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Public Policy and the Environment:
A Survey of the Literature

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Abstract

This paper notes that market failure, policy failures, and population pressures are major sources of environmental degradation and that linkages between economic activities and the environment exist at the levels of macroeconomic objectives, macroeconomic policy instruments, implementation of environmental policies, and measurement of economic activity. This paper also points out that fiscal instruments can, and indeed do, play a significant role in resolving environmental problems. In addition, market-based solutions, including pollution permits, also have merit. This paper further points out that implementing environmental policies poses considerable challenges for public policymakers and concludes by suggesting areas for further research.

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1. Introduction and Summary

Environmental degradation in its many forms, including soil erosion in many parts of the world, desertification in the Sahel, the destruction of forests in Europe and of tropical rain forests in South and Central America, Africa, and South Asia, the ozone hole over Antarctica, pollution of the world's oceans, and global warming, is receiving increasing attention in the international community. In part, this interest has resulted from a growing awareness of the linkages between economic activities and the environment and the public's desire to ensure that in designing public policies due account is given to environmental issues. The work of the United Nations (UN) World Commission on Environment and Development, and its report, Our Common Future (The Brundtland Commission Report), ^{1/} have significantly contributed to this awareness. Reflecting this interest in environmental issues, national governments in developed and developing countries, international organizations, and nongovernmental organizations have all been active in developing and adopting new solutions to the problems of environmental degradation. In addition, there have been debates on environmental issues at a number of international conferences, and a major UN conference on these issues is planned to take place in Brasilia in 1992.

This paper is a survey of the literature on public policies and the environment. It examines the major issues related to the following: (1) the possible interactions between macroeconomic policies and the environment; (2) the potential of fiscal and other instruments for addressing the problems of environmental degradation; and (3) the prospects for, and challenges of, the adoption of environmental protection policies.

Market failure (mainly in the form of externalities), policy failures (such as subsidizing pollution-generating activities), and population pressures are major sources of environmental degradation. This paper points out that the linkages between economic activities and the environment exist at the levels of macroeconomic objectives, macroeconomic policy instruments, implementation of environmental policies, and measurement of economic activity. This paper notes that while no single approach is appropriate or adequate for resolving environmental problems, fiscal instruments can, and indeed do, play a significant role. In addition to fiscal solutions, market-based solutions, including pollution permits, have merit. This paper further points out that implementing environmental policies poses considerable challenges for public policymakers, and concludes by suggesting areas for further research that could enhance our understanding of the interrelationships between economic activities and the environment.

This paper is organized as follows: Section II describes the nature, extent, and sources of environmental problems; Section III covers the relationships between macroeconomic policy and the environment; Section IV examines fiscal and other policies for addressing

^{1/} See the World Commission on Environment and Development (1987).

environmental problems; Section V discusses the prospects and challenges of implementing environmental policies; Section VI makes some suggestions for further research. Finally, the Appendix describes some of the specific environmental problems faced by developing, industrial, and East European countries.

II. The Nature, Extent, and Sources of Environmental Problems

1. Nature and extent of environmental problems

In recent years, public awareness of, and concern about, environmental issues in industrialized, centrally planned, and developing countries has been increasing. Much concern has been expressed about the extent of air and water pollution, the pace of soil erosion, the rate of deforestation and desertification, and the rate of depletion of natural resources, including nonrenewable resources. While the incidence of environmental degradation is confined in some cases to local, regional, or national boundaries, in other cases the incidence of certain air and water pollution, such as acid rain, possible global warming, 1/ pollution of the seas, and threats to the ozone layer, tend to have spillover effects beyond national boundaries with important transnational and global consequences. 2/ High energy consumption,

1/ While the extent of many forms of environmental degradation can be determined, some uncertainties exist concerning the impact of the "greenhouse" gas build up on the global climate. These uncertainties concern the regional magnitude and the timing of potential warming of the global climate. For a detailed discussion of global warming, see Houghton and Woodwell (1989) and Arrhenius and Waltz (1990).

2/ Throughout this paper a distinction is made among national, transnational, and global spillovers. National spillovers refer to situations in which the external effects of production or consumption decisions are contained within the national boundaries. Transnational spillovers refer to situations in which external effects emanating from one nation are felt by a limited, usually bordering, set of other nations. Global spillovers refer to cases where the external effects emanating from one or more nations are felt by all other nations.

In the case of national spillover, property rights may or may not be well-defined. If well-defined and enforceable, internal financial and economic incentives can be designed to reduce the extent of externality. If poorly defined and/or affected by interest group politics, effective resolution of the problem may be hindered. In the case of a transnational spillover (e.g., when acid rain affects the environment in a bordering country), property rights may be well-defined but transactions costs, associated with bilateral or multilateral negotiations, may hinder the resolution of the problem. Finally, in the case of a global spillover, property rights for international common property are generally not easy to allocate--as, for example, with ocean rights and the ozone layer--and, therefore, the effective resolution of global spillover problems may be hindered as a result of high transactions costs involved in negotiating a treaty or settlement to which all countries of the world should theoretically be party.

particularly of fossil fuels (coal, oil, and natural gas), and population growth have been identified as key factors accounting for the current condition of the environment in many countries. 1/ Other important factors determining the nature and extent of environmental degradation in different countries are the type of natural resource base and the manner in which it is exploited; the level and pattern of industrialization; the nature of economic incentives; policies toward agriculture, forestry, fisheries, and mining sectors; and the assimilative and regenerative capacity of a country's environmental endowment relative to the types, forms, and levels of economic activities being undertaken. 2/

2. Sources of environmental problems

Environmental problems are a result of many factors, three of which appear most important: market failure, policy failures, and population pressures.

a. Market failure

To a large extent, excessive environmental degradation is the result of market failure, that is, the nonexistent or poorly functioning markets for environmental goods and services. In this context, environmental degradation is a particular case of consumption or production externalities reflected by divergences between private and social costs (or benefits). 3/

In a market economy, private economic agents have no incentive to "internalize" external costs (such as environmental degradation) which their activities cause. Hence, the standard approach to the design of economic policy toward the environment is to ensure that economic agents take into account the social costs (and benefits) associated with externalities that they cause in pursuing their private pecuniary ends. At the socially optimal level of a pollution-generating activity, the marginal cost of abating pollution should be equal to the marginal benefit from the reduction in pollution; but the resultant level of resource allocation does not require zero levels of pollution. Thus, from an economic perspective, an optimal degree of environmental degradation can be established, at least theoretically. This degree takes into account the carrying capacity of the ecosystem, that is, its ability to repair ecological damage and to regenerate over time. In the

1/ See World Commission on the Environment and Development (1987).

2/ See the Appendix for a detailed description of the nature and extent of environmental problems in developing, industrial, and East European countries.

3/ For a full discussion of externality, environmental degradation, and environmental policy, see Baumol and Oates (1988).

case of nonrenewable resources, it is closely related to the irreversibility of the extraction decisions undertaken. 1/

The existence of market failure, imperfect competition, and imperfect information, while important in static analysis of resource allocation in the short run, are central to the sustainability of economic growth and development in the long run. This is because economic analysis indicates that (a) the existence of monopoly results in underexploitation of nonrenewable resources; (b) the divergence between the social and private discount rates, in which the private rate is higher than the social rate, leads to overexploitation; (c) pervasive risk aversion may give rise to overexploitation or underexploitation; and (d) greater concern for future generations would imply less-than-current rates of exploitation. 2/

Even though there is currently little consensus among economists, ecologists, and environmentalists on a definition of sustainable growth, and on whether current patterns of growth and development are sustainable, the Brundtland Commission Report has promoted the concept of sustainable development, defined as development that allows the present generation to meet its needs without compromising the ability of future

1/ Many ecologists and environmentalists argue that the degree of environmental degradation, as established from an economic perspective, may not necessarily guarantee the sustainability of the carrying capacity of the ecosystem. These views, which tend to place greater emphasis on the irreversibility and dynamic cumulative adverse implications of many economic activities, emphasize that an "ecological gap" is likely to emerge. This is because the "economically optimal" level of environmental degradation may exceed the "ecologically optimal" level, thereby setting in motion a dynamic process in which the carrying capacity of an ecosystem is systematically reduced through time, generating a "doom" solution.

Given the dynamic and intertemporal nature of many externalities, the choice of an "economically optimal" level is heavily influenced by the choice of the social discount rate. In addition, given the evolutionary nature of knowledge concerning environmental and ecological processes, the "ecologically optimal" level of environmental degradation is subject to a great deal of uncertainty (in the form of an incomplete and imperfect information set). It seems, thus, that among ecologists, environmentalists, and economists, a consensus on the choice of the "optimal" level is unlikely to emerge. For a more detailed discussion on the optimal level of environmental degradation, the assimilative capacity of the environment, and sustainability, see Pearce (1976), Tisdell (1988), Daly (1987), Solow (1986), and Pezzey (1989).

