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Tax Policy and the Environment:

Theory and Practice

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Abstract

This paper provides a framework for examining environment taxes. It reviews the theoretical efficiency of three types of environment taxes: taxes on emissions or Pigouvian taxes; taxes on productive inputs or consumer goods whose use is related to environmental damage; and environment-related provisions in other taxes. A survey of environment taxes in 42 countries--drawn from developing countries, economies in transition, and industrial countries--illustrates that the use of environment taxes differs dramatically from the recommendations of environment tax theory. This divergence between the theory and practice of environment taxes can be attributed to several factors; environment taxes are difficult to implement, there are many factors that impede their effectiveness, and their introduction may be discouraged by their implications for other policy objectives.

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Summary

This paper reviews the effectiveness of three types of environment taxes--Pigouvian taxes (per unit taxes on emissions); taxes on inputs or consumer goods whose use is related to environmental damage; and environment-related provisions in other taxes--and surveys the use of these taxes in 42 developing countries, economies in transition, and industrial countries.

The paper finds a wide gulf between the theory and practice of environment taxation. The three types of environment taxes are ranked in terms of conventional efficiency criteria: Pigouvian taxes, with appropriately set tax rates, are efficient; taxes imposed on goods whose use is linked to environmental damage are not usually efficient and are ranked second; and environment-related provisions in other taxes are ranked third. The survey suggests that environment taxes are not used extensively and that Pigouvian taxes, the efficient tax solution to environmental damage, are not generally employed. The conventional efficiency argument in favor of environment taxes is thus typically invalidated by the widespread use of taxes other than Pigouvian taxes.

A number of possible explanations for the wide gulf between the theory and practice of environment taxation are identified: (1) design and implementation factors vary significantly across countries, with the consequence that environment taxes may not be straightforward to use; (2) the effectiveness of environment taxes can be hampered by macroeconomic instability, soft state-owned enterprise budget constraints, and a failure in markets for substitutes for the taxed item; and (3) efficient environment taxes may conflict with other policy objectives such as economic output, employment, international competitiveness, and equity.

The preceding three impediments apply, in varying degrees, to all types of environment taxes, but the difficulty in designing and administering Pigouvian taxes, especially in developing countries, is the most significant obstacle to mitigating environmental damage through the tax system. In circumstances where Pigouvian taxes cannot be employed, environment taxes are not necessarily the best policy. Consequently, in practice, a combination of policies is likely to be required to address environmental damage. The extent to which use is made of environment taxes in these circumstances is defined by their relative cost effectiveness.

Introduction

A number of different types of taxes have been used to pursue environmental objectives. Two features of environment-related taxes are often overlooked. First, the efficiency argument in favor of environment taxes is invalidated by the widespread use of taxes that differ from Pigouvian taxes which economic theory suggests are the efficient solution to environmental damage. Second, design and implementation factors that determine the effectiveness of environment taxes vary significantly across countries. Consequently, environment taxes may not be straightforward to implement, and may not be the most efficient instruments for mitigating environmental damage, in all circumstances.

The paper has three main parts. First, a theoretical examination of three types of environment taxes provides a ranking of these taxes in terms of conventional efficiency criteria: Pigouvian taxes, that are imposed on emissions, are most efficient, taxes imposed on goods whose use is linked to environmental damage are ranked second, and environment-related provisions in other taxes are ranked third (Section I). Second, the use of environment taxes in 42 countries--economies in transition, developing, and industrial countries--is surveyed. Environment taxes are not used extensively. Of those environment taxes that are implemented, Pigouvian taxes are used infrequently; more common is the use of environment-related provisions in other taxes (Section II). Third, a number of factors are identified that contribute to an explanation of the wide gulf between the theory and practice of environment taxation. These include the difficulty of designing environment taxes, factors that impede the effectiveness of environment taxes, and the trade-offs between environmental and other policy objectives that can discourage their use (Section III). Policy implications and conclusions are presented in a final section (Section IV).

I. Theoretical Aspects of Environment Taxes

Taxes influence environmental damage by changing relative prices. 1/ There are three categories of these environment taxes: (1) taxes on emissions or Pigouvian taxes; (2) taxes on productive inputs or consumption goods whose use is related to environmental damage or indirect environment taxes; and (3) environment-related provisions in other taxes. This section examines the effectiveness of these three categories of taxes. Pigouvian taxes are the most efficient tax measure for pollution abatement according to the theory of externalities. However, the fundamental efficiency case for Pigouvian taxes does not apply to the variety of environment tax

1/ For the purposes of this paper, environmental damage is defined to arise when the marginal social cost of using environmental resources exceeds the marginal social benefit. The divergence between marginal social cost and benefit can arise due to: market failure--the failure of markets to equate marginal social cost and benefit or policy failure--a microeconomic policy that encourages excessive use of an environmental resource.

measures that countries may employ and this is often overlooked in considering environment tax policy. Other types of environment taxes are efficient in only a limited set of circumstances. Indirect environment taxes and environment-related provisions in other taxes can be equally cost effective for pollution abatement. However, unintended, incentive effects of environment-related tax provisions may make them less cost effective than specifically targeted indirect environment taxes. This suggests a general efficiency ranking of environment taxes; most efficient are Pigouvian taxes followed by indirect environment taxes, and, least efficient are environment-related provisions in other taxes.

1. Pigouvian taxes

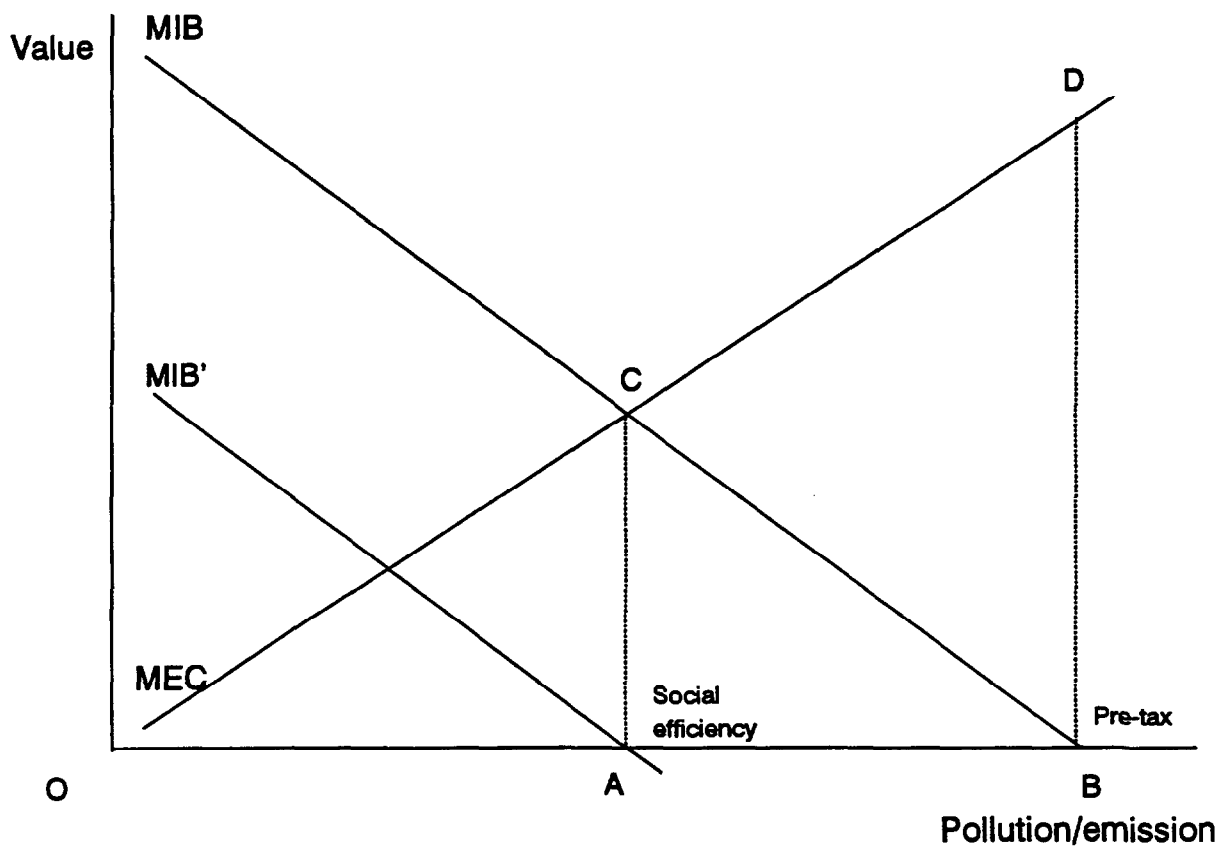
Pigouvian taxes are specific rate taxes on units of emissions or damage. ^{1/} The rate of tax is equal to marginal social cost at the socially efficient level of emissions. The socially efficient level of emissions occurs where the marginal benefit to firms from waste emissions equals the marginal social cost of those emissions. By raising the price of polluting to reflect social cost, Pigouvian taxes ensure that polluters face the private and social costs of their actions.

