. See the Appendix.

country provides estimates of how pollution control expenditures influenced output, prices, and productivity over time. These observed effects will reflect different underlying economic and technological relationships in each country. Thus, an equivalent expenditure in two countries has potentially different effects on output, productivity, and output prices in those countries.

The primary disadvantage of the small-systems approach is the flip side of its advantage: because of the high level of aggregation used in this analysis, it is impossible to achieve the level of detail provided in macroeconomic or sector-modeling approaches. The small-systems model also is subject to the same criticisms as macroeconomic models, including the inability to capture many of the unmeasured effects associated with pollution control.

Another disadvantage the CBO approach shares with large-scale macroeconomic models is that the economic effects it reports may actually result from the model structure. To examine the extent to which the model's results were influenced by its structure, the U.S. model was reestimated using a different structure. Specifically, the original model was based on the assumption that the economy's endowments of capital and labor varied, but that their price was fixed; that is, all employers could obtain as much capital and labor as desired at the going market price. The reestimated version of the model employed the assumption that the economy's endowments of capital and labor were fixed but that their price varied; that is, a given amount of capital and labor exists and their prices rise or fall until all of that endowment is used up. The changes in output obtained using this version were similar to those obtained in the original model but were smaller in magnitude. The models were then changed a second time to examine the effects of different mathematical specifications. The results were disappointing and, in some cases, counterintuitive. Thus, the results are somewhat sensitive to the model's assumptions and more so to the mathematical specification of its underlying relationships. Therefore, although the CBO model might accurately indicate the direction of various economic effects, the magnitudes of the effects must be viewed with caution.

EFFECTS OF REGULATION IN THE UNITED STATES

Despite differences in methodology and definitions, most economywide studies of the impact of pollution regulation conclude that environmental regulations have lowered measured productivity (see Table 17). Productivity growth in the United States over the period 1973 through 1979 was slightly

TABLE 17. ESTIMATES OF U.S. PRODUCTIVITY LOSSES ATTRIBUTED TO ENVIRONMENTAL REGULATION

Study	Productivity Measure	Method	Years	Average Annual Decline in Growth Rate of Productivity (In percents)
CBO (1984)	Total factor productivity	Small systems	1973-1982	0.28
Christainsen et al. (1980)	Labor productivity, average of other measures	Survey of other studies	1973-1979	0.25
Crandall (1981)	Industrial output per manhour	Single-equation econometric	1973-1976	1.5
Denison (1979)	Nonresidential business income per employed person	Growth accounting	1969-1973 1973-1976 1975-1978	.05 .22 .08
DRI (1981)	Labor productivity	Large-scale econometric	1974-1979	0.1 to .25
Farber et al.(1984)	Nonfarm output per person	Growth accounting	1972-1982	.09
Kutscher et al. (1977)	Private output per manhour	Growth accounting	1966-1977	0.1
Norsworthy et al. (1979)	Private nonfarm output per manhour	Growth accounting	1973-1978	.09
	Manufacturing output per manhour	Growth accounting	1973-1978	.19
Siegel (1979)	Nonfarm output per manhour	Single-equation econometric	1967-1973 1973-1979	0.1 0
Thurow (1980)	Private output per manhour	Single-equation econometric	1973-1978	0.2

SOURCE: Congressional Budget Office.

lower than it would have been in the absence of environmental regulations. If the two extreme estimates are ruled out (Siegel's and Crandall's), estimates of declines in growth of U.S. productivity as a result of environmental regulation range from 0.09 percent to 0.28 percent a year (the CBO estimate).

The CBO results indicate that the negative effects of environmental regulations on U.S. productivity growth may have been dissipating since 1975--a finding also made by Siegel; Farber, Dreiting, and Rutledge; and Denison. Siegel, for example, finds that environmental regulations are not statistically significant determinants of labor productivity by the mid-1970s. Denison finds that the loss in productivity growth attributable to environmental regulation declines to 0.08 percent by the late 1970s from a 0.22 percent difference between 1973 and 1975. Farber, Dreiting, and Rutledge find annual productivity losses declining from 0.21 percent to 0.08 percent between 1976 and 1979. The CBO results indicate that the difference in productivity measured with and without pollution control expenditures is less than 5 percent by 1982, or 0.28 percent annually. Since 1975, however, the productivity loss attributable to environmental regulation appears to be declining; that is, as seen in Table 18 and Figure 1, the difference in productivity levels between the PCE and WPCE cases declines after that year.

If the CBO simulations are correct, then productivity losses in the United States associated with environmental legislation and regulations such as the Clean Air Act and Clean Water Act are slowing, and if the trends continue, productivity advances could occur in the future. Productivity levels 16 years after the beginning of the current environmental regulatory regime are only 5 percent lower than if there had been no regulations in effect for the entire period, compared with after eight years, when they were almost 7 percent lower. Thus, while the earlier losses have not yet been offset, the economy's annual productivity losses stemming from environmental regulation are declining.

This evidence reinforces the conjectural explanations and descriptive statistical evidence provided in Chapters III and IV. These findings, however, are not universal. The DRI labor productivity findings show increasing productivity loss from 1975 through 1979. Haveman and Christainsen assert that between 12 percent and 21 percent of the slowdown in the growth of labor productivity in the manufacturing sector between 1973 and 1978 is attributed to increased environmental regulation; they strongly imply that this loss in productivity is increasing over time.

The question of productivity slowdown or loss associated with environmental regulation may be moot. First, a great deal of uncertainty surrounds these estimates. The evidence that environmental regulations have had a statistically significant effect on measured productivity is weak according to Siegel, to Haveman and Christainsen, and to CBO. Second, a number of recent studies have questioned whether there was indeed any slowdown in

TABLE 18. ENVIRONMENTAL REGULATION AND TOTAL FACTOR PRODUCTIVITY: THE UNITED STATES, CANADA, JAPAN, AND WEST GERMANY, 1967-1982 a/

Year	United States		Canada		Japan		West Germany	
	PCE	WPCE	PCE	WPCE	PCE	WPCE	PCE	WPCE
1967	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1968	1.06	1.07	.98	1.00	1.00	1.00	1.09	1.09
1969	1.12	1.13	1.05	1.07	1.17	1.18	1.19	1.19
1970	1.15	1.18	1.07	1.09	1.38	1.40	1.31	1.31
1971	1.23	1.27	1.15	1.17	1.53	1.55	1.34	1.34
1972	1.32	1.38	1.31	1.33	1.75	1.77	1.46	1.46
1973	1.44	1.53	1.51	1.52	2.15	2.19	1.48	1.48
1974	1.52	1.61	1.69	1.71	2.54	2.61	1.45	1.45
1975	1.43	1.52	1.93	1.96	2.76	2.83	1.32	1.46
1976	1.58	1.68	2.29	2.32	3.18	3.24	1.56	1.70
1977	1.75	1.84	2.60	2.65	3.59	3.63	1.61	1.74
1978	1.95	2.05	3.11	3.17	4.01	4.03	1.62	1.74
1979	2.13	2.22	3.63	3.69	4.52	4.54	1.82	1.93
1980	2.11	2.20	NA	NA	4.91	4.94	NA	NA
1981	2.15	2.25	NA	NA	5.29	5.33	NA	NA
1982	2.08	2.17	NA	NA	NA	NA	NA	NA

SOURCE: Congressional Budget Office.

NOTES: NA = not available.
PCE = pollution control expenditure case.
WPCE = without pollution control expenditures.

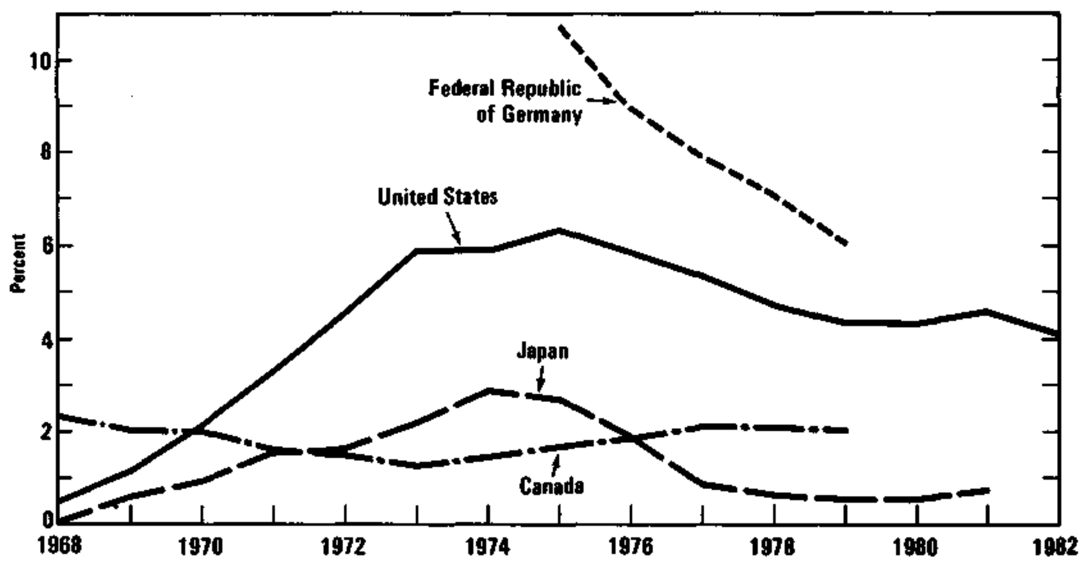
a. Total factor productivity as an index is constructed as a function of total inputs and total outputs. Total inputs are defined as the equilibrium solutions of each model for capital quantity, labor quantity, the capital cost share, and the labor cost share, respectively, with and without pollution control expenditures. The equilibrium solution for output quantity is divided by this total input quantity index to form the total factor productivity index, which is subsequently normalized (1967 = 1.00). The reader should note that these are model solutions, not historical data that one would typically find in growth-accounting measures.

productivity in the United States during the 1970s. 7/ If these studies are correct, the relatively small point estimates contained in Table 17 become even smaller.