2/ These conclusions abstract from the impact on the rate of exploitation of nonrenewable resources of the fear of nationalization as well as adverse changes in tax regimes which may be important in some developing countries. For a discussion of the optimal rate of exploitation of nonrenewable resources, see Solow (1974) and Stiglitz (1976).

generations to meet theirs. ^{1/} Consistent with this concept is the view that a balanced relationship must be struck between economic growth and development and the environment, that is, a country's natural resource base and environment should be viewed as valuable national assets which must be utilized in a manner consistent with maintaining or improving a country's income stream (and hence net wealth) over the long term. In contrast with the view expressed by some environmentalists and ecologists who have advocated steady-state zero growth strategies, the Brundtland Commission Report, the World Bank, and others have stressed that economic growth, the alleviation of poverty, and sound environmental management can be, and in many cases are, mutually consistent objectives. ^{2/}

b. Policy failures

Government policies may aggravate the extent of environmental degradation in many ways. First, they may do so through implicit or explicit incentives to expand activities which are characterized by external costs that have not been "internalized." In the agricultural sector, for example, government subsidies for pesticides and fertilizers tend to encourage excessive applications and could aggravate an existing problem of environmental degradation, with adverse effects on water, animal life, and insect resistance. Similarly, inadequate agricultural pricing policies sometimes lead to soil erosion because they reduce agricultural profitability and, therefore, farmers' financial ability and incentives to pursue sound land management practices. In the consumption sector, price controls on petroleum products tend to encourage inefficient energy use and often exacerbate emissions of carbon gases, including carbon dioxide--one of the "greenhouse" gases. And, in the forestry sector, policies that encourage rapid exploitation may threaten the renewal of forest resources and biodiversity, increase the pace of soil erosion, and contribute to possible global warming.

Second, government policies may also encourage the overexploitation of resources and neglect marginal ones if such policies underprice the true values of resources, if uncertainty prevails about the renewability or duration of contracts for exploiting resources, or, if leases are short term. Many developing countries that are dependent on tropical agricultural and/or forestry products may be forced by their high import bills to adopt policies damaging to the environment, especially if

^{1/} In a recent survey of sustainable growth and development, Pezzey (1989) has noted 25 different definitions (15 from economists) of, or criteria for, sustainability, and pointed out that most of the criteria derive from ethical principles regarding intra- and intergenerational equity and that the criteria are mostly constraints rather than optimality conditions. He concludes that conventional environmental policies, such as those discussed in this paper later, may improve sustainability.

^{2/} See Warford (1987).

erosion-producing crops are favored at the expense of those providing tree cover or more extensive root systems on hillside lands. 1/

Finally, high levels of government expenditures, not matched by high levels of government revenues, may force reductions in the expenditures of environmental protection agencies, especially if the activities of such agencies are not accorded a high priority by the authorities.

In many developing countries, serious market distortions are created by price controls, subsidy policies, and other obstacles to the proper functioning of market forces. These hinder the achievement of not only economic objectives but of environmental objectives as well. 2/

In certain industrial countries, a few policy failures have also contributed to environmental degradation. First, in the face of conflicting environmental, trade, distributional, and regional objectives, governments have sometimes tended to subsidize the mining of coal and have levied low taxes on energy. Second, agricultural policies have worsened environmental degradation by linking agricultural subsidies to production decisions. 3/ Third, intra- and intergenerational distributional conflicts have sometimes inhibited environmental protection. Finally, uncertainty and inadequate knowledge about environmental relationships, weak and inexperienced environmental regulators, ill-defined property rights, and costly enforcement of environmental policies have contributed to environmental degradation.

In countries with centrally-planned economies, government investment policies, which rarely have been based on market signals or incorporated environmental externalities, have caused excessive levels of pollution. It is hoped that recently instituted economy-wide reforms that strengthen competitive market pressures, enforce bankruptcy, clarify property rights, and bring energy prices into line with world prices, will help alleviate environmental degradation in these countries. 4/

1/ It is by no means clear that policies that promote export of agricultural commodities rather than food staples will always accelerate soil erosion. In Haiti, for example, high export taxes on coffee (an export commodity) and artificially high prices for some food staples (maize, beans, and sorghum), maintained through import restrictions, caused farmers to grow more food. However, this aggravated soil erosion because the annual staples did not hold soil better than the perennial coffee trees. A case-by-case analysis is, therefore, necessary.

2/ See Hansen (1988b).

3/ See U.S., Economic Report of the President (1990).

4/ For a more detailed discussion of the causes of environmental problems in developing, industrial, and East European countries, see the Appendix.

c. Population pressures

The high rates of population growth in many developing countries cannot be sustained by available environmental resources, given reasonable expectations about technological progress, improvements in food security, and energy supplies. Population growth in these countries tends to aggravate the problems of both urban and rural environments, because as the demand for food increases, marginal lands are exploited for agricultural purposes, with long-term detrimental effects on future productivity. In urban areas, water and air pollution, sanitation and waste disposal, and congestion may become critical. Furthermore, because of rapid population growth, many developing countries are likely to be trapped in poverty--a condition that often does not accord priority for environmental concerns. ^{1/}

III. Macroeconomic Policy and the Environment

A review of the literature reveals that the linkages between macroeconomic policy and the environment exist at four levels. First, the pursuit of macroeconomic objectives relating to output, prices, and the balance of payments may interact with the environment. Second, the choice, or mix, of policy instruments to achieve these objectives may affect the environment. Third, implementation of environmental policies may affect the achievement of macroeconomic objectives. Finally, a change in the economic accounting framework, from the conventional system of national accounts (SNA) to an accounting system for sustainable economic growth and development, could fundamentally alter one's assessments of macroeconomic achievements and the effectiveness of policy instruments.

1. Macroeconomic objectives

The long-run objectives of economic policy usually consist of economic growth, full employment, and equity. In the short run, when imbalances emerge between aggregate demand and supply, the objectives often include price stabilization and attainment of a viable balance of payments. The pursuit of some of these objectives can, and does, interact with the environment in several ways. For example, achievement of high rates of economic growth may, in some cases, require a faster-than-sustainable rate of extraction of natural resources, including mineral and forestry.

As another example, the pursuit of high rates of industrial growth can raise the level of environmental degradation by increasing waste emissions (water and air pollution, and industrial waste) to levels which exceed the environment's assimilative capacity.

^{1/} For a more detailed discussion of the impact of high rates of population growth in developing countries on their environment, see the World Commission on Environment and Development (1987).

Finally, high rates of economic growth, industrialization, and urbanization are also likely to increase the use of energy--one of the key factors underlying air pollution. At present, the primary sources of energy--coal, oil, natural gas, and conventional nuclear power--are nonrenewable. The pursuit of high rates of growth are likely to increase the rate of energy use, which could increase environmental risks and uncertainties, including (a) the possibility of global warming caused by emission of "greenhouse" gases (the most important of which is carbon dioxide) produced by combustion of fossil fuels; (b) urban-industrial air pollution from the combustion of fossil fuels; (c) acidification of the environment from the same sources; and (d) risks of nuclear reactor accidents and the problems of disposing of nuclear waste materials.

2. Macroeconomic instruments

The most important macroeconomic instruments used to achieve the objectives noted in the preceding section include monetary policy (reserve requirements, open market operations, interest rates), fiscal policy (expenditure, taxes, public enterprise pricing), and exchange rate and trade policies. The mix of the instruments obviously depends on the specific objectives under consideration and the structure of, and the specific problems faced by, the economy in question. Use of these instruments can, and does, affect the environment.

For example, adoption of a high interest rate policy, aimed at encouraging savings and efficient investment policies, may encourage a faster-than-optimal rate of exploitation of nonrenewable natural resources in the short run. ^{1/}

As another example, devaluation of the exchange rate, aimed at reducing aggregate demand, may encourage expenditure switching in favor of nontradables in domestic consumption, while, at the same time, improving the competitiveness of the country's exports and encourage it, especially if that country is dependent on exports of natural resources to accelerate the exploitation of its natural resources beyond the level that is sustainable.

^{1/} In a market economy, the owner of a nonrenewable resource is likely to exploit the resource at a rate such that the net (of extractive costs) price of the resource increases at the rate of interest. Other things remaining the same, an increase in the rate of interest may stimulate a higher rate of exploitation of the resource because the owner could earn more by more rapid extraction of the resource and investing the profits in the market than by greater preservation. For a comprehensive discussion of the optimal rate of extraction of nonrenewable resources, see Solow (1974). Stiglitz (1976) discusses the optimal rate of extraction of an exhaustible resource by a monopolist.

As a third example, when demand and supply are out of balance, an appropriate policy response might be a reduction in the level of absorption through cuts in public expenditure. While such cuts are often targeted toward waste and inefficiency or toward lower priority needs, they may also curtail expenditures for environmental protection, resulting in poorer monitoring and use of environmental assets and services. On the other hand, cuts in expenditures on complementary inputs in the use of environmental assets and services, such as maintenance and enhancement of relevant access roads, may slow the rate of environmental degradation. 1/

As a final example, despite the fact that population growth in developing countries is a major cause of environmental degradation, government income tax policies in many of these countries often provide incentives for having large-size families, through child abatements beyond two, three, or even four children. 2/

The fact that the application of a macroeconomic instrument can have an adverse impact on the environment or the rate of depletion of natural resources does not, however, mean that it should be abandoned. Rather it may require that appropriate microeconomic instruments be applied or adjusted to compensate for the adverse impact caused by the macroeconomic instrument. As an illustration, in order to address external and domestic imbalances in an economy, a government might raise interest rates which might, as noted earlier, result in a faster-than-sustainable rate of exploitation of mineral resources. 3/ To compensate for this effect, an increase in the rates of mineral taxation may be considered.