A Pigouvian tax is illustrated in Chart 1 which shows the costs and benefits that arise from firms emitting waste. The marginal internal benefit (MIB) schedule shows the marginal benefit to firms from emitting waste at various levels of emissions. This marginal benefit is defined in an opportunity cost sense as the savings earned by the firm from being able to emit waste. Firms will emit waste as long as the benefit to them exceeds the private cost. Consequently, in the absence of environmental policy, firms will emit waste to the point, shown by B, where any further emission fails to yield benefits. This waste emission exceeds the socially optimal level which is shown as A in Chart 1. This emission level is defined by the equality of the MIB schedule and the marginal external cost (MEC) schedule; the latter schedule shows the marginal social cost of environmental damage from emissions. The Pigouvian solution is to introduce a tax at a rate per unit of pollution equal to the marginal social cost at the socially optimal level, or, in Chart 1, a tax equal to AC per unit of waste emitted. This tax reduces the marginal benefit to firms from emitting waste by the tax rate. Thus, the marginal internal benefit schedule shifts to MIB' and firms optimize by emitting waste to point A which coincides with the socially efficient emission level.

Two distinctive features of Pigouvian taxes make them attractive from the perspective of social efficiency. First, the costs of environmental policy may be reduced by taxes because they rely on the price system in contrast to the administrative costs of command and control policies.

^{1/} Discussion of the extensive literature on Pigouvian taxes, not considered here, is found in a variety of sources such as Baumol and Oates (1988).

Chart 1. Pigouvian Taxes



Second, Pigouvian taxes reduce pollution in the least cost manner by encouraging (a) the greatest pollution abatement by firms able to adjust at lowest cost, and (b) least cost abatement by each firm. Thus, as firms reduce waste emissions from point B to point A in Chart 1, they determine the combination of lower output, changes in inputs, and investment in new technology that reduces emissions at least cost. For example, a Pigouvian tax on vehicle emissions may induce a reduction in automobile miles traveled, improved maintenance of vehicles, and investment in catalytic converters.

2. Indirect environment taxes

An indirect environment tax is intended to encourage pollution abatement by taxing productive inputs or consumption goods whose use is linked to environmental damage, rather than taxing emissions directly as is the case under a Pigouvian tax. Indirect environment taxes provide price incentives that induce producers and consumers to change their emissions behavior so that the socially efficient level of emissions may be achieved. However, the fundamental efficiency case for environment taxes is, in general, invalidated by the use of these taxes.

The key to assessing the efficiency of an indirect environment tax is the nature of the linkage between the indirect environment tax base and the environmental damage. The importance of this linkage is illustrated by comparing two indirect environment taxes; a carbon (fossil fuels) tax--which is an efficient indirect tax--and a gasoline tax which is not efficient. A carbon tax is intended to minimize global warming which arises, inter alia, from carbon dioxide emissions. Carbon dioxide emissions will be reduced efficiently whether the input--fossil fuels--or the emission--carbon dioxide--are taxed because there is no "end-of-pipe" technology that permits a change in the fixed proportional relationship between the combustion of fossil fuels and emissions of carbon dioxide. ^{1/} Thus, reduction of carbon dioxide emissions is effectively met by either an indirect tax--a carbon tax--or a Pigouvian tax levied directly on carbon dioxide emissions. However, the carbon tax is an exception. In most cases an indirect tax, such as a gasoline tax intended to address local air quality concerns, is not as efficient as a Pigouvian tax because there is not a fixed proportional relationship between the use of gasoline and local air quality. An efficient tax on vehicle emissions would result in lower emissions from a combination of measures determined by their relative costs. Indirect environment taxes such as petroleum taxes do not encourage abatement on all margins. In fact, they may discourage the use of some efficient methods of emissions abatement, such as use of catalytic converters, that are made more expensive by the tax. Consequently, an indirect environment tax will generate a socially efficient level of emissions in the least cost manner only if there is a fixed proportional linkage between the taxed item and the other adjustment variables.

^{1/} Taxing inputs may, however, remove the incentive for innovation of end-of-pipe technology that could reduce emissions.

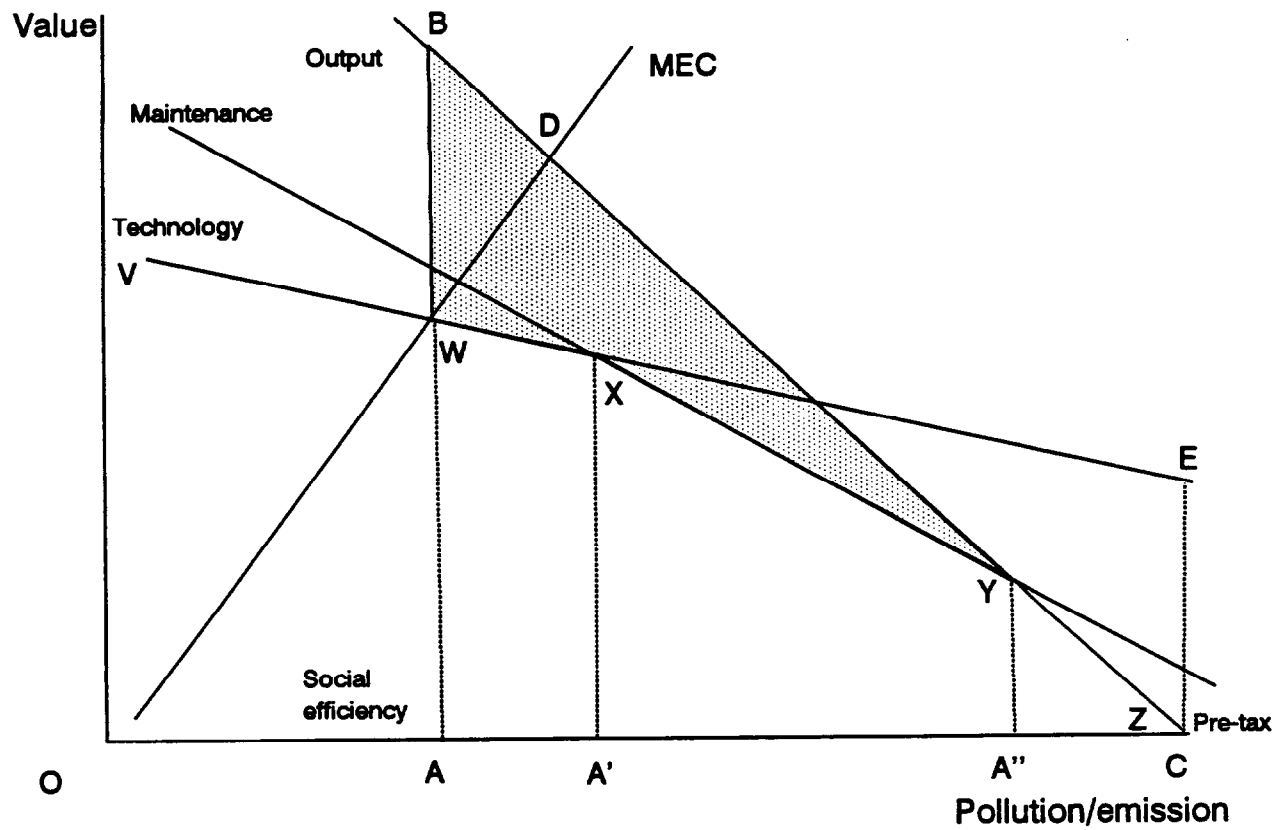
Chart 2, which is similar to Chart 1, illustrates the efficiency characteristics of an indirect tax by examining the implications of various methods of emissions abatement. The marginal external cost schedule (MEC) shows the marginal social cost of the environmental damage. The marginal internal benefit to the firm from polluting is conceptually the same as in Chart 1 but in Chart 2 the component parts of the schedule are illustrated. Assume that it is technically possible for the firm to reduce emissions on three dimensions; output, maintenance, and technology. The cost of abatement in each of these dimensions determines the firm's marginal internal benefit schedule; the "output" schedule is the marginal cost of abatement secured by lower output; the "maintenance" schedule is the marginal cost of abatement attributable to improved maintenance; and the "technology" schedule is the marginal cost of abatement from investments in technology. As constructed, abatement of emissions from the pretax level is achieved at lowest cost via lowering output. However, once emissions decline to point A' it becomes efficient to reduce emissions further via improved maintenance and, beyond point A', lower emissions are best secured via investment in technology. The marginal internal benefit schedule is thus composed of the least cost segments of each abatement cost schedule and denoted VWXYZ. The intersection of the marginal external cost and marginal internal benefit schedules indicates that social efficiency requires pollution abatement of AC.