EFFECTS OF REGULATION: A CROSS-COUNTRY COMPARISON

The effect of environmental regulation in other nations has been explored in a number of studies. The OECD, for example, in 1978 commissioned a series of macroeconomic evaluations of the implications of increasing environmental regulations. 8/ In the U.S. analysis, which used a DRI macroeconomic model, real output in the United States ranged from 0.5 percent to 2.2 percent lower as a result of environmental programs. In Japan, production was found to be only 0.01 percent lower with environmental regulations. No estimates were made for West Germany and Canada. In a second report, however, OECD maintained that for Canada there was "no evidence that

Figure 1.
Percentage Differences in Productivity Between WPCE and PCE Simulations, 1968-1982



SOURCE: Congressional Budget Office.

7. Michael R. Darby, "Productivity Slowdown: A Case of Statistical Myopia," *American Economic Review*, vol. 74, no. 2 (June 1984), pp. 301-334.

8. Organization for Economic Cooperation and Development, *Trade and Environmental Issues*, Committee Document No. 5 for the 31st Session of the Environment Committee (April 1982), p. iii.

environmental policies have created distortions in the patterns of international trade." 9/ The OECD studies indicate that environmental regulations have had only a very small effect on price levels: in Japan, prices are 0.1 to 0.2 percent higher; in the United States, consumer prices appear to be 0.3 percent higher.

Kendrick, using growth-accounting techniques, finds that total factor productivity declined approximately 0.4 percent a year for Canada, the United States, and West Germany during the mid- to late-1970s as a result of all regulations (health and safety regulations included) and approximately 1.0 percent a year for Japan. If environmental regulations are assumed to account for half of this effect (a reasonable estimate, given Denison's findings), the loss in productivity growth for Canada and West Germany is similar to that of the United States and within the range of the findings presented in Table 17. Japan's productivity loss appears to be approximately twice that of the United States, given Kendrick's results. The CBO found, however, that productivity losses in Japan are smaller than in the United States.

Estimates by the CBO model of productivity levels, both with and without pollution control expenditures, are presented in Table 18. The effects on output price, output quantity, capital quantity, labor quantity, and gross domestic product (GDP) are presented for the United States and the other three countries in Table 19. Using these results and the results of other studies, the effects of environmental regulation in the four nations can be compared.

United States. As discussed above, the effects of pollution control expenditures appear to be decreasing over time, having peaked in 1975. GDP is 1.9 percent lower in that year (owing to pollution control expenditures), and prices are 0.25 percent higher. By 1982, however, these effects are considerably smaller; prices are only 0.13 percent higher, and the loss in GDP falls to 0.8 percent.

Japan. The Japanese model demonstrates larger price effects and smaller productivity and output effects than does the U.S. model. In 1975 in the WPCE case, the model suggests that because of environmental regulation, GDP is 0.11 percent lower in Japan compared with 1.9 percent lower in the United States. Japanese prices rise by 1.8 percent in that year, compared with 0.25 percent in the United States. By 1981, however, the size of these

9. Organization for Economic Cooperation and Development, *OECD Economic Surveys, 1982-1983: Canada* (Paris, June 1983), p. 40.

effects is much smaller. The increase in Japan's output prices declines to 0.49 percent, and the GDP loss falls to only 0.02 percent. Productivity differences by 1981 are negligible and indistinguishable from zero using conventional statistical criteria. The Japanese model suggests that Japan has incorporated pollution control expenditures with less dislocation than

TABLE 19. PERCENTAGE CHANGE IN MACROECONOMIC VARIABLES, ASSUMING NO POLLUTION CONTROL EXPENDITURES: UNITED STATES, JAPAN, CANADA, AND WEST GERMANY a/

	1968	1970	1972	1974	1975	1976
United States						
Output price	-0.03	-0.10	-0.21	-0.24	-0.25	-0.23
Output quantity	0.19	0.78	1.61	2.05	2.23	2.04
Capital quantity	0.42	1.70	3.62	4.70	4.91	4.59
Labor quantity	0.26	1.09	2.32	3.00	3.32	3.07
GDP	0.23	0.85	1.59	1.78	1.87	1.60
Japan						
Output price	-0.38	-0.96	-1.49	-2.20	-1.84	-1.33
Output quantity	0.04	0.10	0.14	0.23	0.21	0.15
Capital quantity	-0.05	-0.12	-0.16	-0.26	-0.23	-0.17
Labor quantity	0.55	1.47	2.43	4.59	4.40	3.12
GDP	0.04	0.06	0.12	0.14	0.11	0.08
Canada						
Output price	NA	-0.49	-1.43	-1.05	-0.86	-0.59
Output quantity	NA	0.49	1.42	1.18	0.96	0.67
Capital quantity	NA	-0.98	2.95	-2.60	-2.14	-1.53
Labor quantity	NA	1.00	3.00	2.61	2.17	1.53
GDP	NA	0.04	1.03	0.66	0.50	0.31
West Germany						
Output price	NA	NA	NA	NA	-0.77	-0.68
Output quantity	NA	NA	NA	NA	2.17	1.79
Capital quantity	NA	NA	NA	NA	17.76	14.92
Labor quantity	NA	NA	NA	NA	2.29	2.00
GDP	NA	NA	NA	NA	1.29	1.03

SOURCE: Congressional Budget Office.

NOTES: GDP = gross domestic product; NA = not available.

the United States. Expenditures relative to GDP were also lower in Japan during the latter half of the decade. Between 1976 and 1979, GDP in Japan rose faster than in the United States, Canada, or West Germany. In its 1978 report, OECD finds the price effects in the Japanese model to be approximately half those in the U.S. macromodel. Production losses are also

TABLE 19. (Continued)

	1977	1978	1979	1980	1981	1982
United States						
Output price	-0.21	-0.18	-0.16	-0.15	-0.15	-0.13
Output quantity	1.87	1.63	1.49	1.48	1.56	1.41
Capital quantity	4.26	3.79	3.52	3.42	3.57	3.12
Labor quantity	2.85	2.25	2.29	2.31	2.44	2.25
GDP	1.38	1.11	0.94	0.89	0.86	0.76
Japan						
Output price	-0.61	-0.46	-0.38	-0.38	-0.49	NA
Output quantity	0.07	0.05	0.04	0.04	0.05	NA
Capital quantity	-0.08	-0.05	-0.04	-0.04	-0.06	NA
Labor quantity	1.46	1.04	0.90	0.93	1.22	NA
GDP	0.03	0.02	0.01	0.02	0.02	NA
Canada						
Output price	-0.27	-0.29	-0.35	NA	NA	NA
Output quantity	0.30	0.31	0.38	NA	NA	NA
Capital quantity	-0.72	-0.74	-0.93	NA	NA	NA
Labor quantity	0.71	0.73	0.90	NA	NA	NA
GDP	0.13	0.13	0.14	NA	NA	NA
West Germany						
Output price	-0.60	-0.53	-0.47	NA	NA	NA
Output quantity	1.57	1.43	1.21	NA	NA	NA
Capital quantity	1.83	1.73	1.53	NA	NA	NA
Labor quantity	1.83	1.73	1.53	NA	NA	NA
GDP	0.88	0.76	0.62	NA	NA	NA

a. Percentage change estimates are calculated by removing pollution control expenditures in the WPCE case and calculating $\frac{\text{WPCE - PCE}}{\text{PCE}}$ results.

smaller. The OECD report also suggests that Japan fared somewhat better than the United States with environmental regulations. 10/

Between 1980 and 1983, a period outside the sample on which the parameters of the CBO model for Japan were estimated, the Japanese economy manifested smaller rates of growth in output, GDP, and productivity along with dramatic declines in inflation, a result generally attributed to a weakening export demand. 11/ Bruno, analyzing the components of the productivity slowdown in manufacturing in Japan and other countries, finds that the slowdown of total factor productivity in Japan (1974 through 1980, relative to 1955 through 1973) was in large part explained by slower growth in export and domestic demand and rising input prices. 12/ The residual in which environmental regulations may be considered to have played some part is rounded to 0.00. Bruno, therefore, implicitly finds that environmental regulations had no effects on the slowdown in Japanese productivity, a result comparable to the extremely small effects found in this analysis.

Canada. The CBO simulations of the Canadian model between 1970 and 1977 reveal a pattern similar to that measured in the United States and Japan--dissipating effects in the latter half of the decade. Despite a slight increase in the absolute value of these effects between 1977 and 1979, a comparison between simulation results in 1975 and 1979 reveals smaller effects for each variable. In 1975, for example, GDP was 0.50 percent lower as a result of environmental regulation, compared with 0.14 percent lower in 1979. Similarly, prices were 0.86 percent higher in 1975, but only 0.35 percent higher in 1979. Productivity differences in Canada resulting from pollution control are comparable to those found in Japan. Declines in productivity in Canada during the latter 1970s seem not to be attributable to pollution expenditures, a conclusion echoed in a recent OECD report. 13/

West Germany. The German model simulations reveal a similar pattern of declining negative effects as a result of environmental regulation between

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10. Organization for Economic Cooperation and Development, *Macroeconomic Evaluation of Environmental Programmes* (Paris, 1979), p. 9.

11. Organization for Economic Cooperation and Development, *OECD Economic Surveys: Japan* (Paris, July 1983).

12. Michael Bruno, "World Shocks, Macroeconomic Response, and the Productivity Puzzle," National Bureau of Economic Research Working Paper 942 (July 1982), p. 12.

13. ". . . nor do governmental regulatory measures such as pollution control appear to have played a substantive role [in the post-1973 productivity slowdown in Canada]." OECD, *OECD Economic Surveys 1982-1983: Canada* (Paris, June 1983), p. 40.

1975 and 1979. Output decreases and price increases resulting from the imposition of pollution control expenditures are 1.20 percent and 0.47 percent, respectively--similar to the price effects in Japan and Canada and to the output effects in the United States. The limited availability of data regarding such expenditures in West Germany, however, makes it difficult to place extreme confidence in these results.