3. The impact of environmental policies on macroeconomic performance

Interest in assessing the impact of environmental policies on macroeconomic performance arises from concerns that economic growth, 4/ conventionally measured, 5/ could slow and that employment and

1/ However, see Section IV.1.b.(2), which points out the two-way relationship between operations and maintenance expenditures and environmental degradation.

2/ The economic literature continues to explore the linkage between economic incentives and family-size and birth-spacing choices. Evidence to date on the strength of such relationships is tentative.

3/ See footnote 1, page 8. On the other hand, the decline in the level of economic activity, arising from the higher interest rates, may reduce the demand for mineral resources.

4/ The OECD (1974) has assessed the macroeconomic costs of pollution control programs; the OECD (1978) has also evaluated the macroeconomic implications of environmental programs from the point of view of overall economic development.

5/ Excluding, for example, the improvement in the quality of the environment.

productivity could fall, prices rise, and the balance of payments deteriorate. 1/

The impact of environmental policies on macroeconomic objectives depends on, among other things, the environmental standards required and the resultant increase in abatement expenditures to control pollution. For example, an OECD study, 2/ taking Austria, Finland, France, the Netherlands, Norway, and the United States as case studies, has concluded that: (a) the effects of increased pollution-abatement expenditures on output growth are not uniformly predictable across countries--growth could be higher (by as much as 1.5 percent over a 10-year period, as in the case of Norway) or lower (by 1 percent, as in the case of the United States); (b) the effects on the price level could be unfavorable (by an average of between 0.3 to 0.5 percent per year); and (c) employment could rise, primarily because of the stimulative impact of the increase in abatement expenditures. More generally, increased investment in pollution control equipment would tend to increase output in the short term especially if some unutilized capacity exists; but in the long term, lower levels of profitability and/or higher prices would erode some or most of the short-term gains. Overall, the study concluded that the macroeconomic effects of environmental policies are small. Other studies based on economies of industrial countries have come to similar conclusions but have noted that the impact of increased pollution-abatement expenditures on the trade balance (e.g., in the United States) can be negative and significant. 3/

In some developing countries, the implementation of environmental policies could have more unfavorable economic effects than those observed in industrialized countries. In part, this is because abatement costs and the levels of capital imports required for pollution abatement are likely to be higher for some of these countries than they are for industrialized countries. At the same time, the stimulative impact of the increase in abatement expenditures is likely to be small, primarily because of the dependency on imports for capital equipment. In both industrial and developing countries, the unfavorable effects of implementing environmental policies could be substantial if the desired environment standards are pitched too high. 4/

1/ See Leontif and Ford (1972), Walter (1973), and Conrad and Morrison (1989).

2/ See OECD (1974).

3/ See Conrad and Morrison (1989), and Robinson (1988).

4/ While there are a few empirical studies on the impact of specific environment policies for some, mainly industrial, countries, a great deal of work is required to develop a systematic framework, applicable to different types of economies, for analyzing the economy-wide effects of implementing environmental policies.

4. Accounting system appropriate for sustainable growth and development

The overall measurement of economic performance, as one guide for conducting macroeconomic policy, makes use of conventional national accounts. However, as an indicator of long-term sustainable economic growth and development, conventionally measured national income has been faulted on three grounds. First, costs incurred in protecting the environment are currently treated as an addition to product when incurred by government but as an intermediate expenditure when incurred by enterprises. Second, depletion of nonrenewable resources (fossil fuels and other minerals) is not charged against current income to reflect diminished potential future production. As a result, measured growth can be illusory, and the prosperity it engenders transitory, if the apparent gain in income means a permanent reduction in the stock of wealth. Finally, the degradation of renewable natural resources (forests, fisheries, soil, and water), through deforestation, overfishing, or soil erosion, can reduce the environment's productive capacity. Such a reduction in productive capacity is also not charged against current income in conventional measures of national income.

Because integrating environmental impact into the UN's System of National Accounts (SNA) would take time, there are interim proposals for developing separate "satellite" accounts to reflect environmental factors and to supplement current measures of gross domestic product (GDP) and national income. These "satellite" accounts should provide improved macroeconomic guidance as data become available. ^{1/}

5. The trade-offs between economic and environmental objectives

In some cases, environmental and economic objectives (conventionally measured) are obviously complementary. ^{2/} Several examples of such complementarity, noted earlier, include elimination of subsidies on pollution-generating inputs or outputs. In many other cases, however, there can be serious conflicts between environmental and economic objectives necessitating that policymakers decide on trade-offs. A few illustrations follow.

First, fiscal or other policies designed to "internalize" externalities tend to increase the costs of production and prices of relevant goods and services. The resultant increase in domestic prices could

^{1/} For a more detailed discussion of accounting systems for sustainable growth and development, see Repetto, et al. (1989) and Ahmad, et al. (1989).

^{2/} In principle, environmental goods and services are economic goods and services; environmental objectives, therefore, should be considered as economic objectives. However, the predominant practice in most of the recent literature has been to regard environmental objectives as being separate from economic objectives and this has been accepted for the purposes of discussion here.

adversely affect economic growth (conventionally measured) as well as employment and international competitiveness.

Second, trade-offs could arise from a requirement that (short-term) macroeconomic objectives be pursued in a manner consistent with long-term sustainability. For a country dependent on a narrow export base of natural resources, placing a limit on the rate of exploitation of such resources might imply that balance of payments viability could only be achieved through a greater reduction in absorption and with reduced prospects for economic growth (as conventionally measured) in the short run.

Finally, trade-offs could arise from international policies designed to address global environmental issues. A poor developing country, with, say, abundant brown coal, may not be willing to consider slowing its current rate of industrialization, or afford to substitute domestic coal with imported oil, because of the concern for global warming.

To conclude this section, the pursuit of short-run macroeconomic objectives and the use of macroeconomic instruments toward these objectives can have a bearing on the objectives of maintaining environmental quality and achieving sustainable growth and development in the long run. It would seem to make little sense to reorient macroeconomic policies completely to meet environmental objectives alone or, in the main, reduce their effectiveness for the achievement of economic objectives. Rather, it may be more appropriate to adjust fiscal and other microeconomic instruments to offset any adverse impact on the environment, if any, that macroeconomic policies may cause. The next section reviews the scope and possibilities of such instruments.

IV. Fiscal and Other Solutions to Problems of Environmental Degradation

Sectoral and microeconomic policies aimed at improving efficient resource allocation, principally through the elimination of economic distortions, are designed to increase output capacity. In the past, monopolies and other forms of imperfect competition, public sector pricing policies, government price controls, taxes and subsidies, import tariffs and quotas and regulations, have been considered the main sources of distortions. In recent years, the importance of distortions arising from environmental externalities in the economy has also been recognized. This type of distortion has, in some cases, been exacerbated by policy failures, as mentioned earlier.

There is no one approach or solution appropriate for all problems of environmental degradation. In practice, the choice of an approach or solution depends on a number of considerations, including practicability, efficiency, equity, ecological incidence, information requirements and availability, transition problems, and administrative costs. This section reviews the various fiscal (tax and expenditure) and other

(regulation, extension of property rights, and pollution permits) solutions that have been suggested for controlling environmental degradation.

1. Fiscal solutions

The fiscal solution to an environmental externality, following Pigou, is either to tax or subsidize the polluter so that the polluter "internalizes" the externality. ^{1/} In cases where fiscal policies aggravate externalities, as when environmentally damaging activities are granted tax concessions or subsidies, elimination of such implicit and explicit subsidies would be an important part of solutions to environmental externalities. Finally, operations and maintenance as well as public investment expenditures, and debt-for-nature swaps, can be used to promote environmental objectives.

a. Environmental taxes

Environmental protection calls for environmental taxes (ETs) to "internalize" environmental externalities; however, any attempt to implement optimal ETs faces several practical difficulties. To begin with, calculation of the optimal level of tax in practice requires a great deal of information on the social costs or damage to the environment which, ordinarily, is not available to decision makers. ^{2/} In order to overcome the lack of information, iteration is called for; however, this too is difficult, because without knowing the optimal level of output there is no way to judge whether a given change in the trial level of the tax will improve resource allocation. (Monitoring of compliance with the quality standard will also be administratively complex and costly.) One possible solution to these difficulties would be to combine a tax on the source of an external cost with the regulatory approach according to which a quality standard is set on the environmental medium (air or water) in question.

Following this approach, a minimum environmental standard is set (through the political process) for a particular medium, and any pollution-generating activity discharging into the medium pays a fixed tax

^{1/} See Pigou (1920). If the polluting firm remains in production after corrective measures are imposed, the optimal level of pollution would be the same for a fiscal program using taxes or subsidies provided that the marginal taxes are equal to the marginal subsidies. However, in a competitive industry, the number of firms would be larger under a subsidy program than under a tax program. As a result, the level of output and that of pollution would be larger under a subsidy program compared with a tax program.