Two results are drawn from comparing the effectiveness of a Pigouvian tax and an indirect environment tax in securing social efficiency.

a. The indirect environment tax will impose greater costs than a Pigouvian tax. In response to a Pigouvian tax, firms reduce emissions by the least cost combination of adjustment on all possible dimensions; in Chart 2 from C to A' by lowering output, from A' to A' by improving maintenance, and from A' to A by investing in new technology. The total cost of abatement is the area under the marginal internal benefit schedule over the relevant range which is the area AWXYZ. In contrast, an indirect environment tax, that only encourages lower output to achieve the targeted reduction in emissions, imposes higher costs. The firm adjusts to the tax by moving along the "output" abatement schedule and not the marginal internal benefit schedule. The abatement cost of the indirect environment tax thus amounts to ABC which is more costly than the Pigouvian tax by the amount shown by the shaded area.

b. It may be preferable to permit continuation of the environmental damage rather than employ an indirect tax to achieve the socially efficient emissions reduction. This results because the private costs of reducing emissions may exceed the social benefits of the lower environmental damage over some ranges of emissions reduction (e.g., this occurs over the range DB in Chart 2). Indeed, excessive abatement costs may lead to greater social costs than the costs of the environmental damage that the tax is intended to mitigate. Therefore, it may be appropriate to either scale back the targeted emission reduction or to not employ any environment tax when a Pigouvian tax is not feasible.

Chart 2. Indirect Environment Taxes



In sum, indirect environment taxes are similar to Pigouvian taxes because they use the price system rather than a command and control policy and, thereby, indirect environment taxes may reduce the cost of environmental policy. However, unlike Pigouvian taxes, they will not encourage abatement of environmental damage at least social cost unless there is a fixed proportional linkage on all abatement margins. To avoid the risk that the indirect tax imposes excessive abatement costs, it is still important that the policymaker knows the marginal internal benefit and marginal external costs schedules. Indirect environment taxes do, however, have the advantage that it is often easier to tax goods that are linked to the damage than the damage itself as is required by the Pigouvian tax solution.

3. Environment-related provisions in other taxes

Environmental goals may be pursued through provisions in other taxes. These provisions can have similar effects to indirect environment taxes. For example, measures that provide incentives to invest in pollution abatement equipment are analogous to indirect environment taxes because they may only target one dimension of abatement. As a result, abatement may not occur in the least cost manner. Indeed, these measures may distort technology choices, leading to environmental and economic inefficiencies. 1/

The effect of a tax incentive for pollution abatement can also be illustrated by using Chart 2. For example, consider the case where an investment incentive is offered to firms to use equipment, such as a coal scrubber, to reduce emissions. Assume that the use of the technology affects only the emissions and is unrelated to other factors of production. In these circumstances, the firm will only use the environmentally favorable technology if it is compensated for the cost that is reflected in the "technology" abatement schedule. If the policy objective is to reduce emissions from point C to point A the minimum possible subsidy will be the area under the technology schedule or AWEZ. In this case, firms will be indifferent between using the technology or polluting. The social cost of abatement under the investment incentive exceeds the abatement costs of a Pigouvian tax by the area XYZE. The government budget will incur the financial cost of abatement.

Environment-related provisions that take the form of tax expenditures can introduce an additional source of inefficiency that does not characterize indirect environment taxes. Tax expenditures may encourage individual firms to reduce their emissions, however, the subsidy element of the tax expenditure means that exit of polluting firms is discouraged and, in fact, aggregate emissions may increase. 2/ In addition, there is a

1/ See Jenkins and Lamech (1992).

2/ For example, Bramhall and Mills (1966) illustrate this outcome with a subsidy and Baumol and Oates (1988) contrast the cases of using a subsidy with a Pigouvian tax.

danger that environment-related provisions in other taxes, by intentionally using the tax system to modify incentives, will encourage numerous other demands to use the tax system for special treatment of specific activities.

Tax incentives that provide special treatment of specific activities may have unintended harmful environmental implications. These implications are discussed in Appendix II.

II. A Survey of Environment Taxes in Selected Countries

Appendix I surveys tax provisions of 42 countries--economies in transition, developing, and industrial countries--that may have an impact on the environment. The survey shows that environment taxes are not used extensively. In this section, the nature of environment taxes that are used is examined. Table 1, drawn from the survey, identifies environment taxes by country. The table suggests that the use of environment taxes, in practice, is the exact opposite to the ranking that environment tax theory would suggest is desirable. Indeed, environment-related provisions in other taxes are the most common environment tax measures. There are some special, or indirect, environment taxes that are targeted at environmental objectives; however, Pigouvian taxes--the theoretically preferred form of environment tax--are not used widely.

1. Pigouvian taxes

Pigouvian taxes are used only on a limited scale and largely within Europe. ^{1/} Several countries--Australia, Austria, Belgium, Denmark, Finland, France, and Norway--impose waste disposal charges that resemble Pigouvian taxes because they are specific rate taxes related to emissions. Another example is provided by a number of countries--Belgium, France, Germany, the Netherlands, and Switzerland--that impose aircraft landing charges that relate the level of the charge to noise levels. The economies in transition are perhaps most advanced in using Pigouvian taxes. For example, Estonia, Hungary, Poland, and Russia all impose taxes on air and water emissions that take into account factors that affect the level of environmental damage such as quantity and toxicity of emissions.

^{1/} Assessment of these Pigouvian taxes is complicated by the observational equivalence between what some countries term taxes and others charges, penalties, or fees. A tax is an unrequited payment whereas a charge is a requited payment. For example, the government might define property rights over an environmental asset and charge for the right to use that asset for waste disposal or other uses. A possible institutional rationale for use of the term fees or charges is that, in some countries, revenues from these go directly to the ministry responsible for administering the fee whereas tax receipts go to the consolidated revenue fund.

Table 1. Selected Countries: Environment Taxes

	Emissions (Figouvian) Taxes	Indirect Environment Taxes		Environment Provisions in Other Taxes				
		Energy taxes	Other	Personal income tax	Corporate income tax	Sales tax	Fuel tax	Motor vehicle tax
Africa								
Côte d'Ivoire							X	X
Kenya					X			X
Madagascar								X
Nigeria								
Tanzania					X		X	X
Zambia							X	X
Asia								
Australia	X		X		X	X	X	X
India					X			
Indonesia							X	
Japan					X		X	X
Malaysia							X	
New Zealand								
Philippines							X	
Thailand								
Eastern Europe								
Estonia	X						X	
Hungary	X				X	X	X	
Poland	X				X			
Russia	X				X			X
Europe								
Austria	X		X	X	X		X	X
Belgium	X				X	X	X	X
Denmark	X		X		X		X	X
Finland	X	X	X		X		X	X
France	X				X		X	
Germany	X				X		X	X
Ireland					X		X	X
Italy			X				X	X
Netherlands	X	X	X	X	X		X	X
Norway	X	X	X				X	X
Portugal				X		X	X	X
Sweden		X	X				X	X
Switzerland	X			X	X		X	
United Kingdom							X	X
Middle East								
Egypt							X	X
Jordan								X
Western Hemisphere								
Argentina						X	X	X
Bolivia							X	
Brazil					X			
Canada					X		X	X
Chile					X			
Colombia					X			
Mexico					X		X	
United States					X		X	X

Sources: Tables 4 and 5.

It is easy, however, to exaggerate the role of Pigouvian taxes in pollution abatement--suggested in Table 1--for two reasons. First, there is no evidence to suggest that the rates of these taxes reflect marginal external costs. For example, the "two-stage" emissions tax in Russia probably diverges from a true Pigouvian tax because the tax rate increases after a threshold level of emissions is exceeded. Such a rate structure is not optimal unless there is a discontinuity in the marginal social cost curve. More generally, social cost estimates are not readily available making an assessment of rates difficult. There are indications, however, that tax rates are low. For example, Poland's tax on sulfur dioxide (SO_x) and nitrous oxide (NO_x) emissions was approximately US\$80 per ton while abatement costs have been estimated by Bates, Gupta, and Fiedor (1993) to be in excess of US\$500 per ton. Calculations suggest that a tax rate of US\$80 per ton of SO_x and NO_x emissions (Zylicz (1993)) implies an average effective tax rate of approximately 0.1 percent of the price of coal--the major source of SO_x and NO_x emissions. Second, the actual use of these Pigouvian taxes may diverge sharply from the legislated provisions. For example, in the economies in transition the enforcement of the taxes has not been strict--authorities delegated with administration of these measures have used their powers to waive tax payments from companies.