Despite the problem of limited data, the model results are consistent with other estimates. Kendrick, for example, estimates that real GDP growth from 1973 through 1979 averaged only 2.6 percent a year, compared with 4.6 percent a year from 1969 through 1973, and that growth in total factor productivity declined to 2.1 percent a year, compared with 3.2 percent in the prior period. 14/ The causes for all these changes are not readily apparent, yet the role of environmental regulations appears quite minor. Kendrick estimates that all government regulations, including those for environmental health and safety, caused a 0.4 percent decrease in the annual average growth of productivity during the 1973-1979 period. 15/ The results of the CBO simulations indicate that expenditures for pollution control during the period 1975 through 1979 contributed between 0.1 percent and 0.2 percent to the annual loss in measured productivity growth.

14. John Kendrick, *International Comparisons of Recent Productivity Trends* (Washington, D.C.: American Enterprise Institute, 1981), pp. 125-167.

15. Ibid., p. 141.

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CHAPTER VI

POLICY STRATEGIES

The relationship between environmental regulation and the efficiency of the U.S. private economy can be assessed by examining whether environmental regulation has affected output and productivity in the United States differently than has comparable regulation in the economies of major U.S. trading partners. To examine this issue, this study has concerned itself with three questions:

- o Whether regulations are developed and implemented in similar fashions in the United States and abroad;
- o Whether expenditures made to comply with regulatory requirements have been similar in the United States and abroad; and
- o Whether the effects of these expenditures on such measures as output and productivity have been comparable in the United States and abroad.

REGULATION AND PRODUCTIVITY: A REVIEW OF THE EVIDENCE

Environmental regulation appears to have had a small limiting effect on output and productivity in each of the four nations surveyed--the United States, Canada, Japan, and the Federal Republic of Germany. The magnitudes of these measured losses are small enough and comparable enough to support the view that U.S. economic performance in general has not been reduced relative to other nations because of environmental regulation. Yet both the similarities and differences among regulatory regimes and their effects in the four nations are instructive regarding the course of environmental policy in the United States.

Basic Similarities

Both the conduct of regulation and its effects in the four countries studied are often similar. Although exceptions exist, all four nations embrace similar goals for environmental quality. Moreover, the basis for assigning standards for individual polluters is also similar, particularly in that each of the four nations commonly bases discharge controls on state-of-the-art technology as determined by a centralized regulatory bureaucracy. The measured new capital expenditures for pollution control are also comparable; they appear to decline over time as a share of gross domestic product in each nation, but do vary--ranging from roughly 0.04 percent of gross domestic product in Canada to 0.28 percent in the United States.

To some extent, these similarities are not surprising. Information on the harm caused by pollution is disseminated within an international scientific community. Thus, environmental regulators in each of the nations have access to the same set of facts. Similarly, comparable observed expenditures on pollution control might result from the application of comparable regulatory requirements to countries with similar compositions of output (particularly the share of manufacturing and the importance of automotive transport and generation of fossil-fuel electricity).

A more striking similarity concerns the effects of measured pollution control expenditures on aggregate economic measures such as output and productivity. In each of the four countries studied, environmental regulation appeared to have a negative effect on output and productivity immediately following the passage of environmental statutes in the late 1960s and early 1970s. The magnitude of these negative effects, however, appears to have peaked in the mid-1970s in the United States, Japan, and West Germany. Since then, the levels of economic output, prices, and productivity in all four nations have been approaching what they would have been in the absence of pollution expenditures (as estimated by econometric simulations discussed in Chapter V) but at different rates. In other words, the estimated economic losses attributable to environmental regulation have been shrinking since the mid-1970s.

Several explanations could account for this recurring "catching up" effect. First, the benefits achieved through environmental regulation probably take some time to occur, and those resulting from regulation imposed in the early 1970s likely began to reveal themselves only later in the 1970s. Second, all of these nations made larger investments in pollution control in the years immediately following the passage of major environmental legislation than in the later 1970s and 1980s. This suggests that early expenditures were aimed at controlling a "backlog" of older pollution sources, and that expenditures for pollution control have now reached a "steady state" in which they are applied to new facilities. 1/ Smaller annual

1. While this may be true regarding implementation of the Clean Air Act and Clean Water Act, a new "wave" of regulatory requirements may be forthcoming as the Congress considers legislation on pollutant transport (acid rain) and disposal of hazardous and toxic wastes.

investments might now be needed to maintain environmental quality. Finally, it is likely that much has been learned in all nations as both regulators and the regulated gain experience at their tasks. This knowledge might contribute to more efficient regulation over time.

Important Differences

Although the similarities in environmental regulatory regimes and the effects of regulation on aggregate measures of economic performance are instructive, the differences among them are important as well. Environmental goals and standards are roughly similar in all four nations, but Japan's are often more stringent and Canada's less so, with the United States and West Germany falling between these two extremes. These differences are consonant with each nation's geography and demography. Japan's mountainous terrain, high industrial density, and crowded urban centers make the harm done by any level of emissions more severe than in the other nations, while Canada's more varied terrain and lower population density lead to the opposite situation. These differences in regulations parallel differences in spending on pollution control, which generally yield the same ranking--Japan spent the most on control in the 1970s (when measured as a proportion of gross domestic product) and Canada the least. (In recent years, however, Japan's spending for pollution control appears to have fallen below the U.S. level.)

Although Japan has enacted more stringent environmental regulations to achieve comparable environmental quality--and spent more on pollution control relative to GDP in the early to mid-1970s--paradoxically, its control expenditures appear to have had a less damaging economic effect than similar expenditures by other nations. Pollution control expenditures in Japan appeared initially to cause the largest output price effect observed in any country (prices were 2.2 percent higher in 1974, but only 0.4 percent higher by 1980 because of environmental regulations), but Japan's observed loss of output is as low as any other country's in the sample. Moreover, its estimated productivity loss is the smallest of the four countries. No econometric model can explain definitively this result. Part of the explanation probably lies with Japan's overall industrial performance and with conditions in the world market that have made Japan's goods desirable. The nature of the Japanese regulatory process also probably explains a portion of Japan's relative success in incorporating environmental expenditures into its economy.

Implications for Policy

Several implications for environmental policy may be drawn from these findings. First, environmental regulation has not been a prominent contributor to the "productivity slowdown" that many economists identify as having occurred in the late 1970s and early 1980s. The measured output and productivity sacrificed by the U.S. economy by virtue of pollution control expenditures appears to be both small and comparable to losses experienced in other nations. Thus, no statistical evidence was found to support the contention that environmental regulation has hampered the efficiency of the U.S. economy in the aggregate.

Second, these results, in the United States and in other nations, are consistent with the idea that regulation has benefited from the learning that accompanies experience over time. This learning process likely will continue in all nations, and further improvements in the efficiency of environmental regulation must therefore be achieved if the United States is to maintain its position with respect to its trading partners.

Third, the nature of environmental regulation itself may affect economic performance. Japan, for example, employs great flexibility when assigning limits to individual sources of pollution. Discharge limitations can be strengthened or relaxed according to the situation of the individual source: if more pollution can be controlled at small increase in cost, then the standards are tightened; if meeting the current limits proves unreasonably expensive, standards can be relaxed. Such discretion can be employed at both the local and central government levels, although relaxation of standards usually must be enacted by the central government. Other approaches such as emissions trading, emissions taxes, and special tax incentives for process change (as opposed to end-of-pipe treatment alone) have encouraged the efficient assignment of control costs. Negotiation between the regulatory agency and the source to achieve reasonable deadlines also can avoid unnecessarily high costs. Finally, comprehensive coordination of land use, industrial, and environmental planning such as that practiced in Japan may mitigate the costs of pollution control by siting sources in areas that allow the greatest flexibility in discharge control or minimize population exposure to pollution.

The balance of this chapter discusses some general policy strategies for better reconciling environmental regulation with economic efficiency and, in turn, productivity. While many specific proposals can be made with regard to all or individual environmental programs, three general strategies emerge:

- Change the standards of environmental quality to reflect costs and benefits;
- Change the attainment strategies used to meet these standards; and
- Subsidize the costs of compliance.

CHANGE THE STANDARDS TO REFLECT COSTS AND BENEFITS

Many proponents of economic evaluation of environmental regulations point to the use of cost-benefit analysis as a means of improving regulation. As discussed in Chapter II, environmental regulation can contribute to economic efficiency only if it correctly specifies the societal, or external, costs of pollution and the benefits of reducing it. If economic decisionmakers in a competitive economy are confronted with these societal costs, they will likely respond by adjusting the production and consumption of polluting goods and services until the costs of ameliorating pollution are balanced by the benefits realized through improved environmental quality. Viewed from another perspective, standards must correctly balance the costs of pollution control with the benefits of protecting health and welfare. This view casts environmental standards in economic terms; it bases standards on a correct weighting of costs and benefits by attempting to express the effects of pollution on human health and welfare in monetary terms. This framework for standard setting is not universally shared. But to debate its merits, it is first necessary to understand the current approach for setting standards.

The Congress has based most environmental laws on the principle that to protect public health, government must act to control potentially harmful pollutants despite scientific uncertainty about the precise harm they cause at any level of exposure. The Clean Air Act is the most explicit in this regard; it requires the Environmental Protection Agency (EPA) to set national primary air quality standards at levels that protect "public health, allowing an adequate margin of safety." This statutory basis for setting environmental quality standards does not take economic factors into account. Instead, the Congress has determined that costs are most appropriately considered when designing the best control strategy for achieving these standards in a particular area. Thus, the EPA and the states attempt to take local conditions into account when they negotiate the details of attainment programs by considering the severity of pollution in a given area and the type of industrial base it contains. 2/ But such local concerns are never explicitly considered when setting standards for environmental quality. Thus, some regions, and the nation as a whole, might experience particularly high costs in meeting an ambient standard.