^{2/} Unlike other taxes, such as income taxes, an optimal ET is equivalent to a price for polluting the environment and is set equal to the marginal pollution costs caused by the polluting firm. These marginal costs are not only difficult to calculate, but they also vary with the level of output.

rate per unit of discharge. In the absence of full information on the precise tax rate that achieves the desired environmental standard, the rate could be determined iteratively. While the resulting tax improves resource allocation, and achieves a desired level of environmental standard at minimum cost, it is not necessarily optimal in the Paretian sense because the level of the environmental standard is determined exogenously. 1/

Environmental protection can also be enhanced by reforming certain provisions of other taxes. For example, natural resource taxes sometimes encourage environmental degradation because tax concessions and investment incentives often granted to extractive industries tend to encourage unwarranted degrees of mechanization which could be environmentally degrading. It may well be that in some countries, and for certain environmental media, greater impact on environmental protection could result from reforming such natural resource taxes. 2/

(1) Design of environmental taxes

ETs take various forms and have a variety of tax bases. Examples of ETs include effluent charges or emissions which are levies on pollution-related outputs, such as leaded gasoline; inputs which are closely related to sources of pollution, such as sulphur and carbon; ownership of certain assets (such as cars), the use of which is a source of pollution; certain pollution-generating activities; and emissions by producers whose activities degrade environmental media (such as smoke into the air, or effluent discharge into waters).

The primary objective of ETs is, of course, to protect the environment in an economically efficient way, taking into account the desired environmental standard and the abatement cost of pollution-generating activities. At the same time, each ET needs to be evaluated in terms of allocative efficiency, potential revenue yield, incidence, information requirements, and administrative costs as well as the potential impact on growth, employment, price levels, and the balance of payments.

In general, ETs are unlikely to be a major source of tax revenues, especially if they are truly effective in achieving their ends. 3/ However, their relative importance for a particular country will vary according to the nature and extent of pollution-generating activities and the authorities' commitment to high environmental standards. In

1/ The level of pollution is not optimal in this case because the desired environmental standard is set exogenously through the political process. See Baumol and Oates (1971).

2/ See also Section IV.1.a.(2).

3/ See Hahn (1989). However, it should be noted that certain taxes that generate a substantial amount of revenue might be considered as ETs, particularly the excise taxes on petroleum products which tend to generate substantial amounts of revenue even though they were not necessarily introduced for environmental reasons.

addition, their importance in the revenue structure will also depend on the choice between various environmental protection instruments.

While politically there may be merit in earmarking the revenues of ETs for activities which protect the environment or environmental agencies, because this often makes the taxes more acceptable to those paying them and makes the taxes more acceptable to environmentalists, there is a danger that the expenditure budgets of environmental agencies could become bloated by available tax revenues and make for a wasteful use of fiscal revenues. Therefore, it is preferable, at least from a fiscal point of view, to use such revenues as part of general government revenues.

(2) Possible environmental tax policies

Reforming taxation of natural resources is one way tax policy can be used to promote environmental objectives. This can be illustrated in relation to the forestry and mining sectors.

The major environmental problem pertaining to forestry arises from rapid and unsustainable deforestation mainly in developing countries, such as Brazil, Côte d'Ivoire, Indonesia, and the Philippines, caused by, among other factors, rapid population growth, high rural population demand for fuel wood and crop land, and inappropriate government policies, including tax policies. Tax policies for protecting the environment in this area, therefore, would need to focus, in the first instance, on reforming taxation of forestry resources with a view to ensuring a more sustainable rate of exploitation of the resources, achieving acceptable levels of environmental degradation, and obtaining adequate compensation for governments for ownership of forestry resources. In this regard, concessions and investment tax incentives granted for logging and wood processing, along with export taxes on forestry products, would need to be reformed. ^{1/}

Three major environmental issues are often associated with mining. First, certain environmental externalities (the destruction of plant cover, pollution of streams, changes in stream flow due to mining operations, and changes in soil and plant species due to climatic and biodynamic conditions) often make the recolonization of mined areas extremely difficult.

Second, there are externalities common in the mining of oil or natural gas whereby private owners ignore the impact on others of drilling from the same reservoir. In addition, the success or failure of an oil or a natural gas well of a plot of land conveys valuable information for all neighboring plots. Since the owner of such a plot does not capture all the benefits of the information that he generates by operating his plot, there is an external economy involved, and this information is not likely to be supplied in optimal amounts.

^{1/} For a detailed discussion of taxation of forestry resources, see Repetto, et al. (1989).

Third, is the issue of the optimal or sustainable role of exploiting mineral resources. 1/ For many countries, the taxation of mineral resources includes provisions which aggravate one or more of the foregoing environmental problems. For example, heavy mining machinery is often taxed favorably despite the fact that use of such machinery is more damaging to the environment than use of less heavy machinery. In addition, the taxation of income from mining is often treated favorably through generous depletion allowances and faster write-offs of exploration and drilling costs. In such cases, reform of the existing environmentally harmful tax provisions could significantly enhance environmental quality. 2/

Beyond reforming taxation of forestry or mining resources, ETs would also need to be designed for specific pollution-generating activities, including damage to rivers often used as a vehicle for transporting logs, or damage to land arising from excessive use of heavy machinery for logging or mining.

Currently, the major instrument used for controlling air pollution is direct regulation; however, two forms of ETs are also in use in certain countries. 3/ One is an effluent charge on actual sulphur dioxide emissions by industrial firms, such as the one implemented in 1985 in France, whose revenues are earmarked to finance air pollution-control equipment and research. The other is a tax on fuel, such as the new general fuel charge, which was implemented in 1988 in the Netherlands. This charge consolidates five previous charges and its primary objective is to raise revenues to finance air pollution abatement, soil protection, solid waste treatment, and traffic and industrial noise abatements. Two thirds of the charge is similar to a surtax on excise duties on mineral oil, the rest to a levy on the value of mineral oil. The tax has some incentive features, including the granting of rebates to firms applying certain abatement technologies to sulphur dioxide.

A number of countries, including Australia, France, the Federal Republic of Germany, Italy, and the Netherlands, apply ETs in the form of water effluent charges. The charges in France (on firms, households, and municipalities) and in the Netherlands (on firms and households) are primarily for raising revenues to finance the budgets of water management agencies. The German water pollution charges (on firms and households) and Italian charges (on firms) are closely linked with direct regulations. Revenues from the German system of charges are applied to defray some of the administrative expenses of the water management agencies. An important element of the German system is the provision to reduce the level of charges related to compliance with water standards,

1/ For additional examples of environmental externalities in the mining sector, see Church (1981) and Stiglitz (1975).

2/ For a detailed discussion of preferential treatment in the taxation of mineral resources, see Church (1981).

3/ For a more detailed discussion of these and other ETs discussed below, see OECD (1989).

but the levels of the charges are considered too low to provide incentives for firms and households.

A number of countries, including Australia, Belgium, the Netherlands, and the United States, apply ETs in the form of charges on waste. In Belgium, a charge is levied on dumping of industrial and municipal waste, with recycled materials being exempted. The charge in Denmark, levied on solid waste from households and industrial firms, is also intended to encourage recycling. The federal hazardous waste charge in the United States, levied on site operators, finances restoration of permitted chemical waste sites after their closure. In addition, a series of product charges are levied in the United States for treatment of all other waste sites through the "Super Fund." User charges for collection of solid waste from municipal sources are common in all OECD countries.

Other forms of ETs are product taxes levied on the products that generate pollution in production and/or consumption. These taxes are normally intended as an incentive to reduce the use of the products; they also help finance preventive or curative measures caused by use of the products. Product taxes are levied in several countries and are effective in raising substantial amounts of revenues. With the exception of taxes on nonreturnable containers, most product taxes have little impact on incentives. They are, however, administratively efficient, especially when they are linked to existing taxes or excises. Some countries use differential product taxes, or tax differential systems (TDS). The TDS combine a surcharge to existing product taxes, representing a positive charge on a polluting product and a negative charge on a less-polluting alternative. They have been applied in relation to cars and gasoline in a number of countries, including Germany, the Netherlands, Norway, and Sweden. In applying the systems, cars are classified according to pollution characteristics, such as car size or weight, with "cleaner" or smaller cars being granted a tax advantage. ^{1/} Price advantages of unleaded gasoline have been relatively small and they have had little impact on incentives.

b. Expenditure policies

In addressing certain types of environmental problems, appropriate expenditure policies can complement the environmental taxes of the type discussed above. In so doing, a government can assemble a complete fiscal policy package that is consistent with its environmental objectives. Both current and capital expenditure policies can have an important impact on the environmental quality of a country and on the utilization of a country's natural resources. In terms of current expenditure policies, governments can assess subsidy policy and operations and maintenance expenditures. In the area of capital expenditure policies, governments can ensure that "defensive" public investment

^{1/} The TDS were expected to end in EC countries when all new large and medium-size cars met air pollution specifications.

projects are undertaken in a timely fashion and that adequate emphasis is placed on the conservation component of public investment programs. In addition, governments may ensure that environmental considerations are brought directly into the project evaluation process.

Current expenditure policies can have an important impact on environmental quality and the pattern of use of a country's natural resources. For example, subsidies can exacerbate or ameliorate environmental degradation, while operations and maintenance expenditures can be used to improve efficiency in the use of some environmental resources and to reduce the extent of environmental degradation.

(1) Subsidies

Subsidies can be used as a positive instrument of environmental policy. In many instances, however, they are used in a manner that aggravates environmental degradation. Whether subsidies are used as a positive instrument or in a manner that aggravates environmental degradation, the expenditure implications alter the fiscal balance of a country. Reform of subsidy policy is, thus, an area that can have both beneficial environmental and macroeconomic implications.