2. Indirect environment taxes

Indirect environment taxes--taxes on productive inputs or consumer goods whose use is related to environmental damage--have been implemented more widely but, in general, only by industrial countries; developing countries and economies in transition have not implemented this type of measure. Examples of indirect environment taxes include the special energy taxes introduced by some European countries (Denmark, Finland, the Netherlands, Norway, and Sweden), fertilizer levies (Austria, Finland, the Netherlands, and Sweden), and taxes on beverage containers (Canada, Denmark, Finland, Norway, and Sweden). Five European countries--Denmark, Finland, the Netherlands, Norway, and Sweden--have introduced carbon or carbon-related taxes. These carbon taxes vary somewhat across countries. For example, the Dutch energy tax is based 50 percent on the energy component of the fuel and 50 percent on its carbon content. The Norwegian taxation of fossil fuels consists of an amalgam of taxes including taxation of electricity, mineral oils, petrol, coal, and coke as well as gas consumption in offshore petroleum activities. The introduction of many of these taxes was achieved by restructuring existing energy taxes.

3. Environment-related provisions in other taxes

Environment-related provisions in other taxes are the most commonly used instrument: they have been implemented in industrial countries, economies in transition, and developing countries. Environment-related provisions have been introduced in personal income taxes, corporate income taxes, general sales taxes, fuel taxes, and motor vehicle taxes.

Environment-related provisions in personal income taxes have been limited to industrial countries and include measures such as Portugal's

incentives for expenditure on forms of renewable energy and Switzerland's incentives for expenditure on energy efficiency.

Many countries have provisions in their corporate tax systems that are intended to reduce environmental damage. Examples in industrialized countries include Japan's capital allowance for solar energy saving equipment and Germany's accelerated depreciation for energy saving and pollution reducing equipment. Developing countries have also used incentives to encourage investments that are environmentally benign. Kenya and Tanzania provide accelerated depreciation for investments that are intended to prevent soil erosion and for planting permanent or semipermanent crops. In Eastern Europe, Hungary provides incentives for the manufacture of environmental products and Poland encourages the use of recycled products and investments in environmental protection in the agriculture sector. In Latin America, incentives for reforestation are provided by Brazil, Chile, and Colombia. Chile also provides incentives for earning income from artificial forests.

There are some examples of environment-related provisions in general sales taxes or value-added taxes (VATs) across all countries. ^{1/} Examples of such provisions include: Australia's exemption of recycled paper, solar power equipment, and conversion of engines to natural gas or liquid propane from wholesale tax; Hungary's lower VAT rate that is applied to vehicles with catalytic converters; Austria's higher VAT rate that is applied to large vehicles; Portugal's lower VAT rate that is applied to equipment used for solar power generation; and Argentina's higher VAT rate that is applied to some supplies of electricity.

Many industrial countries, economies in transition, and a few developing countries use motor fuel tax differentiation to reduce environmental damage. For example, many countries have a higher excise tax rate on leaded fuels and a lower rate on unleaded fuels. Such rate differentiation is intended to discourage consumption of fuels that are significant sources of heavy metal particulate matter.

Motor vehicle taxes have been used with varying degrees of sophistication to discourage motor vehicle use and fuel consumption. Countries, including Côte d'Ivoire, Australia, Japan, Russia, Italy, Portugal, and Argentina, apply annual taxes on automobiles but vary the tax rates according to a measure of fuel consumption such as engine horsepower, fuel consumption rate, vehicle weight or engine size. In other cases, vehicle taxes are designed to encourage the use of vehicles with lower

^{1/} The environmental implications of varying VAT rates is limited to final consumption goods. VAT paid on productive inputs is creditable against subsequent VAT liabilities thus levying a high rate on an environmentally damaging input only calls for a higher credit. The differential rates of VAT can thus only have an environmental effect on those items which are finally consumed or are used as business inputs in sectors ineligible for credits on input tax.

emissions. Austria's annual vehicle tax, for example, is lower if the vehicle has a catalytic converter. Other countries encourage consumption of less environmentally degrading motor fuels by varying their annual vehicle taxes according to the type of fuel consumed by the vehicle. Kenya's tax on vehicles with diesel engines is twice that of the tax on nondiesel engines and Finland applies an annual levy to diesel vehicles.

In sum, Pigouvian taxes are used rarely and mainly in European countries. Indirect environment taxes and environment-related provisions in other taxes are more common--the former have been introduced by industrial countries and the latter by a wide range of countries.

III. The Scope for Environment Taxes

Environment tax theory suggests that Pigouvian taxes rather than other forms of environment taxes should be used for pollution abatement if policy decisions are based solely on efficiency grounds. A comparison of the non-Pigouvian taxes concluded that indirect environment taxes are likely to be superior to incorporating environment-related provisions in other taxes. However, in practice, environment-related tax provisions in a variety of taxes are relied on more than either indirect environment taxes or Pigouvian taxes to pursue environmental objectives. 1/

The divergence between efficient environment tax theory and the practice of environment taxes can be explained by examining three types of factors that influence the introduction of efficient environment taxes. First, efficient environment taxes are difficult to design and administer. Second, country specific economic and structural conditions can hinder the effectiveness of environment taxes. Third, the introduction of efficient environment taxes may conflict with other policy objectives such as economic output, employment, international competitiveness, and equity. Aspects of these factors apply to varying degrees to all three types of environment taxes examined in the paper but it is the difficulty in designing and administering Pigouvian taxes that is the most significant obstacle, especially in developing countries, to efficiently mitigating environmental damage via the tax system.

1/ One conclusion that might be drawn from the survey--based on the limited use of environment taxes--is that many countries simply do not choose to pursue environmental aims by using taxes. Indeed, there may be little political motivation to actively use taxes to pursue environmental objectives. In many circumstances of industrial pollution, for example, limited sources account for the bulk of environmental damage. In these cases, there may be effective political opposition to the use of environment taxes because the polluters are small in number (and perhaps well organized) whereas the beneficiaries of pollution abatement are large in number or diffuse. As a result, regulations or marketable permits may be preferable to environment taxes for pollution abatement because they can be designed to protect the interests of established enterprises.

1. Design and administration of environment taxes

a. Design

In theory, the calculation of an efficient environment tax is relatively straightforward: determine the marginal internal benefit schedule and marginal social cost schedule for a source of pollution. The intersection of these schedules defines the efficient tax rate. In practice, however, the determination of the schedules will be difficult and remains the key challenge in designing an efficient environment tax. 1/

The determination of the marginal social cost schedule is a difficult valuation problem because there often are many dimensions to social cost. For example, estimating the social cost of a particular polluting activity may require an understanding of the impact of pollution on human health, the appearance of human habitats, natural parks and recreation facilities, and biological diversity. An additional layer of complexity is added to the valuation problem if the impact of pollution on these factors varies intertemporally or spatially. Similarly, the marginal internal benefit schedule will be difficult to measure. This schedule will depend on the many dimensions of pollution abatement such as adjustment in inputs, output reductions, and technological change. All of which may be difficult to assess empirically.

These aspects of defining the efficient Pigouvian tax rate also apply to indirect environment taxes. The design of indirect environment taxes suffer from another difficulty: they can involve uncertainty in estimating the responsiveness of the pollution to indirect environment taxes. Indeed, setting an indirect environment tax rate based on a quantity target requires an understanding of the elasticity of the damaging activity to the tax and the elasticity of the pollution to the damaging activity. This is especially important because of the potential for excessive abatement costs associated with indirect environment taxes. In fact, uncertainty in defining the tax rate to achieve a target emissions level may justify the use of quantity-based policies. The policy issue here is whether setting the quantity incorrectly or, via a tax, setting the price incorrectly will cause the greatest cost. 2/

b. Administration

Pigouvian taxes are analogous to specific rate excise taxes. Specific rate excise taxes on goods, such as alcohol and tobacco products, are viewed as easy to administer because they apply to goods that are easily identifiable. They are also subject to control if excisable goods cannot be released from bonded warehouses prior to payment of tax. This feature of excises does not, however, apply to Pigouvian taxes because it may be

1/ Cropper and Oates (1992) discuss the various means of valuation that might permit the setting of an efficient Pigouvian tax rate.

2/ See Oates (1992) and OECD (1993b).

technically or practically difficult to measure and monitor physical quantities of pollution. For example, it may be relatively simple to measure pollution from a single emitting source such as a factory effluent pipe or smokestack but it is obviously quite difficult to measure each pollution source when there are many sources such as, for example, in the case of automobile exhaust pipes.