Most analysts recognize that while the practice is not codified, "economic and other practical considerations are surely taken into account

2. Exceptions to this rule exist. For example, federal standards for emissions from new sources and for all hazardous air pollutants do not take variations in local conditions into account. Thus, consideration of costs when setting discharge standards is usually applied to older sources, which are not covered by uniform federal standards. These sources typically are responsible for the most pollution in a given area and are the most expensive to clean up.

in setting standards, even if no one is willing to admit it." 3/ In setting standards for environmental quality, the EPA scrutinizes carefully its regulatory analyses, which report the national and sometimes regional costs of meeting standards. As a practical matter, the EPA has strong incentive not to establish a standard that would cause widespread plant closings or economic disruption. Yet this practice does not mean that all standards reflect economic calculation. For example, when the EPA proposed a new ambient carbon monoxide standard in 1980, it defined the relevant exposed population as people with angina pectoris. Some critics argued that a more sensitive population--hemolytic anemics--would not be protected at the proposed standard level. Despite the EPA's limited definition, the costs were substantial. The President's Regulatory Analysis and Review Group, comparing the carbon monoxide standard the EPA was proposing with a less strict alternative, showed that each sick day prevented by the stricter standard would cost the nation between $6,000 and $250,000. 4/ A comparable study for ozone identified the cost of reducing each manhour of exposure as between $2,000 and $4,000. 5/

Some movement toward incorporating economic calculations when setting standards has already occurred. The EPA itself has attempted to make such decisions more explicit in the standard-setting process. Its Carcinogen Policy, drafted in the early 1970s but never enacted, would have allowed the consideration of risk and mortality in determining the priority for setting standards for hazardous air pollutants (typically carcinogens). The courts, however, held that the law did not provide the EPA this discretion.

Although the Carcinogen Policy was abandoned, the EPA continues to take cost and regional economic considerations into account in a variety of ways. A recent example involves a proposed 1983 standard covering arsenic emissions from copper smelters. The standards would have required controls on a number of industrial plants, and the EPA explicitly sought public comment from the exposed local population on how it should deal with cancer risks. Specifically, the residents of Tacoma, Montana, were asked whether a small estimated increase in lung cancer in the area was acceptable to avoid closing a plant situated there, a possible outcome if the

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3. Robert W. Crandall and Paul R. Portney, "Environmental Policy," in Paul R. Portney, ed., *Natural Resources and the Environment* (Washington, D.C.: Urban Institute, 1984), p. 53.

4. Council on Wage and Price Stability, "Environmental Protection Agency National Ambient Air Quality Standards for Carbon Monoxide," Report of the Regulatory Analysis Review Group (November 25, 1980), p. 26.

5. Crandall and Portney, "Environmental Policy," p. 54.

EPA was to impose further controls. The issue later became moot, however, when the plant's owners announced plans to close the plant.

The use of economic analyses in assigning standards is based on the premise that sufficient data exist to evaluate the potential costs and benefits of alternative standards. But such data often do not exist, and the risk of misspecifying benefits may be high. Indeed, a great deal of uncertainty exists in quantifying even such straightforward effects as crop damage from pollution; the difficulty in assessing the costs of mortality is even greater. In its report to the Congress in 1981, the National Commission on Air Quality described a number of deficiencies in the use of cost-benefit analysis, including the lack of complete information and the difficulty in calculating the costs of morbidity and mortality. 6/ The report showed that similar analyses provided benefit estimates that differed by an order of magnitude or more, with wide variations reported in estimating the value of life and health. 7/

Moreover, by applying a cost-benefit framework to standard setting, some rate of mortality caused by pollution would have to be accepted. To opponents of this approach, this is tantamount to arbitrarily depriving those who will die or become ill from pollution exposure of their political rights to life and liberty, and is therefore unacceptable. All sides to the cost-benefit debate, however, generally recognize that standard setting does not take place in a vacuum, and that a great deal of economic judgment is employed implicitly, if not explicitly.

If the Congress seeks to incorporate economic calculation into standard setting, it would have to amend current law. A sweeping approach could consist of amending the goals of the Clean Air Act and Clean Water Act to specify the incorporation of cost-benefit analysis when establishing standards of environmental quality. A more limited approach could consist of allowing the administrator of the EPA to disallow regulations that he or she finds in "gross" violation of economic calculation, perhaps according to some specified criterion or subject to a Congressional prerogative to reinstitute the regulation.

Both options would allow regulations to reflect the costs and benefits of pollution control, as they are understood at the time of promulgation.

6. National Commission on Air Quality, *To Breathe Clean Air* (1981).

7. One of the major problems is how to value life and health in monetary terms. Some techniques value health by the economic losses resulting from employee absence and health care costs. Other approaches attempt to measure health and mortality costs by willingness to pay; that is, by asking how much a person is willing to pay to avoid sickness and pollution-related death. Still other approaches value health and life as the difference between an individual's lifetime income and consumption. Clearly, each technique provides markedly different benefit estimates.

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Standards based on such calculations might be more conducive to measured economic efficiency. Aside from economywide benefits, such standards may better avert potential economic disruption in industries that are markedly affected by individual standards. But a cost-benefit approach could expose the standard-setting process to greater legal scrutiny. Opponents of individual standards could delay their imposition by examining calculations that necessarily would be based on imperfect knowledge, as any standard is, to varying extent. Moreover, the issue would remain as to whether standards should reflect the societal and ethical considerations that are often held to override the calculus of costs and benefits.

Finally, while evidence exists that U.S. environmental standards are sometimes more stringent than economic calculation may suggest, such standards are generally less stringent than those promulgated by the Japanese. Yet the observed effects of environmental regulation on Japanese productivity and output appear more benign than comparable effects in the United States. Thus, the actual standards set by the regulatory process may be less important in determining economic effects of regulation than is the manner in which the regulations are carried out.

CHANGE THE ATTAINMENT STRATEGIES

A second approach to changing regulatory practice is to change the attainment strategies allowed by regulations. Proposals to do so can be grouped according to the kind of latitude they provide polluters in achieving compliance. Attainment strategies can be changed to:

- Allow emissions trading either among or within plants,
- Tax emissions rather than specify effluent or discharge standards, and
- Specify standards that are performance-based rather than engineering-based.

Emissions Trading

One approach for improving the efficiency of environmental regulations would allow sources to trade the emissions they are allowed. The principle behind emissions trading is this: A group of dischargers is faced with meeting a common regulatory standard, but some sources in the group can reduce pollution at less cost than others. The group then devises a scheme for dischargers with high control costs to purchase additional reductions from the dischargers with low control costs, providing protection equal to the original standards but at less expense.

Such schemes have already received limited application in the United States, in some cases at the encouragement of regulatory agencies. The most common use of trading in the United States has been under the "offset policy" of the Clean Air Act, which was initially designed under the Ford Administration to allow industrial growth in areas that did not meet existing standards. New plants in such a region could be licensed if they offset all of their required emissions reductions, or more, by paying for reductions in emissions from existing plants, in effect allowing new development in "nonattainment" regions without allowing further pollution loadings. To be sure, most offsets occurred within companies rather than between them, although many examples of the latter exist. But in the absence of an offset policy, new economic activity in nonattainment areas would be severely restricted, if not impossible.

The offset policy has also given rise to such policies as emissions "bubbling" and the "marketable permit system." Bubbling refers to emissions trading within one plant. Current regulatory practice defines each individual facility within a plant as a separate source of air pollution. Thus, when a new plant is built, each facility within the plant must meet a separate set of new source performance (pollution discharge) standards. A bubble policy allows the managers of a plant to trade emissions among the facilities within the plant, as if a bubble had been drawn over the entire plant and the total emissions leaving the bubble were the sole concern. This practice allows a group of facilities emitting pollutants at several points to control their emissions in proportion to their costs and could permit the plant to use a more cost-effective mix of measures to reduce emissions. To date, the EPA has permitted bubbling within and between plants under certain conditions and on a case-by-case basis.

A marketable permit system extends the emissions trading policies to all the firms in an area. The system allows firms to sell any emissions reductions that occur over levels determined by standards and to buy such a new reduction and credit it toward their own standards. Thus individual firms are given the incentive to search out opportunities in other firms to reduce emissions most economically. Similar schemes have been tried by a few states (most notably, California) under the offset policy described earlier. In these programs, emissions offsets are "banked" in a central clearinghouse (run by the state) and are available for sale to other firms.

Greater use could be made of all types of emissions trading. The Carter Administration extended emissions trading to single plants and groups of plants, but stopped short of permitting trading between old and new sources. The Reagan Administration has also attempted to expand emissions trading. Under existing trading policies, over 90 bubble applications had been put forward by early 1982 under the Clean Air Act, and 18 bubbles had been approved by the states and the EPA, with estimated savings of $50 million. 8/

Emissions trading policies--be they offsets, bubbles, or marketable permits--offer the advantage of reducing the costs of achieving any level of environmental ambience. They do so by providing each pollution source with a broader set of compliance alternatives, thereby increasing the opportunities to lower the costs of pollution control. Offsets and marketable permits expand the universe of possible pollution control activities, since they allow new sources, which are now regulated, to satisfy regulators by reducing emissions at old sources, which are subject only to (generally less stringent) state regulation. Bubbles provide the same benefit, only on a more limited scale. Marketable permits also have the advantage of setting an absolute limitation on total emissions in an area by issuing a fixed number of permits to polluters. While polluters would then be able to buy and sell "the right to pollute," total allowable emissions would remain unchanged.

The use of emissions trading policies, however, poses disadvantages as well. One disadvantage concerns the greater regulatory resources required to implement these policies. First, both marketable permit systems and offset systems can bring currently unregulated sources (from the federal perspective) into the regulated sphere. Thus, they can increase the amount of monitoring necessary to ensure compliance. Second, all emissions trading systems produce highly individualized results, and therefore require greater effort by the regulatory agency. For example, before a new source bubble permit could be approved, the total emissions for both the old and new facilities within the plant must be calculated. Presumably, this emissions "baseline" could be derived from current regulations. But determining baseline emissions may be difficult because of the nature of some new source performance standards, which require a percentage reduction of pollution emissions rather than a simple volume limit. Moreover, a new facility's or plant's emissions often depend on the process chosen and the level of control required of those processes. Thus, defining baselines for any emissions program will require considerable agency resources for negotiation and review.