Subsidies that are used as positive instruments of environmental policy are aimed at compensating those who voluntarily reduce the amount of pollution they generate. Examples include subsidies for installing a solar-generating capacity; for planting trees as windbreaks against soil erosion; for taking marginal, highly erodible, soil out of production or converting such land into permanent grasslands; and for installing certain types of emission or discharge-reducing equipment. ^{1/} For such subsidies, decision makers must determine whether the costs involved in attaining a specific environmental objective are minimized via the use of a subsidy, or whether other instruments--especially taxes--could be used to attain the target at lower cost, thus reducing budgetary burdens. ^{2/}

In cases where subsidies actually aggravate environmental degradation, decision makers need to review the original justification for such subsidies and analyze whether the subsidies can be reduced--perhaps through targeting--or eliminated. In many cases, of course, the elimination of such subsidies will have important income distribution

^{1/} Often, such subsidies are effected via the tax code, and may be classified as tax expenditures.

^{2/} In general, only if there are strong political objections to taxes, should subsidies be used in place of taxes (or fees). This is because taxes may, in many instances, have certain clear advantages. While, in principle, there is an equivalence at the level of the firm between subsidies and taxes in terms of cost per unit of pollution reduction, a tax penalizes a polluter more than a subsidy does; not only would a subsidy protect an otherwise unprofitable firm from bankruptcy, it could encourage the entry of more polluters into an industry.

consequences, which must be simultaneously analyzed. Prime examples of subsidies which may actually move an economy further away from an economically sound level of environmental degradation, and which policy-makers should therefore carefully assess, include subsidies on chemical fertilizers, pesticides, water resources, and energy. 1/

The original justification for chemical fertilizer subsidies was that farmers initially were said to need inducement to learn new agricultural techniques associated with the Green Revolution and to overcome misperceptions of the risks involved in their adoption. After decades of experience, many believe that such inducements may no longer be necessary. Despite this, large amounts of fertilizer subsidies continue to be granted by many developing countries, which tend to induce substitution in favor of chemical fertilizers and against organic manures and crop residues. In addition, such subsidies may result in environmental damage (from chemical runoff into ground water), reduced soil productivity, and topsoil erosion (caused by complementary farming techniques). 2/ Furthermore, fertilizer subsidies are often a substantial fiscal burden for some developing countries. There is, therefore, a strong case for the elimination or reduction of fertilizer subsidies for fiscal and environmental reasons. 3/

The use of pesticides may pose serious environmental and ecological risks, as these chemicals build up within the ecosystem and spread through the food chain. 4/ Side effects include damage to fragile ecosystems, human health degradation, and potential threats to the survival of certain animal species. Subsidies to such chemicals encourage excessive use, thus aggravating the initial problems of environmental degradation. Rational pest management can be achieved in the absence of such subsidies, with other less damaging control techniques being employed, such as integrated pest management schemes.

1/ A proper analysis of the impact of subsidies requires a thorough review of overall pricing policy. While most of such subsidies are provided at the input level, an analysis of output (producer) prices is necessary to understand the sectoral and general equilibrium implications of subsidy policy.

2/ See Schramm and Warford (1989), especially Chapter 6, for further details.

3/ However, some such subsidies can be beneficial, as in economies where traditional systems of bush fallow and shifting cultivation is practiced because of increasing population pressure and decreasing soil productivity. In such cases, increased use of fertilizers could reduce the intensification of pressures on the land that leads to both soil degradation and loss of coverage. The need for subsidies per se, of course, has to be carefully assessed as farmers may use fertilizers in such instances without artificial inducements. Here again, as before, a case-by-case analysis is called for.

4/ See Repetto (1985) for a comprehensive review of the issues involved.

The underpricing of water resources may encourage excessive or careless use of water, with implications for soil waterlogging, salinization, the water table, and the sustainability of underground aquifer resources. ^{1/} The subsidies involved can pose an important fiscal burden in addition to degrading the environment.

Energy products, especially petroleum products for automobiles and trucks, kerosene for cooking and lighting, and electricity, are subsidized either explicitly or implicitly in numerous countries. ^{2/} Such practices may lead to an overconsumption of greenhouse gas-generating resources and the development of energy-intensive industrial sectors. In addition, household production patterns may also become unduly biased toward energy-intensive activities. In general, such subsidies can have strong negative implications for the fiscal and balance of payments positions of countries employing them, while at the same time being environmentally damaging. ^{3/}

(2) Operations and maintenance expenditures

In many cases, operations and maintenance expenditures on public social and economic infrastructure have high rates of return and can forestall the need to replace systems and expand capacity. In addition, operations and maintenance expenditures can serve to reduce losses of scarce resources, and promote environmental and conservation objectives. Thus, for example, a well-maintained road network may improve transport vehicle fuel efficiency, thereby saving scarce resources and reducing the emission of harmful exhausts. Operations and maintenance expenditures to insure efficiency of water use (such as canal lining), including minimizing water loss through evaporation or runoff, can have a high economic rate of return and can reduce depletion of water resources, which play a critical role in the maintenance of natural ecosystems' balances. Finally, operations and maintenance expenditures which insure efficiency in the operation of national power electric grids can, in many instances, yield high rates of return by minimizing energy losses arising from inefficient generation, transmission, or utilization. Such energy losses are wasteful and often degrade the environment through harmful emissions.

It should also be noted that it is a two-way interaction between operations and maintenance expenditures and environmental degradation. While operations and maintenance expenditures can reduce waste due to inefficiency--thus promoting conservation objectives--and diminish

^{1/} See Schramm and Warford (1989), op. cit.

^{2/} See Kosmo (1987) for an extended discussion of energy subsidies.

^{3/} A case for such subsidies, however, can be made in instances where rapid deforestation, due to the gathering of wood for cooking and other activities, has endangered the balance of the natural ecosystem. Nonetheless, these subsidies can be provided on a targeted basis and limited to a transitional period during which efforts to reverse the deforestation cycle could be undertaken.

environmental damage, sound environmental policies and practices can reduce the need for these expenditures. For example, environmental policies that encourage soil conservation can reduce operation and maintenance costs for irrigation networks and hydropower projects as a result of lower soil loss and hence less water siltation. The same policies may also reduce operating costs for road networks.

(3) Capital expenditure policies

As with current expenditure policies, government capital expenditure policies can also have an important impact on the environment. Such impact can be indirect as with power projects, which may have an environmental impact; or direct as with conservation or pollution-abatement projects, which have been rightly called environmentally defensive expenditures.

Public investment in environmental protection is often justified when private investment is inefficient, as in the cases of public goods and/or when there are scale economies. ^{1/} Water purification and sewage treatment plants are cases in point. Many conservation projects, including watershed management, soil management through the planting of trees for windbreaks, energy conservation, wildlife protection, natural habitat projects that ensure biodiversity, and park and range land projects, can have very high rates of return especially when appropriate forms of cost-benefit analysis are applied. ^{2/} It is increasingly recognized that environmental considerations should be taken into account in project evaluation, either quantitatively, through appropriate shadow pricing techniques to account for external costs and benefits, or qualitatively, through the use of supplementary environmental impact assessments. The use of such assessments allows policymakers to weigh the risks of alternative projects and can be useful when quantification is not possible.

Unfortunately, a lack of institutional capability on the part of national planning departments, to evaluate environmental and conservation projects and/or to incorporate environmental impact evaluation into standard project analysis, prevents many governments from recognizing the potentially harmful longer-term side effects of the projects being pursued. Thus, development of such capabilities may be an important first step in the pursuit of sustainable development.

^{1/} These types of projects may also have a substantial positive impact on the lifespans, efficiency, and operations and maintenance costs of other infrastructural investments, such as roads, dams, hydropower plants, and irrigation networks.

^{2/} For a discussion of public investment programs aimed at protection of the environment, see United Nations Development Program and World Resources Institute (1989).

(4) Debt-for-nature swaps

Debt-for-nature swaps are a relatively new phenomenon which allow countries, commercial banks, and nongovernmental organizations to trade off market discounted debt for environmental concerns, including habitat preservation. ^{1/} Examples of such swaps, including those that have taken place in Costa Rica, Madagascar, and Bolivia, have been on a limited scale. The swaps could also be considered as "debt-for-expenditure" swaps, because the organizations--typically nongovernmental--involved in such swaps are often interested in obtaining domestic currency at a discount, which they subsequently use for conservation expenditures or which they want the government to use for that purpose. Viewed in this way, one of the relevant issues of such operations is the degree to which the swaps are "additional"--that is, the extent to which they increase expenditures on environmental and conservation programs above what they would have been without them.

2. Other solutions

In addition to the fiscal solutions noted above, many nonfiscal solutions have also been identified in the literature. Three of these are described below.

a. The extension of property rights and unitization

In some cases, the problem of environmental externality derives from the lack of (or ill-defined) property rights. In such cases, it may be more efficient for the government to assign (or clarify) property rights and allow private economic agents to handle problems of environmental quality through negotiations among affected parties. ^{2/}

Such an option is practicable only if the property rights to be assigned are enforceable. This, in turn, may require the development of mechanisms to establish and enforce legal liability. At a national level, this task can be handled by the legal system. However, in the case of transnational or global spillover, the assignment of property rights (through multilateral or international treaties) for such transnational or global problems as acid rain and depletion of the ozone layer may not obviate free-rider problems unless enforceable mechanisms to establish liability are sufficiently strong. Political resistance to such solutions, however, may also arise, especially as the assignment of previously unassigned or ill-defined property rights is likely to have both strong allocative and redistributive consequences.