For Pigouvian taxes on some types of pollution, there may be significant numbers of taxpayers providing negligible amounts of revenue to the treasury. Indeed, the incentive to effectively administer efficient environment taxes will be reduced if revenue per unit of administrative outlays is low. In addition, the multiplicity of environmental problems implies that many taxes are required and this multiplies the difficulty of administering efficient taxes. Further administrative difficulties arise if spatial or temporal aspects of an environmental problem are addressed by taxes because measurement of emissions across geographic regions may be difficult. For example, the tax authorities would be required to determine the levels of emissions in urban and rural areas and impose taxes accordingly if an efficient environment tax on automobile emissions was to be adopted.

Many of these administrative difficulties would not have to be dealt with, in general, if an indirect environment tax were introduced because the tax would be calculated on the price of productive inputs or consumer goods. Thus, indirect environment taxes may be easier to administer even though more difficult to design than Pigouvian taxes.

2. Economic and structural conditions

Economic and structural conditions in a country may limit the effectiveness of efficient environment taxes. This could be a significant impediment to the introduction of such taxes. Three aspects of these conditions may be important: macroeconomic stability, the role of state-owned enterprises, and the prevalence of market failure.

a. Macroeconomic stability

Pigouvian taxes are difficult to maintain in the presence of macroeconomic instability. For example, high and/or variable inflation rates will limit the effectiveness of Pigouvian taxes because they are specific rate taxes. Inflation quickly erodes the real value of tax rates that are intended to reflect marginal social costs. Effectiveness can be maintained, in part, by providing mechanisms to adjust nominal tax rates frequently in order to maintain real tax rates. In practice, however, nominal tax rate adjustments may be difficult to implement. This has been confirmed by the experience of the economies in transition. ^{1/}

^{1/} See, for example, Zylicz (1993) and Pomazi and Zsikla (1993).

Macroeconomic instability also limits the effectiveness of indirect environment taxes and environment-related provisions in other taxes. High or variable inflation mitigates the effectiveness of price signals thereby reducing the effects of indirect environment taxes. Inflationary conditions will also erode the incentive effects of some forms of tax expenditures.

b. State-owned enterprises

Environment taxes may well be ineffective in circumstances where state-owned enterprises play an important role because these enterprises may not be responsive to the price signals created by environment taxes.

Industrial pollution problems are often dominated by a few industries, particularly in the materials processing sectors, which in many economies are dominated by state-owned enterprises. Table 2 shows the most important polluting industries based on three measures of pollutants. Subject to the industrial structure of the country under consideration, it would not be unusual for a few industries to account for the major part of industrial pollution. Thus, in Indonesia, for example, Wheeler and Martin (1993) are able to identify five industries that account for well in excess of 50 percent and in some cases almost all of the industrial pollutants.

Although direct evidence is unavailable, it is hypothesized that in many countries not only are state-owned enterprises important they are dominant in some of the most pollution-intensive sectors. 1/ In Poland, for example, the power industry, chemical industry, metallurgy, and building material industry account for 60 to 70 percent of total air pollution. 2/ In these instances, it is important to evaluate whether or not taxes will provide the appropriate incentives for reducing environmental damage. The results of a study evaluating the likely responsiveness of enterprises to higher energy prices in Poland showed that "in the short to medium term, these changes would have little impact on either the pattern of industrial fuel use or the general level of fuel efficiency." 3/

c. Market failure

When there is failure in the markets for substitutes to an item subject to an environment tax, environmental damage may be exacerbated by the imposition of the tax. Table 3 suggests that some developing countries are characterized by substantial environmental damage. As a result, the

1/ State-owned enterprises play a significant role in many countries although their importance varies significantly across countries (see Milanovic (1989)). In the case of Poland, for example, while over 80 percent of the retail trade had been privatized by the end of 1992, only some 12-15 percent of industrial production was accounted for by privatized industry (see Bates, Gupta, and Fiedor (1993)).

2/ See Poland Ministry of Environmental Protection, Natural Resources, and Forestry (1991).

3/ World Bank (1991), p. 16.

Table 2. Major Industrial Sources of Pollution

ISIC	Sector	BOD <u>1/</u>	TSP <u>2/</u>	TOX <u>3/</u>
<u>Assembly Sectors</u>				
3210	Other textile products			
3220	Wearing apparel			
3230	Leather and products			X
3240	Footwear			
3320	Furniture, fixtures			
3410	Other paper products		X	X
3420	Printing, publishing			
3520	Other chemical products	X		
3560	Plastic products			X
3810	Metal products	X		
3820	Other machinery n.e.c.			
3825	Office and computing machinery			
3830	Other electrical machinery			
3832	Radio, television, etc.			
3840	Transport equipment			
3841	Shipbuilding, repair			
3843	Motor vehicles			
3850	Professional goods			
3900	Other industries			
<u>Materials Processing Sectors</u>				
3110	Food products	X	X	
3130	Beverages	X		
3140	Tobacco			
3211	Spinning, weaving	X		
3310	Wood products		X	
3411	Pulp, paper	X	X	
3510	Other industrial chemicals			X
3511	Basic industrial chemicals	X		X
3512	Agricultural chemicals			X
3513	Synthetic resins			X
3522	Drugs and medicines			
3530	Petroleum refineries			
3540	Petroleum and coal products	X	X	
3550	Rubber products			
3610	Pottery, china, etc.			
3620	Glass and products		X	
3690	Nonmetal products n.e.c.		X	
3710	Iron and steel		X	X
3720	Nonferrous metals	X	X	X

Source: Wheeler and Martin (1993).

X refers to upper quartile in distribution of 38 ISIC intensities by pollutant.

1/ BOD is biological oxygen demand resulting from the emission of organisms into waterways.

2/ TSP is total suspended particulates.

3/ TOX is toxic emissions including waterborne toxic metals and carcinogenic compounds.

Table 3. Selected Countries: Environmental Damage Estimates 1/

Country	Form of Environmental Damage	Annual Damage Costs (As Percent of GNP)
Burkina Faso	Crop, livestock, and fuelwood losses due to land degradation	8.8
Ethiopia	Effects of deforestation on fuelwood losses due to land degradation	6.0-9.0
Madagascar	Land burning and erosion	5.0-15.0
Malawi	Soil erosion	0.5-3.1
Mali	On-site soil erosion losses	0.4
Nigeria	Soil degradation, deforestation, water pollution, other erosion	17.4
Indonesia	Soil erosion and deforestation	4.0
Hungary	Pollution damage (mainly air pollution)	5.0
Poland	Pollution damage	4.4-7.7
Germany <u>2/</u>	Pollution damage (air, water, soil pollution, loss of biodiversity)	1.7-4.2
Netherlands	Some pollution damage	0.5-0.8
United States <u>3/</u>	Air pollution control Water pollution control	0.8-2.1 0.4

Source: Pearce and Warford (1993).

1/ Various years in the latter half of the 1980s.

2/ Pre-unification.

3/ Benefits of environmental policy, that is, avoided damages rather than actual damages.

imposition of an otherwise efficient Pigouvian tax may, while resolving one environmental problem, change relative prices in such a way that other forms of environmental damage are exacerbated. Indirect environment taxes could also induce such substitution effects. An example of this problem is the use of an indirect environment tax on petroleum fuels that worsens the problem of market failure in forests. By raising the relative price of fuels there is resort to fuelwoods whose price is unaffected by the change in policy. Another case arose in Thailand where a tax on chemical fertilizers, which in most circumstances is environmentally beneficial, resulted in environmental damage because it encouraged a technological substitution from intensive farming to extensive farming which was accomplished by clearing and cultivating marginal forest lands. ^{1/}

3. Other policy objectives

The use of inefficient environment taxes may be attributed to the balancing of environment policy objectives against other policy objectives such as economic output and development, employment, international competitiveness, and equity of the tax system. The balancing of these competing policy objectives could be a significant impediment to the introduction of efficient environment taxes.

a. Economic output

Environment taxes are likely to harm economic output although this conclusion can only be made usefully on the basis of a comparison of the output costs of alternative taxes. Although environment taxes provide social benefits in the form of reduced environmental damage, they are like other taxes in the sense that they lead to modifications in production decisions or consumption patterns. Such modifications may lead to reduced economic output. ^{2/} As a result, policymakers may consider balancing reduced economic output against the gains from an efficient environment tax. This may lead to modification of efficient environment tax proposals so that indirect environment taxes or environment-related provisions in other taxes are introduced. However, such measures may still involve a trade-off between environmental and output goals because relative to broad-based tax measures, indirect environment taxes can have significant output costs. Goulder (1992), for example, shows in a general equilibrium model of the United States that output costs of employing energy taxes significantly exceed the costs of increasing personal or income taxes and, by a bigger margin, the use of a broad-based consumption tax.