Emissions trading systems also pose technical problems. Offset or marketable permit systems would probably be applied within any one of the

8. Claudia Copeland, *Bubble Concept of Pollution Control*, Congressional Research Service Issue Brief Number IB82007 (April 6, 1982).

"air quality control regions" defined by the EPA. The country is divided into several hundred regions, typically the size of several counties. Although any of these trading systems could provide the same level of pollution control within the region, they could also produce local "hot spots," particularly if a major source is allowed to meet its performance standard by securing offsets or purchasing permits elsewhere in the region. The effects of such hot spots would have to be identified and incorporated into emissions trading approvals in order to provide protection equivalent to the current standard for the entire population.

A more long-term problem concerns the retirement of the sources involved in trades. In all emissions trading systems, compliance on the part of an individual plant (or facility within a plant) depends on activities that occur elsewhere; under the current system, all compliance activities take place at the plant or facility in question. This difference is important because a new facility or plant will no longer be in compliance once the older source, with which it bubbles or secures offsets, retires. This would require the redesign of any emissions trade. A facility that has achieved compliance through trading with such a source would have to find a new one, or resort to the use of the "best available control technology" found in the original new source performance standards governing it. This process would require administrative resources and would compromise the savings created by emissions trading.

Previous CBO studies have examined the potential savings resulting from emissions trading. A study of the bubble policy examined two hypothetical cases from the electric utility industry and the rubber tire industry. 9/ In the electric utility example, modeled after the power station in Homer City, Pennsylvania, the application of a bubble among its five generating units would reduce projected annual operating expenses from $429 million to $416 million. In the rubber tire example, using a bubble to control hydrocarbon vapor emissions at a multifacility tire manufacturing plant would lead to a 60 percent reduction in estimated annual costs of emissions reduction, from $662,000 to $242,000.

Another CBO study examined the possible application of an offset policy to electric utilities on a state-by-state basis. 10/ This study compared the current new source performance standards for coal-fired electric utilities with an emissions trading policy that enforced the same level of pollution control but allowed new coal-fired units to secure offsets from

9. See Congressional Budget Office, *The Bubble Policy* (September 1982).

10. See Congressional Budget Office, *The Clean Air Act, the Electric Utilities, and the Coal Market* (April 1982).

older units for sulfur dioxide emissions within their state boundaries. The study found that the offset policy would lower total annual industry operating costs for pollution control from an estimated $14.1 billion to $10.8 billion by the year 2000 (all figures in 1980 dollars). Total electric utility capital outlays for pollution control between the years 1980 and 2000 would be lowered from $33.4 billion to $14.7 billion. Another way of expressing these projected savings is to compare the current new source performance standard and its offset equivalent with the less stringent standard that was found in the original 1971 Clean Air Act. When compared with this standard, the current new source performance standard would reduce sulfur dioxide emissions at a cost of $2,411 per ton. The statewide offset policy, in contrast, would reduce emissions at a cost of $550 per ton.

All of these savings estimates, however, must be considered upper bounds, since they do not include the possibility that old sources retire during the life of new plants, and because carrying out the offset policy on a statewide basis could produce local hot spots that would require modification of the offset agreements assumed. Nonetheless, the study demonstrated sizable savings attributable to an offset policy.

Emissions Taxes

A second approach to increasing the latitude offered polluters when complying with environmental regulations is to tax emissions rather than to specify effluent or discharge standards for individual sources. Many authors have recommended such an approach; a recent legislative proposal to tax sulfur dioxide emissions can be found in S. 2001, proposed by Senator Durenburger. Emissions taxes are employed in Japan for air pollutants and in the Ruhr Valley in West Germany for water pollutants to reduce emissions beyond the levels suggested by discharge standards and to raise revenue for environmental programs.

The major advantage associated with emissions taxes is that they can be completely neutral with respect to pollution control activities; they favor or disfavor no specific control strategy. By doing so, they theoretically lead the polluter to use every pollution control technique available whose costs (per unit of pollution abated) are lower than the tax. In this sense, they are equivalent to a discharge limitation for each polluting source in that any emissions tax will lead to some level of pollution. If this resulting level can be anticipated correctly, emissions taxes can achieve environmental ambience at the lowest total cost to polluters and regulators.

The practical disadvantages of effluent taxes concern the amount of information they require regulators to have. They require explicit knowledge of each polluter's production process, as well as how output is likely to change as a result of the emissions tax. Moreover, in order to calculate the taxes owed by each polluter, some reliable mechanism for monitoring pollution levels from every pollution source must be put in place. The current level of monitoring would be grossly inadequate by this standard, even if effluent taxes were imposed only on those "major" sources covered by discharge standards. For example, 13,304 major air polluters were reported to be in compliance with source performance standards in 1981. Of this total, only 4 percent were certified on the basis of "stack tests" that actually measured emissions. Sixty percent were certified by site inspections that checked to see if pollution control equipment had been installed or if the pollutant content of fuels was as reported to the EPA, and 36 percent were "self-certified," meaning that they had written to the EPA to attest to their own compliance. 11/ Similarly, in 1978, the General Accounting Office inspected 921 air pollution sources reported (through a variety of techniques) as being in compliance, only to find that 22 percent of them were not. 12/ Comparable results can be shown for surface water quality, and no national monitoring system exists for groundwater quality, despite the growing use of this source of fresh water. Thus, the current monitoring system would have to be dramatically improved if only to cover existing major sources. Given that the existing monitoring program was funded at $40 million in fiscal year 1983, significant additional funds would be needed to monitor an effluent tax system.

Other types of information might also be required, depending on the basis for setting the level of the effluent tax. If emissions taxes are used to reflect the external costs of pollution, then they will be useful only to the extent that these costs are known; they offer no solution to the existing problem of scientific uncertainty regarding the effects of pollution. A separate problem involves setting taxes to achieve some desired level of environmental quality, which requires regulators to know the level of effluents that will result from any given level of emissions tax. This information can be estimated, but with low reliability. In the absence of this information, either taxes would have to be continually reset in a trial-and-error procedure (which may create severe uncertainty for individual polluters, a contributor to poor productivity performance in its own right), or an unintended level of environmental quality would have to be accepted.

Finally, emissions taxes may lose some of their advantages in the absence of ideal market behavior. Some dischargers may choose to pay the tax penalty rather than control their pollution--even if the cost of

11. Crandall and Portney, "Environmental Policy."

12. General Accounting Office, *Improvements Needed in Controlling Major Air Pollution Sources* (January 2, 1979), p. 6.

controlling the pollution was lower than the tax--if their influence over the market is great enough to allow them to pass the emissions tax through to the consumer. Yet establishing a more punitive tax to account for this possibility would penalize further those sources that lacked this power.

Emissions taxes, however, need not be the sole instrument used to achieve environmental quality. The advantages and disadvantages of such taxes might suggest that they be used as a supplement to other practices--for example, in areas found out of compliance with ambient air or water quality standards, or as a source of revenue for environmental programs, as now occurs in Japan and West Germany.

Engineering Versus Performance Standards

Ideally, limitations on the discharge of pollution from individual sources should allow wide flexibility in the choice of compliance strategy, including changes in the production process that creates pollution as well as installation of "after-the-fact" control hardware. This flexibility helps reduce the cost of complying with regulations. Engineering standards, which specify one engineering or technological process, tend to exacerbate compliance costs by limiting the options available to the polluter. Performance standards, in contrast, simply specify a discharge limitation without any restrictions on the compliance method. By virtue of their neutrality with regard to compliance strategies, performance standards allow polluters to identify the least-cost set of control activities.

To be fair, there are few, if any, "pure" engineering standards, and some of those that have been adopted may be unavoidable. Certain regulations governing hazardous waste disposal, for example, specify the type of containment liner to be used at hazardous waste sites. Such regulation seeks to reduce both the risk that wastes will escape and the volume of waste that does escape. In this situation, it may be easier to carry out an engineering standard for waste linings, since it is more difficult to measure the level or risk of discharge from the closed waste site--a measurement necessary when implementing a performance standard.

As discussed in Chapter II, many performance standards are said to be technology-based, that is, the performance demanded of polluters is based on some state-of-the-art technology. The technology itself is not demanded, but the polluter must perform as well as if the state-of-the-art technology had been used. One issue regarding such technology-based performance standards is whether they can be justified on cost-benefit terms, as discussed earlier in this chapter. A second issue, however, is whether technology-based performance standards are becoming more restrictive--that is, becoming more like engineering standards.

A technology-based performance standard can be indistinguishable from an engineering standard if only one technology can possibly deliver the level of performance that regulation demands. A case in point is the recent new source performance standard for electric utilities, which requires utilities both to remove a percentage of the sulfur dioxide they emit and to meet an absolute emissions limit. This percentage-removal requirement makes it impossible for a utility to meet the standard simply by burning low-sulfur coal; it eventually forces the utility to use flue gas desulfurizers (scrubbers) as well. Many feel that this is, in effect, an engineering standard, since only one technology now appears to satisfy the percentage-removal requirement. 13/ By being so restrictive, this regulation might force utilities to pay substantially more to achieve only marginally lower emissions. Lower-cost emissions reductions might be obtained from standards written in terms of absolute discharges rather than technological equivalents.

SUBSIDIZE THE COSTS OF COMPLIANCE

A third strategy suggested for reconciling the effects of environmental regulation on economic efficiency is to subsidize the costs of compliance for U.S. firms. Subsidies can be either general or targeted.

General Subsidies

Each of the nations examined in this report provides some subsidy for expenditures made to control pollution. In all countries, capital expenditures made to abate pollution are subject to accelerated depreciation tax treatment, and investment tax credit is provided for all classes of capital expenditures. In the United States, for example, capital investments for pollution control are afforded the same five-year depreciation life that is assigned to all other equipment. Thus, while this tax feature subsidizes pollution control expenditures, it does not do so relative to other types of investments.