Once property rights have been assigned (or clarified), private agents, through the legal system or other arbitration channels, including bilateral or multilateral negotiations, can buy and sell the

^{1/} See Hansen (1988a).

^{2/} For a full discussion of the assignment of property rights, see Coase (1960).

rights, and, in so doing, reduce the environmental externality to its optimal level. The efficacy of such an approach will, however, depend not only upon the enforceability of the rights themselves, as mentioned above, but also on the transactions costs associated with, for example, civil litigation. Thus, where such transaction costs are relatively low in comparison to the administrative costs of other forms of pollution-reducing mechanisms, the development or clarification of property rights and their attendant requisite structures are desirable. Even if such a system is clearly specified and delineated, however, there may still be instances where transactions costs are significant, due, for example, to intransigence on the part of a particular claimant to a dispute (a free-rider problem). In such cases, government intervention may be justified if the costs faced by the government in securing an optimal solution are less than the transactions costs arising from negotiations and/or litigation. 1/

Finally, an optimal allocation of resources could also be achieved through consolidation (or unitization) of the operations of firms affected by each other's activities. 2/

b. Regulation

The regulatory approach seeks to reach a given quality target of an environmental medium by regulating the behavior of economic agents. The typical approach specifies pollution permits (discussed below) which are not negotiable. Another approach stipulates the state of technology to be applied in abatement or production. The product norms approach specifies the quantity of pollutants that can be contained in goods (e.g., DDT in agricultural products).

The regulatory approach is widely used in environmental policy. Its major advantage is its ecological incidence: if the target is properly set, and emitters do not violate the law, then the quality target will be attained. It is primarily for this reason that the approach is popular with environmentalist groups. Its major disadvantages are that (a) it is inefficient because it does not take into account differences in abatement cost structures; (b) it is administratively cumbersome because agencies have to issue permits specifying the allowable quantity of emissions for specific equipment within firms; (c) it creates barriers to entry because the permits tend to perpetuate the given structure of existing firms; (d) it does not provide incentives for the introduction of new abatement technology; and (e) as with other forms of regulations, environmental regulators run the risk of being unduly influenced by one or more of the interest groups.

1/ See Turvey (1963).

2/ Thus, for example, a merger of an upstream polluting firm with a downstream fishing firm would "internalize" the externality, because, in order to maximize the profits of the new consolidated firm, the new firm would have to take into account the effects of the pollution generated by its upstream activities on downstream fishing operations.

c. Pollution permits

Whereas taxes are levied to limit the aggregate level of emissions, pollution permits act to set the aggregate level first, and allow the permit price to adjust in response. The permits convey the right to pollute up to a pre-set level. The permits may initially be allocated to firms, or they can be auctioned. In either case, they must be marketable after being initially allocated or auctioned, if they are to be dynamically efficient.

The principal attraction of pollution permits is that they have a greater certainty of achieving a given environmental standard of the medium than the tax approach. They have the added advantage that environmental agencies do not have to be concerned with the correct price relationship among different types of pollutants, because once different quality standards are determined, the market will find the relative prices for pollution types. A major disadvantage of pollution permits is that their markets have to be competitive--a condition that does not always exist, even in developed market economies. ^{1/} A second disadvantage is that their use requires an ability to determine the optimal level of emission and the technology to meter effectively the level of emissions. Finally, as with the tax approach, any "license to pollute" is unacceptable to environmental groups.

Implementing an "ideal" pollution permit scheme is obviously difficult because of the substantial information requirements placed on the decision maker and the amount of metering needed. To get over these difficulties, it has been demonstrated that, given a desired predetermined level of environmental standard and knowledge of the relationship between waste emissions and that standard, the granting of marketable pollution permits to pollution-generating firms can result in the attainment of the desired environmental standard at minimum cost, ^{2/} provided that (a) the permits are freely marketable; (b) the market for them is competitive; and (c) the use of revenues from the sale of permits, or the expenditure requirements of relevant environmental agencies, are not factors in the design of pollution permit schemes. This result forms the basis for marketable emission permits which have been used mainly in the United States and, to a lesser extent, the Federal Republic of Germany.

Of the four applications of marketable pollution permits, three are in the United States. ^{3/} For example, the Wisconsin Fox River scheme, which was implemented in 1981, aimed at allowing firms greater flexibility in choosing abatement cost options while maintaining water quality

^{1/} The reason for absence of competition is that in some cases, such as effluent discharge into a river basin, the demand (and supply) for a pollution permit at a particular location is severely limited.

^{2/} See Dales (1968), and Baumol and Oates (1988).

^{3/} For an empirical survey of pollution permit schemes, see Hahn (1989).

standards; the program also allowed limited trading of the discharge permits. In assessing the scheme, cost savings to firms have been found to be minimal. Performance of the scheme has also been considered poor, primarily because the market is not competitive. Finally, there have been multiple restrictions on the sale of permits (only one trade has taken place), which has substantially raised transactions costs in trading the permits.

While the Federal Republic of Germany has also implemented an emission trading program, by far the most significant program is that implemented in the United States. The objective of the U.S. program has been to reduce abatement costs for attaining air quality standards, as required under the Clean Air Act, by giving firms flexibility to change the mix of abatement technologies envisioned in the Act.^{1/} Under the program's emission reduction credit scheme, any firm that decides to control emission to a lower level than required under the regulations can obtain certification of the excess as an emission reduction credit. While the scheme's impact on environmental quality has been insignificant, leading to little or no net change in the level of emissions, there have been substantial cost savings for participating firms.

3. Evaluation of alternative solutions

The diversity and complexity of environmental problems and the uncertainty of incidence of solutions suggests that no single approach to environmental degradation could possibly be appropriate in all situations. While most of the solutions discussed above are alternatives, some of the approaches are complementary. For example, the elimination or reduction of implicit or explicit tax or expenditure subsidies, which aggravate environmental externalities, complements most of the approaches discussed above. Similarly, operational maintenance and investment expenditures, and debt-for-nature swaps, are suited for addressing special environmental problems and are, in this regard, complements to the other approaches discussed above. At the same time, the extension of property rights, regulations, taxation, subsidies, and pollution permits are, in most cases, alternative solutions to the problems of environmental degradation. These solutions are evaluated below.

In the choice between the tax and regulatory approaches, the following observations are relevant.^{2/} First, environmental taxes are often the least-cost method of securing a given environmental standard. Second, the tax approach provides incentives for the polluter to seek less polluting technologies, which may reduce pollution even below the

^{1/} Pollutants covered under the policy include volatile organic compounds, carbon monoxide, sulfur dioxide, particulates, and nitrogen oxides.

^{2/} The comparison is between the regulatory approach and the tax approach as advocated by Baumol and Oates (1971)--that is, a pollution tax that attains a pre-set environmental standard at minimum cost.

set standard. Third, the tax approach requires less information than the regulatory approach because it does not require information on the abatement cost structure of the firms involved nor does it require monitoring of the quality of the environmental medium into which the effluent is discharged; only the monitoring of the effluent discharge of each firm involved. Fourth, iterating to determine the level of the pollution tax that is consistent with the set environmental standard introduces a major element of uncertainty (to the affected firms) concerning the optimal level of investment to minimize costs of achieving the environmental standards.

The tax and regulatory approaches, however, differ in their distributional consequences, primarily because the tax turns what otherwise would be a free input into one with a price attached. As regards administrative and enforcement costs, it is difficult to say, a priori, which approach has lower costs; however, because the tax approach yields tax revenues in a less distortionary manner than most taxes, it is often attractive to governments strapped for budgetary revenues.

The experience to date seems to suggest that the objectives, design, and effectiveness of environmental taxes vary widely among countries and according to the environmental media they are intended to protect. While a few have had a significant impact on the behavior of economic agents, the effect of most has been limited by the fact that they have generally been superimposed on existing regulations with limited attempts made to raise their rates sufficiently to affect the behavior of economic agents. For the most part, the taxes have been levied to raise revenues, with their impact on incentives being regarded as a by-product. Even so, the revenues from the taxes have, at best, been adequate to finance total abatement costs only in a limited number of cases. They have not, therefore, been a significant source of budgetary revenues. Similarly, their effects on growth, prices, and international competitiveness are not considered to have been large.

The choice between taxes and subsidies is likely to hinge on the following factors. First, if the firm remains in production after corrective measures are imposed, the optimal level of pollution would be the same under a fiscal program using taxes or subsidies, provided the marginal taxes are equal to the marginal subsidies. However, in a competitive industry, the number of firms would be larger under a subsidy program than under a tax program. As a result, the level of output and that of pollution would be larger under a subsidy program, compared with a tax program. Second, for goods that are traded internationally, subsidies violate the "polluter pays" principle that has been adopted by the OECD countries. ^{1/} Third, while taxes strengthen fiscal

^{1/} In May 1972, members of the OECD Council adopted the so-called "polluter pays" principle, according to which the polluter bears the expenses of preventing or controlling pollution, so that the abatement costs are reflected in the costs of the goods and services that cause pollution. Such costs are not to be subsidized, to avoid distortions in international trade and investment. See OECD (1975).

performance by providing additional government revenues, subsidies do the exact opposite. Finally, subsidies could be more difficult to sell, politically.