^{1/} See Reed (1992), p. 105.

^{2/} This argument is simplified by assuming that the environmental externality has no effect on productivity and output. If productivity is harmed by environmental damage, the environment tax, to the extent that it alleviates that damage, may raise productivity. Should this occur, the excess burden for taxpayers should reflect both abatement costs and improved productivity (see Nellor (1994)).

b. Employment

The possibility that labor bears the environment tax burden could influence the use of or design of environment taxes. Environment taxes may well harm employment of labor for two reasons. First, to the extent that these taxes result in lower output, as suggested above, they are likely to harm employment prospects. Second, employment prospects could be harmed further if the cost of labor is increased by the use of environment taxes. Although there is no general conclusion on the implications of environment taxes for relative labor costs there are a number of circumstances in which employment of labor could be made less attractive because labor bears a significant part of the tax burden. Labor, as the immobile factor of production, is likely to bear the major part of the tax burden where goods are tradable and environment taxes increase the costs of productive inputs. Domestic consumers are likely to bear the tax in the case of nontradable goods. However, just because the tax is borne by consumers does not ensure that employment prospects are protected. Labor income earners along with capital income earners as well as recipients of transfers all bear the tax when it falls on consumers. Taxes that raise consumer prices may interact with taxes on labor income adding to the distortion that shifts the supply of labor and discourages employment. 1/

c. International competitiveness

Environment tax measures can, subject to the incidence of the taxes, harm international competitiveness. This concern may be reduced somewhat if an environment tax is on tradable goods and it is levied at the consumption stage. However, the tax may interact with labor income tax distortions to worsen competitiveness. In other cases, the environment tax burden may be exportable. For example, a European proposal for a carbon/energy tax called upon other OECD countries, particularly the United States and Japan, to introduce similar measures. These countries combined are major importers of oil and if they imposed energy taxes it is plausible that the tax burden could to some degree be shifted to energy producers. In the absence of such agreements, international competitiveness concerns may impede the introduction of environmentally desirable taxes. 2/

The European Commission's carbon/energy tax proposal is an example where the environment tax design is modified, reducing environmental effectiveness, to reflect concerns regarding international competitiveness.

1/ See, for example, Bovenberg and de Mooij (1992).

2/ There have been a number of empirical studies evaluating the implications of environment regulations on competitiveness and location of investment. These studies suggest that the concern that environment taxes harm international competitiveness is perhaps misplaced. This is because the cost-reward equation for avoiding environment taxes is not profitable in any but the most energy intensive industry. See, for example, Richardson and Mutti (1976) and (1977), Duerksen and Leonard (1980), Leonard (1988), and Knodgen (1979).

The carbon/energy tax proposal provided for (1) graduated tax reductions for energy-intensive firms that may be disadvantaged relative to competitors in countries not having comparable tax measures; 1/ (2) tax incentives and temporary exemptions from the carbon tax for firms embarking on energy saving investment; and (3) introduction of the tax in Europe was conditional on other OECD countries introducing taxes or measures with similar effect to the European carbon/energy tax. Many of these special provisions reduce the environmental effectiveness of the tax because they do not encourage substitution away from fossil fuels but, from a macroeconomic perspective, they limit the magnitude of the tax on tradable goods and perhaps shift the major tax burden from producers toward final consumption.

d. Equity

Equity concerns may impede the introduction of environment taxes. Many environment taxes are regressive because they raise the price of commodities which comprise a larger share of income of lower income consumers. For example, the empirical literature qualifies, although it does not refute, the common perception that a tax on the carbon content of fossil fuels will be regressive. The raw data for the United States support the conclusion that such a carbon tax is regressive; the percent of income going to fossil fuel consumption in the lowest decile of income is 10.1 percent compared to 1.5 percent of the highest decile of income. 2/ Other factors suggest that the tax may not be as regressive. For example, using permanent income to assess the progressivity of carbon taxes shows that the tax is considerably less regressive and, in a number of European countries, it is no longer regressive at all. Nevertheless, equity concerns are often raised as an impediment to the introduction of environment taxes.

IV. Policy Implications and Conclusions

This paper examined the efficiency of three types of environment taxes: Pigouvian taxes that are levied on emissions, indirect environment taxes that are levied on productive inputs or consumer goods whose use is linked to environmental damage, and environment-related provisions in various other taxes. Of these taxes, Pigouvian taxes are most efficient and, of the non-Pigouvian taxes, specifically targeted indirect environment taxes are likely to be more effective than use of incentives in other types of taxes.

A survey of environment taxes used in 42 countries--developing countries, economies in transition, and industrial countries--suggests that the practice of environment taxes diverges from the theory of environment taxes. Although environment taxes are not used extensively, the most

1/ The graduated tax reductions are available to firms for whom energy costs exceed 8 percent of value added.

2/ See Poterba (1989). However, European data do not unambiguously support this conclusion. See Smith (1992).

prevalent environment taxes are environment-related provisions in other taxes. Pigouvian taxes and indirect environment taxes are not used widely.

The divergence between the theory and practice of environment taxes may relate to three types of factors that influence the introduction of environment taxes. First and foremost, environment taxes are difficult to design and administer due to problems with measurement, monitoring, and compliance. Second, the effectiveness of environment taxes can be hampered by macroeconomic instability, soft state-owned enterprise budget constraints, and failure in markets for substitutes to the taxed item. Third, trade-offs between environmental and other policy aims such as output, employment, international competitiveness, and equity may discourage the use of efficient environment taxes.

Ultimately, the role of environment taxes must be assessed in the context of the range of environmental policy instruments that could be employed. These other policy instruments include structural measures, such as land (property rights) reform, pricing reform for products that are linked to environmental damage, regulatory policies, tradable permits, as well as other fiscal measures such as nontax subsidies. A spectrum of policy combinations can be envisaged: at one extreme lies the Pigouvian tax, which environment tax theory suggests is the most efficient policy instrument, and perhaps at the other end of the spectrum is a regulatory system which could be preferred in circumstances where, for example, tax administration is weak. In practice, a combination of policy instruments is likely to be required to address environmental damage with the relative importance of tax and other environmental policy instruments determined by their relative cost effectiveness. The particular combination--and thus the importance placed on taxes--is defined by equating the marginal efficiency costs of each instrument. ^{1/} The greater the efficiency or other costs of using taxes the smaller the role they should play in environmental policy.

^{1/} The cost effectiveness of tax and other environment policy measures, evaluated on a case-by-case basis, permits the choice between alternative policy instruments to be made. Such an approach is illustrated by Eskeland (1993) who demonstrates, in a study of Mexico City air pollution, that the use of a gasoline tax--which is inefficient in addressing local air pollution problems--combined with regulatory measures requiring automobile monitoring is superior to using either instrument alone. More generally, the conclusion that can be drawn from Eskeland's analysis is that a combination of policy instruments should be used such that the efficiency costs of each instrument are equated at the margin.

A Survey of Environment Taxes

Tables 4 and 5 survey tax provisions of 42 countries--economies in transition, developing, and industrial countries--that may have an environmental impact. These tables briefly describe environment tax measures that have been implemented--Pigouvian taxes, indirect environment taxes, and environment-related provisions in other taxes--and provisions in other taxes that may unintentionally have adverse environmental consequences. The former information has been summarized in Table 1. There are two appendix tables: Table 4 lists Pigouvian taxes and domestic taxes on goods and services, and Table 5 lists income, profits, and property tax provisions.

The survey cannot be comprehensive due to the multiplicity of possible interactions between taxes and the environment. In addition, environment tax provisions in the countries surveyed may have changed considerably since the publication date of the various sources for the survey. Thus, the survey provides an illustrative picture of the state of tax policy and the environment at the end of 1993.

Table 4. Selected Countries: Environment-Related Aspects of Taxes
Pigouvian Taxes and Taxes on Goods and Services 1/

Country	Pigouvian Taxes	Fuel and Energy Taxes	General Sales or VAT	Excises
<u>Africa</u>				
Côte d'Ivoire	...	Specific rate tax on all petroleum products. Rate varies by product.	...	Specific rate taxes on timber production, land area under logging, and forest replacement tax.
Kenya	...	Refinery throughput tax levied on all charges made by a refinery in respect of refining crude petroleum.	Fertilizers and agricultural machinery and equipment are exempt from VAT. Electricity taxed at reduced VAT rate. Motor vehicles taxed at increased VAT rate. Petroleum products taxed at differential specific rates.	...
Madagascar	Livestock, poultry, products subject to fiscal monopolies, health equipment and products, and petroleum products exempt from VAT.	...
Nigeria
Tanzania	...	Excess profit tax on petroleum companies. Specific rate excise taxes on petroleum products.	...	...
Zambia	...	A specific rate excise tax has been proposed for motor fuels. Ad valorem tax levied on domestic production of petroleum products. Exemptions provided for aviation gasoline and low sulphur fuel oil. Mass transit company receives a full concession.	...	...
<u>Asia</u>				
Australia	States levy charges on waste--either license or weight based.	Wholesale sales tax on vehicles. Recycled paper, solar power equipment, and conversion of engines to LPG or natural gas exempt from wholesale sales tax.	Wholesale sales tax on vehicles. Recycled paper, solar power equipment, and conversion of engines to LPG or natural gas exempt from wholesale sales tax.	CFCs tax on production and import.