This was not always the case in U.S. tax law. During the 1970s, pollution control capital was allowed to depreciate more rapidly for tax

13. An alternative to scrubbers--fluidized bed combustion--may become economical in the near future. The cost of using fluidized bed combustion to meet the standard will help determine how restrictive existing utility new source performance standards are.

purposes than were other types of investments. Only end-of-pipe equipment qualified for this treatment, however; capital expenditures that changed the design of production processes so that less pollution resulted were not given this special status. Thus, the tax code discouraged process change during this period. The Economic Recovery Tax Act, however, eliminated this distinction in 1981, and created tax neutrality among the various types of pollution control capital.

Subsidized loans are also available for pollution control equipment in the United States, Japan, and in some regions in West Germany. In the United States, such subsidization takes place through the vehicle of pollution control bonds, which are a variant of industrial revenue bonds, or IRBs. IRBs are bonds that state and local governments may issue to provide financing for private firms, which back the bonds solely with their own good faith and credit. State and local governments commonly use these bonds to promote economic development within their boundaries. Interest income on the bonds is exempt from federal taxation, allowing private businesses to borrow at below-market interest rates, with the cost of the subsidy largely borne by the federal government. 14/ As shown in Table 20, the volume of financing for pollution control bonds amounted to $4.5 billion in 1983. The tax exemption for pollution control bonds, however, together with several other IRB provisions, is due to expire in 1986.

All of the nations examined also provide subsidies for the construction of sewage treatment plants. In the United States, the Federal Water Pollution Control Act provides subsidies of up to 55 percent of construction costs for municipalities that build sewage treatment facilities as of 1985. 15/ Other nations provide subsidies for sewage facilities, but these are more often low-interest loans, which carry a smaller subsidy value. These subsidies exist, in part, because national water quality legislation in both the United States and other nations puts a substantial burden on local governments that must control their discharges from local sewer systems. Given the widespread nature of this problem, U.S. subsidies for this purpose have been substantial. Table 21 presents anticipated federal expenditures on wastewater treatment facilities in the United States.

General subsidies raise two issues; the merits of these specific programs, and the merits of subsidizing investments in pollution control as a

14. For a detailed discussion of industrial revenue bonds, see Congressional Budget Office, *The Federal Role in State Industrial Development Programs* (July 1984), and *Small Issue Industrial Development Bonds* (September 1981).

15. Between 1972 and 1984, the share had been 75 percent. Amendments in 1981 allowed a share of 85 percent for innovative technologies.

strategy for improving the competitiveness of U.S. industries that undertake these investments. In general, the subsidization of environmental investments moves the economy further away from the notion that "the polluter pays," which in turn is linked to the idea that the full external costs of pollution should be reflected in the prices of goods that result in pollution. Subsidies, therefore, compromise this principle by forcing society, through the tax system or public expenditures, to bear these costs instead. Moreover, subsidizing the cost of pollution control expenditures does not lower the total societal cost of realizing environmental goals. Instead, it rearranges these costs, reducing the burdens that individual firms bear but increasing budget deficits by forgoing tax revenues or increasing budgetary expenditures. If higher deficits lead to higher interest rates and, in turn, higher exchange rates, then the exports of U.S. goods and services would still be penalized.

Federal cost-sharing of municipal wastewater treatment facilities began in earnest after the passage of the Federal Water Pollution Control Act of 1972. Grants to defray capital costs are made available to the states using a formula based on population and the EPA's assessments of needs.

TABLE 20. FINANCING FOR POLLUTION CONTROL BONDS IN THE UNITED STATES, 1975-1985
(In billions of dollars)

Year	Volume of Financing
1975	2.1
1976	2.1
1977	3.0
1978	2.8
1979	2.5
1980	2.5
1981	4.3
1982	5.9
1983	4.5
1984 Estimated	5.0
1985 Estimated	5.5

SOURCES: Congressional Budget Office and Department of the Treasury.

Since every municipality is required to build such facilities, the total cost (to all levels of government) of doing so is very large--estimated at $118 billion (in 1982 dollars) by the year 2000.

The federal subsidy for these treatment plants can be justified on the basis of the immense costs imposed on state and local governments by federal requirements for water pollution control. On the other hand, the federal subsidy for these plants magnifies the inefficiencies found in strategies for controlling water pollution. Improvements in water quality resulting from wastewater treatment are often negated by runoff from fertilizers and pesticides--so much so that treated wastewater can often be cleaner than the stream it empties into. Intense farming, natural erosion, or urban runoff can so dominate water quality in some areas that the treatment required of municipal wastewater has little or no measurable effect on the water quality of the receiving body. In some regions, acid drainage from coal mines has left many rivers incapable of supporting life;

TABLE 21. ESTIMATED FEDERAL AND NONFEDERAL CAPITAL OUTLAYS FOR WASTEWATER FACILITIES UNDER CURRENT U.S. POLICY (By fiscal year, in billions of dollars)

Funding Source	1983[a]	1984[a]	1985	1986	1987	1988	1989	1990	Annual Average
Environmental Protection Agency[b]	3.0	2.6	2.7	2.6	2.4	2.4	2.4	2.5	2.6
Other Federal[c]	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Nonfederal	2.0	1.7	1.8	1.7	1.6	2.0	2.1	2.1	1.9
Total	5.5	4.4	4.8	4.6	4.3	4.7	4.9	4.9	4.8

SOURCE: Congressional Budget Office.

a. Actual outlays.

b. Assumes 1985 level of EPA appropriations authorization ($2.6 billion) for 1986 through 1990.

c. Includes outlays for FmHA and HUD grant loan programs at a constant 1984 level.

federal subsidies of wastewater treatment do little to correct this type of problem. Finally, wastewater discharges into coastal waters can often be diluted by ocean currents. A recent study by the General Accounting Office noted that up to $10 billion could be saved by granting waivers of the existing standard for wastewater discharges to 800 coastal communities. 16/

A recent CBO report identified several alternatives to the existing program. 17/ Wastewater treatment subsidies could be given to the states in a block grant, giving the states more leverage and discretion in allocating their allotted funds. Localities could be encouraged to make greater use of user fees or innovative financing arrangements (including bond banks, leasing arrangements, and other mechanisms) to finance their plants. In fact, evidence exists that plants built without federal assistance generally cost less than those built with federal cost-sharing. 18/ Thus, while municipal wastewater treatment grants can be justified in terms of the burden that regulation of water pollution places on local governments, alternative financing mechanisms, and in some cases alternative regulatory compliance strategies, might be able to substitute for this type of assistance.

Targeted Subsidies

Despite the absence of evidence that environmental regulation has handicapped U.S. industries in the aggregate, regulation has probably had severe effects on some individual industries. Most analysts concur that few facilities have been closed because of regulatory requirements, and that many that have been closed were in danger of failure before the imposition of regulation. 19/ On the other hand, some specific industries have been forced to assume very large environmental costs; nonferrous metal smelting is a notable example. In 1970, U.S. zinc smelter capacity was 1.38 million tons. By 1978, this figure had dropped to 850,000 tons, and in 1983 fell to half that level. While zinc prices have fallen in real terms over this period,

16. See General Accounting Office, *Billions Could Be Saved Through Waivers for Coastal Wastewater Treatment Plants* (May 22, 1981).

17. See Congressional Budget Office, *Public Works Infrastructure: Policy Considerations for the 1980s* (April 1983).

18. A forthcoming Congressional Budget Office report discusses future financing alternatives for wastewater treatment investments.

19. National Commission on Air Quality, *To Breathe Clean Air* (1981).

many of these closings might be attributable to environmental standards. 20/ Similar, but smaller, adjustments have occurred in the lead and copper industries.

Facility closures in such industries pose important adjustment costs, especially in industries that are the primary if not sole source of economic activity in their communities. Thus, the advantages of subsidizing the costs of environmental compliance are those of avoiding these adjustment costs. The disadvantages concern the subsidization of uneconomic activity, in that facilities that close because of their inability to accommodate environmental expenditures are as economically unviable as facilities that cannot meet any other type of cost. Moreover, subsidies of expenditures mandated by regulation magnify the distortions of the regulations themselves. If, for example, air quality regulations are considered to be biased in favor of end-of-pipe solutions (as opposed to process design change), then subsidization of regulatory compliance can only encourage that bias. If the societal costs of facility closings are considered excessive, then a variety of other options are available to address these concerns, including capital grants to the industry, or programs to retrain the local labor force or encourage the development of other enterprises.

Pollution control expenditures may lead to facility closings when the price of the good in question is determined in international markets, and when foreign producers, whose costs determine world prices, do not confront comparable expenditures. For example, the U.S. copper-smelting industry is estimated to have incurred $0.9 billion in capital expenditures for pollution control between 1973 and 1977, another $1.2 billion (in 1978 dollars) between 1978 and 1988, and operational and maintenance costs of roughly equal size. Once the compliance deadline of 1988 is reached, the total impact of these expenditures will be between 10 cents and 18 cents per pound of copper, depending on the amount of sulfur dioxide removed. 21/ In contrast, total labor costs for copper mining and milling are said to be roughly 11 cents per pound, which is still high by world standards.

One option when confronted with such a situation is to impose on imports of the good in question a tariff equal to the level of costs that foreign exporters do not bear because of the absence of environmental regulation in their home countries. Supporters consider such a tariff to be

20. See Congressional Budget Office, *Strategic and Critical Nonfuel Minerals: Problems and Policy Alternatives* (August 1983).