In appraising the extension of property rights approach, which allows private economic agents to resolve problems of environmental externalities through negotiations, four major problems need to be mentioned. First, giving rights to a polluting firm and allowing negotiations to take place may increase the firm's profits beyond the maximum that they would otherwise be, because it negotiates to receive subsidies in excess of the private gains it surrenders by reducing output. Second, this approach presupposes that the external costs involve few parties which are readily identifiable.^{1/} Third, assigning pollution rights to the polluter may have unacceptable distributional implications. Finally, if the polluter's output is traded internationally, it may be preferable to adopt the "polluter pays" principle. These difficulties notwithstanding, the approach has merit, especially when property rights are enforceable and where the costs of other forms of intervention are greater than the transactions costs of effecting a negotiated solution.

As for the pollution permits approach, four comments are in order. First, it seems clearly superior to the regulatory approach because its application results in attaining required environmental standards at minimum cost. Second, under competitive conditions and when pollution rights are auctioned, the approach results in pollution levels equal to those under the tax approach. Third, the presence of oligopoly or monopoly among purchasers of pollution rights makes the approach inferior to the tax approach. Finally, the evidence seems to suggest that, provided there are adequate organizational structures and strong environmental protection agencies, as is the case in several developed countries, pollution permit schemes can be implemented with significant cost savings. However, developing countries, particularly small ones, would appear to be in a weak position to implement the schemes: environmental taxes may be a more promising option for such countries.

In summary, the choice of an instrument to address a problem of environmental degradation depends largely on the nature and type of problem; in addition, the instrument chosen must satisfy the considerations of efficiency, practicability, ecological incidence, administrative costs, etc. From an economic point of view, market-based approaches, including taxes and subsidies, are always preferable to regulatory approaches. Of course, subsidies or tax incentives should not be granted to support a negative externality; these should instead be taxed. Given that subsidizing can have an adverse impact on government fiscal accounts, taxes should be preferred even over subsidies which help internalize a positive externality.

^{1/} In fact, many environmental externalities are complex and involve many parties. For further discussion, see Helm and Pearce (1990).

V. Prospects and Challenges for Environmental Protection Policies

The extent to which environmental policies are currently being implemented varies widely even among developed countries. ^{1/} It seems that the major factors explaining such variance, even when environmental problems are strictly confined to national boundaries, are differences in (a) political commitment to environmental protection; (b) technical, analytical, and administrative capacities of specialized government environmental protection agencies; and (c) income per capita and the level of economic development. Addressing environmental issues with significant transnational spillovers or global problems, of course, requires broad and deep commitment by all countries concerned to resolve the issues in the context of relevant bilateral, regional, or multi-lateral negotiations.

Even though many obstacles remain for the effective implementation of environmentally sound and sustainable development policies, there are indications of some favorable trends. Both developed and developing countries have increasingly expressed their commitment to protecting the environment. Important multilateral agencies, including the World Bank and regional development banks, have adopted environmental protection policies in their operations. ^{2/} In addition, UN agencies are examining their operating procedures for their programs with a view to taking due account of environmental concerns. ^{3/} Finally, the use of technologies that are environmentally cleaner and cheaper and the accumulation of experience in implementing environmental policies should make it less difficult and less costly to effect future environmental policies, even among the poorest developing countries.

1. Political commitment and capacities of environmental agencies

The importance of political commitment to environmental protection cannot be underestimated. It is a key ingredient of any plan to address and remedy key environmental problems, nationally, transnationally, or globally. Political commitment to environmental concerns, of course, varies widely across countries, and cannot easily be explained by a limited set of variables. Thus, while political commitment may generally be greater among developed economies, numerous developing countries have also shown a high degree of commitment to environmental issues, indicating that income level, while an important factor, is not a determining factor. At the same time, the form of economic organization seems to explain political commitment to the issue. Despite a centralized decision-making apparatus that would seem to lend itself to ensuring that the external effects of economic activities are taken into account, many centrally planned economies have shown a lower level of commitment to environmental issues relative to that of the market-oriented economies (see the Appendix).

^{1/} See OECD (1989).

^{2/} See Warford and Ackerman (1988).

^{3/} See Environment Resources Limited (1989).

2. The level of economic development

Most developed countries have environmental protection agencies which are technically, analytically, administratively and, in some cases, politically strong. In developing countries, the situation varies widely. In most developing countries, especially the smaller countries, at best there is only a department or Ministry of Natural Resources which, in some cases, is more preoccupied with stimulating the exploitation of mineral and forestry resources than with protecting the environment. Since implementation of sound environmental policies requires considerable specialized technical knowledge, which many developing countries may not have, an important first step would seem to be to establish and develop adequate local institutions in this area.

Most developed countries can afford to demand better environmental quality. Because they have greater resources and more flexibility in generating income from alternative activities than many developing countries, the relative cost for ensuring a better quality environment is less than in developing countries. In addition, as the level of income has increased in many countries, an international translocation of production facilities has occurred, which in many cases has resulted in the relocation of pollution-generating activities to other countries, making these countries more dependent on pollution-intensive economic activities than previously. In some cases, such countries may have welcomed these translocations and, hence, may have deliberately chosen higher levels of environmental degradation than would be acceptable in more developed countries. ^{1/} Such countries, especially if they are developing, are likely to argue that diverting substantial amounts of resources to preserve the environment while its population still lacks sufficient food, adequate medical facilities, and other basic requisites of bare existence, is untenable. This divergence of values on the environment could well complicate implementation of significant transnational and global environmental policies.

3. Transnational and global issues

Domestic policies can generate important environmental spillover effects for other countries when environmental problems transcend national borders. Furthermore, environmental policies can have important international implications because they affect trade flows and several types of international environmental externalities have been identified. First, there are unidirectional externalities involving an imposition of an external environmental cost to other countries without the polluting country being harmed by the victim country or countries. Second, there are reciprocal externalities, in which a group of countries is both the source and the victim of a transnational environmental

^{1/} In this regard, the commonly observed pattern that environmental quality first declines then recovers as industrialization proceeds may actually be "optimal." See Pezzey (1989).

degradation. Finally, there are problems of global environmental degradation which affect all countries of the world. 1/

Different types of transnational externalities call for different types of international coordination. In the case of unidirectional externality, voluntary negotiation between the countries involved could yield an efficient solution irrespective of the distribution of property rights between the one causing the pollution and the other bearing the consequences. However, transactions costs of monitoring and enforcing an agreement may be prohibitive, especially in the presence of asymmetric information. 2/ When more countries are involved, transaction costs are likely to be significant, raising two questions. First is the question of the most cost effective way of reducing environmental degradation. This requires that countries with the lowest abatement costs and those causing the most serious damage play the primary role in reducing the environmental degradation originating in their respective jurisdictions. Second is the question of the distribution of the benefits and provision of incentives to the various countries to entice them to participate in international cooperation. Various compensation schemes are possible, depending on the nature of the environmental problems and the number of countries involved. 3/ For example, the case of possible global climate change could be addressed by establishing a system of pollution permits for the emissions of certain "greenhouse" gases. The system permits would be efficient if countries were allowed to trade them and if countries could earn permits when, for example, they plant trees or preserve tropical forests, which absorb carbon dioxide. As an alternative to using tradable pollution permits, countries could agree to tax "greenhouse" gases. In that case, the international distribution of tax revenues would determine the net benefits for each country. 4/

1/ Deforestation in Nepal, which has resulted in increased flooding in Bangladesh, represents unidirectional externality; cross-border effects of acid rain in Europe represents reciprocal externality; and possible climatic change or depletion of the ozone represents global externality. For further discussion on the different types of international environmental externalities, see Mäler (1990).

2/ International agencies can design incentive structures for countries to correctly reveal their cost structure and estimated benefits. In contrast to the voluntary negotiated solution, this requires countries to delegate some powers to an international agency. For further discussion on this see Mäler (1990).

3/ These schemes often violate the "polluter pays" principle in order to provide incentives because the victim countries must offer source countries incentives to participate. Side payments do not necessarily involve cash payments, but may concern concessions in other policy areas.

4/ For a comparison between taxes and tradable permits to deal with international spillovers, see Mäler (1990).

For several reasons, international coordination may be desirable even in the absence of pollution spillovers. First, it could facilitate enforcement of environmental user charges, such as taxes on fertilizers or gasoline, if neighboring countries levy such charges. Second, coordination could ensure that there is no loss of competitiveness as when major countries simultaneously raise taxes on certain polluting industries. Finally, coordination could also eliminate or reduce the export to other countries of pollution-intensive activities.

Several international agreements dealing with environmental spillovers are currently in force. Some of these agreements deal with transnational pollution, including conventions on the Baltic Sea and the North Sea and treaties on the use of several rivers. Other conventions address global issues, ranging from trade in endangered species to marine pollution. The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer constitutes an important recent example of successful international cooperation.^{1/} However, several factors can complicate further international cooperation in this area. Transaction and negotiating costs can be substantial when many countries are involved and when some countries use environmental issues to extract concessions from others and in other often unrelated areas. Furthermore, countries often differ in their assessments of the seriousness of particular environmental problems, primarily because of considerable uncertainty regarding the impact and incidence of international environmental problems and the effects of environmental policies designed to alleviate the problems. In addition, risk preferences differ considerably between countries, with some countries preferring extremely risk-averse strategies and others preferring to act in a more risk-neutral fashion. Monitoring and policing of international agreements may also be difficult in the face of national sovereignty, especially because countries typically face strong incentives to hide important information and to free-ride on the virtuous behavior of others.