Table 4 (continued). Selected Countries: Environment-Related Aspects of Taxes
Pigouvian Taxes and Taxes on Goods and Services 1/

Country	Pigouvian Taxes	Fuel and Energy Taxes	General Sales or VAT	Excises
India	...	...	...	...
Indonesia	...	Excise tax on motor vehicle fuels.	...	...
Japan	...	Imported petroleum tax, gasoline tax, diesel tax, and local road tax all at specific rates. Excise on gas and electricity. No special taxes on oils.	Standard VAT rate for all energy sources.	...
Malaysia	...	Excise duty on motor vehicle fuels.	Petroleum products exempt.	...
New Zealand	...	Zero tax on oil products and electricity. Energy resources levy on gas and coal.	Standard VAT rate for all energy sources.	...
Philippines	...	Excise tax on motor vehicle fuels. Excise tax on coke and coal, indigenous petroleum. Other excises on fuels.	Petroleum products that are subject to excise tax, fertilizers, pesticides and herbicides, and chemicals for the formulation of pesticides are exempt from VAT.	Specific rate tax on felled timber. Ad valorem taxes on nonmetallic minerals and quarry resources, metallic minerals, and indigenous petroleum.
Thailand	...	...	...	...
<u>Eastern Europe</u>				
Estonia	Effluent discharge and treatment services, and waste collection and treatment user charges. Emission charges for water and air pollution. Differentiated by type of emission. Noncompliance and enforcement penalties.	Tax differentiation for leaded motor fuels.	Firewood exempt from VAT.	...
Hungary	Emission and other pollution penalties.	Lowest ad valorem excise applies to lead from fuels, rates on other fuels vary by octane rating.	Preferential consumption tax rate for cars with catalytic converters.	...

Table 4 (continued). Selected Countries: Environment-Related Aspects of Taxes
Pigouvian Taxes and Taxes on Goods and Services 1/

Country	Pigouvian Taxes	Fuel and Energy Taxes	General Sales or VAT	Excises
Poland	Effluent fees, atmospheric emission fees, waste disposal fees. Water use fees, water transport user fees, geological concession fees, mining extraction fees.	Petroleum use/air pollution fee use a proxy tax on filling of petrol tanks calculated on the weight of fuel purchased.	...	...
Russia	Specific rate environmental charges for allowable levels of discharge. Penalties for excess pollution levels. Levies for the utilization of areas of water and parts of the sea bottom, by prospectors and extractors of mineral resources. Levy on industrial enterprises that have access to water supply systems. Payments for the rights to utilize, prospect, or for other purposes minerals, raw materials, and forest resources.	Differentiated ad valorem excise tax on sale of oil and gas condensate levied on selected enterprises. Ad valorem levy on sales of crude petroleum at prices above minimum state - regulated wholesale producer prices. Single rate ad valorem tax on sales of gasoline, diesel fuel, automotive oils, and condensed and liquified gas used as motor fuel.	...	...
<u>Europe</u>				
Austria	Waste charge levied on tons of waste.	Excise (higher rate on leaded fuel) on motor fuel. Additional special tax on fossil oils. Stock fee on petroleum products.	Standard VAT rate for petrol, diesel, residential fuel oil, gas, electricity, and coal. Zero rate for industrial and heavy fuel oil.	Fertilizer levy.
Belgium	Aircraft noise charge on landings differentiated according to type of aircraft and time of day. Charge on export, import, or transit of waste.	Excise (higher rate on leaded fuel) on motor vehicle fuel.	VAT at higher rate for large vehicles. Higher VAT rate for petrol and diesel. Lower rate for residential fuel oil, gas, electricity, and coal. Zero rate for industrial and heavy fuel oil.	...

Table 4 (continued). Selected Countries: Environment-Related Aspects of Taxes
Pigouvian Taxes and Taxes on Goods and Services 1/

Country	Pigouvian Taxes	Fuel and Energy Taxes	General Sales or VAT	Excises
Denmark	Waste charge per ton.	Excise on motor vehicle fuel. Excise on oil, gas, coal, and electricity products.	Standard VAT rate for petrol, gas, and electricity. Zero rate for diesel, residential and industrial fuel oil, heavy fuel oil, and coal.	Extraction and export of sand and gravel; beverage containers; CFC; disposable tableware; chemical products and pesticides for household consumption; water consumption tax; and packaging tax.
Finland	Charges on waste oil; water; waste management; hazardous waste processing; nuclear waste management.	Excise and environment tax on motor vehicle fuel with higher rate on leaded fuel. CO ₂ tax on oil, gas, and coal. Stock fee, harbor fee, and oil pollution fee on oil products. Excise on electricity.	Standard VAT rate for petrol, diesel, residential fuel oil, gas, electricity, and coal. Zero rate for industrial and heavy fuel oil.	Beverage containers and fertilizers.
France	Aircraft noise charge. Waste oil charge on production of lubricating oil per ton. Water pollution charge. License fees for nuclear plants, fees for protection of sensitive nature areas, and annual fee on establishments that pose an environmental risk.	Excise on motor vehicle fuel with higher rate on leaded fuel. Special taxes to hydrocarbon fund from oils. Gas consumption taxed. Ad valorem tax on electricity. No coal tax.	Standard VAT rate for all energy sources except heavy fuel oil which is zero rated.	Tax on atmospheric pollution payable by plants consuming more than a specified level of energy who discharge sulfur oxides. Taxes on forest clearance and packaging.
Germany	Aircraft noise charge. Domestic refuse disposal charge, hazardous waste disposal by Länder. Waste water fee graduated according to harmfulness of contents.	Excise on motor vehicle fuel with higher rate on leaded fuel. Excise and storage fees on oil. Excise on gas. Tax on electricity for support of coal industry. Zero tax on coal. Aviation fuel is exempt from petroleum tax.	Standard VAT rate for petrol, residential fuel oil, gas, electricity, and coal. Zero rate for diesel, industrial, and heavy fuel oil. Half standard rate on public water supplies.	Effluent tax on sewage and industrial waste water at specific rate depending on harmfulness of contents. Reduced rate if measures taken to reduce emissions.
Ireland	Local disposal charge.	Excise on motor vehicle fuel with higher rate on leaded fuel. Excise on oils. Gas, electricity, and coal are not separately taxed.	Standard VAT rate for petrol and diesel. Lower rate for residential, industrial, and heavy fuel oil, gas, electricity, and coal.	...

Table 4 (continued). Selected Countries: Environment-Related Aspects of Taxes
Pigouvian Taxes and Taxes on Goods and Services 1/

Country	Pigouvian Taxes	Fuel and Energy Taxes	General Sales or VAT	Excises
Italy	...	Excise on motor vehicle fuel with higher rate on leaded fuel. Excise on oil, gas, and electricity. Zero tax on coal.	VAT at higher rate for large vehicles. Standard VAT rate for petrol, residential fuel oil, and gas. Lower rate for electricity and coal. Zero rate for diesel and industrial and heavy fuel oils.	Tax on plastic bags.
Netherlands	Aircraft noise charge based on noise prevention expenditure and noise level of aircraft type. Domestic refuse disposal charge. Water pollution tax.	General funding tax and excise with higher rate on leaded fuel. Excise on oil products. Environmental protection tax on gas. Zero tax on electricity and coal.	Standard VAT rate for petrol, residential fuel oil, gas, and electricity. Zero rate for diesel, industrial fuel oil, and coal.	Fertilizer tax on farms producing more than a specific weight a year. Tax on ground water extraction.
Norway	Waste oil charge.	Excise with higher rate on leaded fuel, CO ₂ tax, and sulphur tax on motor vehicle fuel. Excise, CO ₂ , and sulphur tax on oil products. Excise on electricity but none on gas or coal.	Standard VAT rate for petrol, residential fuel oil, and electricity. Zero rate for diesel, industrial fuel oils, gas, and coal.	Tax on beverage containers; fertilizers; and pesticides.
Portugal	Special aircraft tax progressive with weight of aircraft.	Excise on motor vehicle fuel with higher rate on leaded fuels.	Reduced VAT rates for equipment intended to be used for solar and geothermal energy generation. Standard VAT rate for all energy sources.	...
Sweden	...	Excise with higher rate on leaded fuel, CO ₂ tax, energy tax on diesel, and sulphur tax on motor vehicle fuel. Taxes on oils. Special energy tax on electricity. A coal use tax.	Standard VAT rate for all energy sources.	CO ₂ , HC, and NOx tax and fuel tax on domestic air traffic. Tax on beverage containers; fertilizers; pesticides; and batteries.
Switzerland	Aircraft landing tax by "noise class" of aircraft. Light aircraft landing tax that is reduced by amount to which noise limit is undercut per takeoff.	Excise on motor vehicle fuel with higher rates on leaded fuels. Excise on oil products and gas.	Petrol and diesel at 9.3 percent. Zero rate for other energy sources.	...