21. Louis J. Sousa, *The U.S. Copper Industry: Problems, Issues, and Outlook*, U.S. Bureau of Mines (October 1981), p. 49.

the equivalent of a countervailing duty against imports that are sold below price, or "dumped," a procedure sanctioned by the General Agreement on Tariffs and Trade. If the cost of environmental compliance is viewed as an unavoidable component of the costs of producing a good, then nations that do not impose environmental restrictions on their producers are, in effect, subsidizing them by allowing some amount of environmental degradation as a result of their production. In this view, the absence of environmental regulation is like the subsidization of any other cost of production. Alternatively, the need for environmental protection is not uniform worldwide, since ambient conditions or levels of population exposure might differ from nation to nation. Moreover, other nations might assign a lower value to the cost of pollution control when confronted with choices between environmental quality and economic development. This issue is particularly important as the world's poorer nations seek economic growth. These nations face difficult trade-offs and might be more willing to sacrifice environmental amenities to secure development. In effect, these nations could be seen as exporting their environmental quality to the United States. Prohibiting them from doing so would lead to the traditional costs of trade restrictions--higher prices for restricted goods in the U.S. market, and reduced output and employment in those industries that use the good as an input into production. It would also lead to the traditional benefits--higher output and employment in the domestic industry receiving protection.

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APPENDIX

THE EMPIRICAL MODEL AND STATISTICAL RESULTS

A small-systems model is used by the Congressional Budget Office in its analysis of the effects of environmental regulation on economic growth and productivity in the United States, Japan, Canada, and West Germany. An econometric model is developed for each country, consisting of five equations: a cost function, a marginal cost function (supply function), derived demand functions for capital and labor, and an aggregate demand function for private domestic goods and services (see Table A-1). Costs, prices, capital and labor inputs, and aggregate demand are assumed to be random variables, the expected values of which are conditional upon the arguments specified in equations (1) through (5). A quadratic cost function is employed to represent the underlying technology for each country. The system appears as:

Cost Function

(1) $$\begin{aligned} C = {} & A + AK \cdot PK + AL \cdot PL + AQ \cdot Q + AE \cdot PE + AT \cdot T + DE \cdot D \cdot Q \\ & + 1/2\,(BKK \cdot PK^2 + BLL \cdot PL^2 + BQQ \cdot Q^2 + BEE \cdot PE^2 \\ & + BTT \cdot T^2) + BLK \cdot PK \cdot PL + BQK \cdot PK \cdot Q + BEK \cdot PK \cdot PE \\ & + BTK \cdot PK \cdot T + BQL \cdot PL \cdot Q + BEL \cdot PL \cdot PE + BTL \cdot PL \cdot T \\ & + BQE \cdot Q \cdot PE + BQT \cdot Q \cdot T + BET \cdot PE \cdot T + \mu_C \end{aligned}$$

Marginal Cost (Supply) Function

(2) $$\begin{aligned} P = {} & AQ + BQQ \cdot Q + BQK \cdot PK + BQL \cdot PL + BQE \cdot PE + BQT \cdot T \\ & + DE \cdot D + \mu_S \end{aligned}$$

Derived Demand Function, Capital

(3) $$\begin{aligned} K = {} & AK + BQK \cdot Q + BKK \cdot PK + BLK \cdot PL + BEK \cdot PE + BTK \cdot T \\ & + \mu_K \end{aligned}$$

Derived Demand Function, Labor

(4) $$L = AL + BQL \cdot Q + BLK \cdot PK + BLL \cdot PL + BEL \cdot PE = BTL \cdot T + \mu_L$$

Aggregate Demand Function

(5) $$Q = AD + BD \cdot P + CD \cdot GP + ED \cdot PI + \mu_D$$

TABLE A-1. ECONOMETRIC MODEL ESTIMATES: UNITED STATES, JAPAN, CANADA, AND WEST GERMANY

Coefficient	United States		Japan		Canada		West Germany	
Symbol	Value	T-Stat	Value	T-Stat	Value	T-Stat	Value	T-Stat
A	-49.8143	-.00	-4289.1100	-.00	-16637.3000	-.25	77.7531	.00
AK	-18754.3000	-3.61	1358.0200	5.63	-277.5000	-1.71	-16190.8000	-4.28
AL	17502.3000	5.42	1358.0200	6.22	931.7300	6.06	12365.7000	5.91
AQ	63.3491	4.07	77.2065	3.33	38.2561	1.67	11.9346	.26
AE	-21.0007	-.02	464.1060	.34	-116.1530	-.87	-492.8560	-.00
AT	-25.1098	-.00	4.8131	.01	16.8867	.25	9.8969	.01
DE	--	--	-.0098	-5.50	.0670	3.83	-.0116	-.43
BQQ	.0009	5.21	.0024	1.11	.0014	.34	.0005	.50
BEE	.0852	1.10	-2.1565	-2.30	-.3265	-1.47	-1086.6900	-.00
BTT	.0256	.01	-.0027	-.01	-.0086	-.25	-.0100	-.02
BQE	.0003	.88	.0024	1.14	.0082	1.23	.6100	.40
BQT	-.0325	-.01	-.0392	-3.31	-.0194	-1.64	-.0058	-.25
BQK	.1267	4.38	.5003	14.24	.2652	12.96	.1400	1.60
BQL	.6088	16.41	.3746	19.96	.3923	15.53	.2300	5.58
BET	.0084	.02	-.2271	-.32	.0594	.87	.4700	.00
BEK	-.2050	-.69	.0155	.23	.4147	2.12	-1189.1600	-6.99
BEL	-.0639	-.70	-.1344	-2.27	-.1307	-1.24	-36.4045	-.36
BLK	32.3030	4.40	7.1080	15.87	2.0509	5.70	-2.3100	-.45
BTK	9.6658	3.65	-1.2013	-6.21	.1140	1.74	8.2900	4.27
BTL	-8.8856	-5.36	-.6824	-5.54	-.4721	-5.99	-6.2400	-5.82
BKK	-32.3030	4.40	-7.1080	-15.87	-2.0509	-5.70	2.3100	.45
BLL	-32.3030	4.40	-7.1080	-15.87	-2.0509	-5.70	2.3100	.45
AD	2140.4500	3.64	30.2077	5.60	64.5930	4.18	857.6200	8.00
BD	-8297.0800	-9.79	-6.7670	.65	-48.2119	-2.26	-877.5000	-5.58
CD	966.2800	10.77	.0578	6.61	.0170	4.87	90.3482	8.16
ED	4241.5400	2.33	-1097.2600	-.85	-15.8200	-1.23	-958.4390	-6.85

R^2 - Measures

	United States	Japan	Canada	West Germany
Cost	.99	.92	.99	.99
Supply	.99	.97	.98	.90
Capital	.94	.95	.98	.99
Labor	.99	.94	.98	.99
Demand	.67	.95	.97	.97

SOURCE: Congressional Budget Office.

NOTE: Coefficients are defined in Appendix equations (1) through (5).

There are 11 variables in each systems model, defined as:

C . . . . . . Costs of production, private domestic sector (deflated)

PK . . . . . . Price of capital service flows (deflated)

PL . . . . . . Price of labor services (deflated)

Q . . . . . . Output quantity, private domestic sector

PE . . . . . . Expenditures for pollution control, private domestic sector (deflated)

T . . . . . . Trend

D . . . . . . Dummy variable (1960 to 1972, D = 0; 1973 to 1979, D = price of energy, deflated)

P . . . . . . Output prices, private domestic sector (deflated)

GP . . . . . . Gross national income per capita

PI . . . . . . Exchange rate relative to United States; for the United States, the weighted exchange rate for other countries.

μ_i . . . . . . Error terms where i = C, S, K, L, D.

Each model contains 26 coefficients, which are assumed to be fixed during the estimation period (1968-1982):

A, AK, AL, AQ, AE, AT, DE, BKK, BLL, BQQ, BEE, BTT, BLK, BQK, BEK, BTK, BQL, BEL, BTL, BQE, BQT, BET, AD, BD, CD, ED.

It is assumed that PK, PL, PE, T, D, GP, and PI are exogenous variables [1]; C, K, P, L, and Q are assumed to be endogenous. The coefficients for each country's equations are estimated simultaneously for the years 1960-1979 using an iterative three stage least squares (I3SLS) estimator that is asymptotically unbiased, given the assumptions. Once the

1. PE is assumed to be a proxy variable for environmental regulations and as such is assumed to be exogenous. Arguments can be advanced, however, to suggest that PE is endogenous, a matter of choice to the producer. If PE is truly endogenous, the I3SLS estimator will be inconsistent. Similar arguments could be made for PK, PL, and GP. In this event, the model advanced in (1) through (5) becomes underidentified. The parameters on such a model cannot be estimated without additional information. Given the small sample, level of aggregation, and the international multidimensional focus of this study, this assumption of exogeneity for such variables must be construed as a limitation, and the econometric results as conditional upon this limitation.

coefficients have been estimated, their standard errors can be examined for statistical inference.

STATISTICAL RESULTS

The statistical results of the econometric investigation of the Christensen-Cummings-Jorgenson data base lead to the following general comments on model fit, statistical significance of coefficient estimates, and appropriateness of signs. 2/ These coefficient estimates are used to construct elasticity estimates and productivity series for each country.

Model Fit

The cost, supply, capital, labor, and aggregate demand functions estimated as a system reveal that the models fit the data quite well. This is surprising for a systems estimation, where it is not unusual to find negative R^2 measures reported. With the exception of the aggregate demand function in the United States, R^2 measures range from .90 to .99, a particularly encouraging result for simultaneous equation systems. Individual equations manifest serial correlation in each country, however, an indication that I3SLS may be inefficient yet still asymptotically unbiased. When attempts to correct for serial correlation of the first order were made by using a generalized least squares system estimation, the models did not converge. This leads one to speculate that while a more efficient (smaller mean squared error) estimator for the system might well exist, it is not readily apparent that such an estimator is computationally tractable for this system.

Statistical Significance

Approximately half (12) of the estimated coefficients are statistically significant in each model (that is, one can reject the null hypothesis that each coefficient is equal to zero) at a 5 percent level (see Table A-1). The critical region for a 5 percent t-test (two-tail) is 1.96.