VI. Areas of Further Research

Although the literature on the interaction between the economy and the environment is vast and growing, there are important gaps in our understanding; these gaps make it very difficult to formulate and, particularly, to implement environmental policy. Research is needed to fill some of these gaps. Below, three of the more obvious gaps are outlined; research on some of these is, or may already be, underway.

First, at the macro level there is a need to extend the existing analytical framework for macroeconomic policy so as to integrate the impact of macroeconomic policy with the environment. To complement this research, it would also be helpful to gain greater understanding of the empirical relationships between macroeconomic policy instruments and the environment as well as between environmental policies and macroeconomic

^{1/} See Dorfman (1988).

policy instruments applicable to different types of economies. Greater understanding in this area would enhance the appreciation of the trade-offs associated with specific environmental policies and would help policymakers to integrate environmental concerns into economic objectives.

Second, at the micro and sectoral levels, there is a need to bridge the wide gap between the theoretical solutions to problems involving environmental externalities and the practical fiscal or nonfiscal solutions to specific types of environmental externalities. Similarly, at the same level, there is a need to gain better understanding of the nature and magnitudes of specific forms and types of aggravations of environmental externalities caused by existing tax codes, subsidies, and other policy measures. This would require studies on specific countries and types of pollution, similar to some now being made by the World Bank.

Finally, the number of definitions of sustainability, even among economists, is large and confusing; and, at present, the concept does not provide a consistent basis for formulating public policy toward "sustainable" growth and development. In view of the importance of this concept to the analysis of many environmental issues, there is need for clarification of the concept, making it more precise, and reaching greater consensus.

Environmental Degradation in Developing,
Industrial, and East European Countries

All countries face environmental problems of one kind or another. However, the nature, extent, and sources of the problems often differ among industrialized, developing, and East European countries. Thus, while there are some developing countries facing serious pollution from industrial sources, these sources are, in general, more characteristic of industrialized countries. Similarly, the most significant forms of environmental degradation in developing countries are associated with the exploitation of natural resources including forestry, mineral, and soil resources. Population growth and poverty are also important sources of environmental degradation in many developing countries. In East European countries, water pollution and atmospheric pollution, the latter caused primarily by the use of brown coal (which has a relatively higher sulphur content), are the areas of greatest concern.

1. Developing countries

Some developing countries are particularly vulnerable to environmental deterioration because natural resources are so vital to their economies. Typically, primary production (agriculture, fisheries, forestry, and mining) contributes over a third of GDP, over two thirds of employment, and over half of export earnings in many of these countries. And, far more than in industrial countries, natural resources are the principal economic asset. Further, because of rapid population growth, more and more people have to be supported on a deteriorating resource base. In many of these countries, interrelated economic activities have eroded natural resources to an extent that threatens sustainable economic development. ^{1/} For example, deforestation has hurt not only the long-run availability of forest products but has also reduced the fuelwood supply, harmed soil quality, disrupted water supply systems, and contributed to possible global warming. Furthermore, devegetation, soil erosion, and desertification have depressed agricultural yields in a number of countries. Moreover, deterioration of watersheds as well as soil salinization and degradation, all of which are partly due to inappropriate fertilizer and pesticide use, have harmed the livelihood of many farmers. The degradation of the environment has also contributed to the risk of loss or the extinction of plant and animal species, thereby reducing the genetic resources available to future generations. Water pollution together with inadequate waste disposal and water supply result in unsanitary living conditions and raise the costs of water supply. Air pollution levels in several urban centers have become hazardous to human health.

The causes of environmental degradation in developing countries are complex. Rapid population growth exerts pressure on natural resources; poverty is another major contributor because it tends to shorten planning horizons and forces farmers to exploit fragile marginal lands.

^{1/} See Warford (1987).

Moreover, low income levels reduce the resources available for environmental protection. The scarcity of foreign exchange associated with balance of payments problems often raises the cost of importing pollution-abatement equipment and increases the incentives to export certain products at rates that degrade the natural resource base. Lack of modern technology complicates the monitoring of environmental policies, collection of environmental data, and installation of pollution-abatement equipment. When combined with poor maintenance, obsolete technology also causes environmental damage. Moreover, many developing countries face major difficulties in monitoring and enforcing environmental regulations because environmental institutions tend to be poorly equipped and staffed. Political commitment of governments is sometimes lacking, especially when governments pursue their own interest at the expense of that of the public at large because the population cannot exert sufficient control on the public sector. Finally, the international translocation of production facilities has in many cases meant that pollution-intensive activities have moved to developing countries, which, due to a lack of administrative capability or expertise, are unable to enforce tight standards or which tend, perhaps purposely, to implement weaker standards.

Policy failures often worsen environmental problems. Many developing countries encourage the excessive use of natural resources through a variety of subsidies, including tax and tariff concessions and low-interest loans. Examples include the subsidization of irrigation, livestock production, (imported) agricultural machines, timber mining, fertilizers, pesticides, petroleum, as well as inadequate user charges for the use of water and timber resources, irrigation, waste disposal, and energy (mostly electricity). Poorly defined and ill-secured property rights together with policy uncertainty and inadequate levies for the harvesting of publicly owned natural resources (such as tropical forests) also cause environmental degradation. Policies that discriminate against the agricultural sector worsen urban pollution by encouraging rapid urbanization through rural migration. At the same time depressed farm profitability reduces the returns to and, therefore, incentives to investment in land development and conservation.

2. Industrial countries

Air and water pollution are the major environmental problems confronting industrial countries. In these countries, pollution is currently a significant contributor to several global environmental problems, including marine pollution, possible climate change, and ozone depletion. Air pollution is often closely related to energy use, transportation, and emissions by the industrial sector, which plays a major role in the economies of industrial countries. The dumping of waste (including toxic substances) poses a threat to the quality of soil and of ground and surface waters. Agricultural activities also often pollute the soil as well as ground and surface waters. Furthermore, emissions by industry, public utilities, traffic, and agriculture result in the deposition of acidifying substances, or acid rain, which reduces

the vitality of the forests and the quality of the soil. The presence of international spillovers complicates adoption of policies for addressing these problems. Protectionist trade policies sometimes pursued by industrial countries aggravate the environmental problems facing developing countries insofar as these policies discourage some developing countries from exporting labor-intensive commodities, thereby forcing them to rely more heavily on resource-intensive exports. Agricultural support policies in some industrialized countries may harm the natural resource base of many developing countries by depressing producer prices for farmers.

In industrial countries, policy failures can contribute to environmental degradation in several ways. First, in the face of conflicting environmental, trade, distributional, and regional objectives, governments sometimes subsidize the mining of coal and levy low taxes on energy. Second, agricultural policies often worsen environmental degradation by linking agricultural subsidies to production decisions. ^{1/} Third, intra- and intergenerational distributional conflicts often inhibit environmental protection. Finally, uncertainty and inadequate knowledge about environmental relationships, weak and inexperienced environmental regulators, ill-defined property rights, and costly enforcement of environmental policies contribute to environmental degradation. Nevertheless, compared with many developing countries and East European countries, industrial countries seem in recent years to have shown greater concern for protecting the environment. ^{2/} They have relied mainly on regulatory approaches, but recently several countries have been, or have expressed interest in, complementing regulation by market-based approaches because incentive-based approaches promise to reduce costs and encourage the development of environmentally friendly technologies.

3. East European countries

East European countries face a number of serious environmental problems, including significant air pollution primarily associated with the extensive use of brown coal. In many areas, water pollution is also a problem, owing to inadequate sewage treatment, agricultural runoff of fertilizers, and discharge of saline mine water and other kinds of untreated industrial waste. Some areas face shortages of fresh water because of water pollution and the inefficient use of water resources. Furthermore, toxic waste, use of heavy metals, and excessive use of fertilizers have contributed to contamination of the soil in several locations.

^{1/} See U.S., Economic Report of the President (1990).

^{2/} See OECD (1989).

The causes of environmental problems confronting East European countries are many and complex. Their histories of central planning with heavy emphasis on industrialization and energy trade within the Council for Mutual Economic Assistance (CMEA)--and particularly with the USSR--has played an important role. At the same time, the absence of well-defined property rights and competitive discipline of market forces (including bankruptcy) have led enterprises to inefficiently use inputs (including those damaging to the environment). Other factors contributing to environmental degradation have been the use of obsolete technology and the availability of brown coal. Moreover, environmental regulations have been largely ineffective because the state, which was both polluter and regulator, did not enforce them and lacked information and necessary expertise. The lack of political accountability may also have allowed economic enterprises and government agencies to further their organizational self-interest at the expense of the public interest by pursuing environmentally damaging policies.

During the transition of East European countries toward more market-based economies, sound environmental policies could be important. Market signals incorporating environment externalities could guide the allocation of new investment. This could prevent market failures from resulting in an excessive specialization in polluting activities as trade with the rest of the world expands. Economy-wide reforms that strengthen competitive market pressures (enforce bankruptcy), clarify property rights, and bring energy prices in line with world prices, could all help alleviate the environmental degradation in these countries. In addition, taking advantage of the assistance and experience of other countries, the governments could develop the capacity to monitor and enforce stable and broad-based environmental standards. Fees and fines might have to be raised in order to encourage enterprises to take into account environmental costs. Other market-based instruments, including tradable pollution permits, could also be considered.

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