Because of its importance in the study, consider the coefficient BQE. The coefficient BQE--the partial derivative of output price with respect to

2. Laurits Christensen, Gregory Cummings, and Dale Jorgenson, "Economic Growth, 1947-73: An International Comparison," in National Bureau of Economic Research, *New Developments in Productivity Measurement and Analysis* (1980), pp. 610-624.

pollution control expenditures--is statistically insignificant in all countries; therefore, the null hypothesis that BQE = 0 cannot be rejected. If BQE = 0, the pollution expenditures have no effect on output price or quantity, an implausible result. Some effect, even if small, should be manifested. One might question the power of a t-test in such a model; that is, the probability of not rejecting the hypothesis BQE = 0, even when this hypothesis is false, could be very large.

The estimates of the pollution abatement coefficient appear somewhat volatile when estimation is pursued with slightly different model specifications and subsamples. This is a likely result of the aggregate nature of the model, apparent multicollinearity, and the relatively small sample of actual pollution control expenditures. This volatility underscores the uncertainty associated with such estimates.

Signs of Coefficients

Interpreting the magnitude of each of the coefficients in each of the models is difficult because all quantities and prices are measured as indexes. For that reason, percentage changes or system elasticity estimates are derived (see Table 19, Chapter V). The magnitude and direction of the percentage changes in output and input quantities, output prices, and gross domestic product are calculated by equations (6) through (10) for each country in each year, 1968 through 1982. See simulations using system elasticities on page 113.

The signs of individual estimated coefficients, however, are quite important. For example, the aggregate demand curve is downward (negatively) sloping (BD is less than or equal to 0), and the aggregate supply curve is upward sloping (BQQ is greater than or equal to 0).

Anticipated versus actual signs of estimated parameters are reviewed in Table A-2. For the most part, the signs of the estimated coefficients appear as anticipated. Those that do not comply with expected signs are indicated with an asterisk (*). Note that the effect of pollution expenditures on output price captured by BQE is positive for all countries. Output prices indeed appear to rise with pollution expenditures as output drops, although not in a statistically significant manner. The degree of the price rise in this system, predicated on equilibrium, however, depends on the price flexibility (elasticity) of the aggregate demand function as well as the magnitude of BQE.

Although the null hypothesis that BQE = 0 cannot be rejected at a reasonable confidence level, the estimates for BQE are greater than zero for all countries, as theory would lead one to believe. That is, increases in abatement expenditures, holding output constant, should increase average and marginal costs of production, shifting the aggregate supply curve to the left and raising the equilibrium price. With a downward-sloping demand curve, this shift in aggregate supply leads to a reduction of output at the higher price level in equilibrium. This produces an interesting dilemma.

TABLE A-2. ANTICIPATED AND ESTIMATED SIGNS OF COEFFICIENTS FOR SYSTEMS MODELS OF THE UNITED STATES, JAPAN, CANADA, AND WEST GERMANY

Anticipated Signs		Estimated Signs: United States		Japan		Canada		West Germany	
A	(I)	-		-		-		-	
AQ	(I)	+		+		+		+	
AE	(I)	-		+		-		-	
AT	(I)	-		+		+		+	
AK	(I)	-		+		-		-	
AL	(I)	+		+		+		+	
BQQ	+	+		+		+		+	
BEE	(I)	+		-		-		-	
BTT	-	+	(*)	-		-		-	
DE	-	NA		-		+	(*)	-	
BQE	+	+		+		+		+	
BQT	-	-		-		-		-	
BQK	+	+		+		+		+	
BQL	+	+		+		+		+	
BET	(I)	+		-		+		+	
BEK	+	-	(*)	+		+		-	(*)
BEL	+	-	(*)	-	(*)	-	(*)	-	(*)
BKK	-	-		-		-		+	(*)
BTK	(I)	+		-		+		+	
BTL	(I)	-		-		-		-	
AD	(I)	+		+		+		+	
BD	-	-		-		-		-	
CD	+	+		+		+		+	
ED	+	+		-	(*)	-	(*)	-	(*)

SOURCE: Congressional Budget Office.

NOTE: NA = not available.
(I) = indeterminate sign.
(*) = unanticipated sign.

Although estimates of BQE are greater than zero, as anticipated, there are exceptionally large confidence intervals associated with this crucial parameter for each country. Large confidence intervals imply that much uncertainty remains about the estimates of BQE. This is likely to be a data problem. The sample is limited in its pollution data. In addition, given apparent multicollinearity in the equation systems, the estimated t-statistics are probably biased, but it is not clear in which direction. The estimates for BQE, however, are greater than zero for all countries.

Alternative Model Formulations

Because pollution expenditures appear to be statistically insignificant determinants of output price levels in the system, and are likely to be subject to measurement errors, alternative formulations of the aggregate production function dual to the cost function (1) were estimated for the U.S. model. In this case, capital and labor are assumed to be exogenous, an assumption reflecting the classical macroeconomic view. Cobb-Douglas, quadratic, and translog production functions were estimated with and without first-order conditions, and accompanying aggregate demand function. The results were spurious. Capital and labor quantities between 1960 and 1975 are correlated at the .97 level. As a result, severe multicollinearity occurred during the estimations where input quantities appeared as regressors in the production function and first order conditions.

As one alternative to this dilemma, the capital service flow of pollution control equipment (PE*) was formulated and subtracted from the capital service flow initially labeled K. The net capital service flow (K*) was combined with L, T, and PE* to estimate a Cobb-Douglas form for the production function (see Table A-3).

There seems to be less variation in measured output effects during the mid-1970s with the Cobb-Douglas model, with peak effects occurring during 1976-1977, compared with the 1974-1975 peak in the quadratic system model. The overall output effects, however, seem to be declining in both models since 1976. These effects should be considered illustrative rather than conclusive, given the different definitions of PE* and PE, as well as the different underlying assumptions in the two approaches. The model results appear reasonable, but given the limitations of the sample and the sensitivity of the results to initial model formulation, caution must be used in interpreting the results of the simulations.

Simulations Using System Elasticities

Using parameter estimates in Table A-1 associated with each country's model, the pollution expenditures may be changed from their historical values in the model. The values of input demands for capital and labor, output produced, the marginal costs of production, output price, and domestic consumption will adjust systematically. To determine by how much decreases or increases in abatement expenditures over the period 1968-1982 would have affected output price, quantity, and input demands, system point elasticity estimates are given in equations (6) through (10).

The sign of the system point elasticities indicates the direction of the impact. The size of the elasticity indicates the potential magnitude of the change in these variables produced by hypothetical changes in pollution control expenditures. For example, a system price elasticity of .10 implies that a 10 percent increase (decrease) in pollution expenditures increases (decreases) output prices 1 percent, allowing capital, labor, and output to adjust. System elasticities allow the effects of different environmental regulations (as indicated by the proxy variable for pollution control expenditures) to change simultaneously input quantities, costs of production, and output quantities and prices. These elasticities are obtained by taking total derivatives of equations (1) through (5) and multiplying the results by equilibrium solutions for Q, P, K, L, and GDP divided by PE.

TABLE A-3. COMPARISON OF PRODUCTION FUNCTION AND SYSTEMS MODELS: ELASTICITY OF U.S. OUTPUT WITH RESPECT TO POLLUTION CONTROL EXPENDITURES

Year	Cobb-Douglas [a]	Quadratic System [b]
1968	-.001	-.002
1970	-.005	-.008
1972	-.011	-.016
1974	-.011	-.021
1975	-.013	-.022
1976	-.014	-.020
1977	-.014	-.019
1978	-.013	-.016
1979	-.011	-.015
1980	-.011	-.015
1981	-.011	-.016
1982	-.011	-.014

SOURCE: Congressional Budget Office.

a. Calculated as $\frac{PE^{*}dQ}{QdPE^{*}}$ where $Q = e^{-44.29} K^{.22} L^{.31} e^{-.0038\ PE}$

b. Calculated as $\frac{PEdQ}{QdPE}$, see equation (6)

Because the system is linear in parameters, these elasticities precisely capture what would have happened (according to the model) for many levels of pollution abatement adjustments (that is, 5, 10, or 100 percent change).

The percentage changes in output quantity with respect to pollution expenditures are:

$$(6) \quad EQPE = \frac{PEd\hat{Q}}{\hat{Q}dPE} = BQE \cdot BD(1-BD \cdot BQQ)^{-1}\ PE/\hat{Q}$$

where $\hat{Q}$ is the equilibrium solution for quantity.

The changes in equilibrium prices for output are related to pollution expenditures:

$$(7) \quad EPPE = \frac{PEd\hat{P}}{\hat{P}dPE} = BQE(1-BD \cdot BQQ)^{-1}\ PE/\hat{P}$$

where $\hat{P}$ is the equilibrium solution for price.

The percentage changes in capital quantity with respect to percentage changes in pollution expenditures becomes:

$$(8) \quad EKPE = \frac{PEd\hat{K}}{\hat{K}dPE} = BQK(BQK \cdot BD(1-BD \cdot BQQ)^{-1} + BEK)\ PE/\hat{K}$$

where $\hat{K}$ is the equilibrium solution for capital quantity.

The labor quantity elasticity with respect to pollution expenditures becomes:

$$(9) \quad ELPE = \frac{PEd\hat{L}}{\hat{L}dPE} = BQL(BQL \cdot BD(1-BD \cdot BQQ)^{-1} + BEL)\ PE/\hat{L}$$

where $\hat{L}$ is the equilibrium solution for labor quantity.

The change in the value of gross domestic product associated with pollution expenditures is written:

$$(10) \quad EDPPE = \frac{PE}{GDP}\ \frac{d(GDP)}{dPE} = \frac{EPPE}{\hat{Q}} + \frac{EQPE}{\hat{P}}$$

where EQPE and EPPE are defined in equations (6) and (7).

The estimates for the system elasticities necessarily change for different values of PE, Q, P, K, and L. The elasticities are reported for selected years (1968-1982) in Table 19, Chapter V, using parameter estimates presented in Table A-1. The elasticities illustrate potential percentage changes in output prices and quantities, real domestic product, and capital and labor input demands that would have occurred had the pollution control expenditures been decreased by 100 percent in each country and during each time period.