Table 4 (continued). Selected Countries: Environment-Related Aspects of Taxes
Pigouvian Taxes and Taxes on Goods and Services 1/

Country	Pigouvian Taxes	Fuel and Energy Taxes	General Sales or VAT	Excises
United Kingdom	...	Excise on motor vehicle fuel with higher rates on leaded fuels. Excise on oil products. No tax on gas, electricity, and coal.	Petrol, diesel, and residential and industrial fuel oils at 17.5 percent. Zero rate for gas, electricity, and coal.	...
<u>Middle East</u>				
Egypt	...	Motor fuels subject to specific rate tax. Petroleum products subject to various specific rate taxes.	Petroleum products exempt.	...
Jordan	...	Specific rate tax on electricity.	...	...
<u>Western Hemisphere</u>				
Argentina	...	Excise tax on fuel oils, naptha, airplane fuels, and gas distribution.	Increased VAT rate on some supplies of gas and electricity.	Excise on tires.
Bolivia	...	Tax on value of production of petroleum products.	...	...
Brazil
Canada	...	Excise (higher rate on leaded fuel) on motor vehicle fuel. Provincial sales taxes may apply.	Standard VAT rate for all energy sources.	At provincial level, taxes on alcohol beverage containers, tires, lead-acid batteries, and quarry materials.
Chile	...	Specific rate tax applies to first sale or importation of automotive fuels and diesel oil. Tax not included in VAT base. Tax creditable against VAT if used in a production process.	...	...
Colombia	...	Gasoline distributors' tax, retail gasoline tax, retail margin tax. Coal tax (except for purchases by electric power and synthetic fuel plants). Pipeline tax. Special specific rate tax on crude oil, natural gas, coal, and ferronickel.	Special VAT rate of 45 percent applies to some cars and airplanes. Special VAT rate of 20 percent applies to motorcycles, landrovers, and domestically produced cars.	Mining and oil taxes (surface taxes, royalties, and special taxes on production).

Table 4 (concluded). Selected Countries: Environment-Related Aspects of Taxes
 Pigouvian Taxes and Taxes on Goods and Services ^{1/}

Country	Pigouvian Taxes	Fuel and Energy Taxes	General Sales or VAT	Excises
Mexico	...	Differential rate excise tax for airplane, diesel, and gasoline fuel.	...	...
United States	...	Motor fuel taxes at federal and state level. State and local tax on residential fuel oil, gas, and electricity. No tax on industrial fuels and coal. Tax on petroleum refiners on basis of hazardous substances and oil spill liability.	Taxes at the state level.	Superfund excise tax on hazardous chemicals per ton. Hazardous substances and imported chemicals tax on each ton sold of specified chemicals. Excise on ozone depleting chemicals.

Sources: Coopers and Lybrand International Tax Network (1993); Foreign Tax Law Publishers (1993); Gaines and Westin (1991); Gofman and Gusev (1993); IBFD (1993a, 1993b, 1993c, 1993d, 1993e); various IMF REDs; Jenkins and Lamech (1993); Kallaste (1993); OECD (1993a); Pomazi and Zsikla (1993); and Zyllicz (1993).

^{1/} The table identifies tax provisions which may have direct environmental implications. The table is not comprehensive because of the numerous possible interactions between the tax system and the environment as well as data limitations relating to various tax provisions. Subject to these qualifications, the absence of a text entry in the table indicates that the tax does not have direct environmental implications.

Table 5. Selected Countries: Environment-Related Aspects of Taxes
on Income and Profits, Property, and Motor Vehicles 1/

Country	Taxes on Income and Profits		Taxes on Property	Taxes on Motor Vehicles
	Individual	Corporate		
<u>Africa</u>				
Côte d'Ivoire	...	General tax holiday, tax holiday for mining companies, special rules for oil sector, incentives for agriculture, mining, and petroleum. Limitations on the deduction of petroleum taxes paid.	Rural land exempt from property tax.	Specific rate vehicle tax varies by horsepower.
Kenya	Commuting expenses and company vehicles are taxable in hands of employee.	Accelerated depreciation for agricultural land improvements and agricultural machinery. Capital expenditure on farm land for the purpose of preventing soil erosion or for clearing and planting permanent or semipermanent crops is treated as a current expense. Rate reduction for mining income.	...	Second-hand motor vehicles tax with a rate that varies with engine capacity. Annual license fee that varies by weight and type of vehicle. Diesel vehicles face rate that is twice that for gasoline vehicles.
Madagascar	...	Lower minimum levy for businesses in the sectors of agriculture, industry, mining, transportation, and tourism. The Government will enter into project specific incentive schemes to promote the establishment, expansion or rehabilitation of enterprises.	Rates for agricultural land vary from FMG 50 to FMG 2,000 per hectare, depending on crop use. Nonagricultural land is taxed as 1 percent of intrinsic value with minimum levy of FMG 500.	Annual specific rate levy on motor vehicle that is based on age and horsepower of vehicle. Rate varies from FMG 750 to FMG 9,500. Rate decreases with age and increases with horsepower.
Nigeria	...	Agriculture and mining incentives, special CIT regime for petroleum companies, tax holidays for "pioneer" businesses.	...	...

Table 5 (continued). Selected Countries: Environment-Related Aspects of Taxes on Income and Profits, Property, and Motor Vehicles 1/

Country	Taxes on Income and Profits		Taxes on Property	Taxes on Motor Vehicles
	Individual	Corporate		
Tanzania	...	Investment allowance for machinery and equipment. Capital expenditures for prevention of soil erosion treated as current expenditure. Incentives for planting permanent or semi-permanent crops and for investing in farm physical plant. Reduced tax rate on mining income.	Differential rates for agricultural land, pastoral land, and other land.	Motor vehicle registration and transfer tax. Rate varies by size of engine.
Zambia	Commuting expenses are not deductible.	Export profits from non-traditional products and income from farming are taxed at reduced rates.	Rural property is not subject to property tax. Urban property is assessed on the commercial market value of land and improvements with rates set by local councils.	Ad valorem tax on sales of motor vehicles. Rate increases with size of engine. An annual license fee is levied on motor vehicles. The amount of the fee is determined by the type of vehicle and by its weight.
<u>Asia</u>				
Australia	Employer provided vehicles and fuel are subject to tax.	Prevention of land degradation is deductible; mine site rehabilitation is expensable; accelerated write-off for water conservation and capital expenditure on environmental impact studies.	...	Wholesale sales tax and transfer fee on purchase. States levy annual taxes usually based on vehicle type and weight.
India	...	Incentives for air and water pollution abatement equipment.	...	State motor vehicle taxes. Automobiles included in base of net wealth tax.
Indonesia	Commuting expenses are not deductible.	Incentives for investments in developing provinces and hardship areas, special tax regime for oil and mining.	...	Transfer duty on cars. Luxury tax on new vehicles.

Table 5 (continued). Selected Countries: Environment-Related Aspects of Taxes
on Income and Profits, Property, and Motor Vehicles 1/

Country	Taxes on Income and Profits		Taxes on Property	Taxes on Motor Vehicles
	Individual	Corporate		
Japan	...	Capital allowance for solar and energy saving equipment, recycling equipment, and pollution prevention equipment. Reduced tax for air, water, and noise abatement facilities, asbestos emission reduction facilities, oil desulphurization facilities, and waste recycling facilities.	...	Ad valorem acquisition tax. Annual vehicle tax on tonnage and cylinder capacity.
Malaysia	...	Various investment incentives.	...	Excise duty on automobiles.
New Zealand
Philippines	...	Tax holidays for new businesses, tax incentives for regional development, accelerated exploration, and development deductions.	National and local tax assessed on value of real property.	...
Thailand	...	Various investment incentives.	...	...
<u>Eastern Europe</u>				
Estonia	...	Reduced tax rate for agricultural enterprises. Royalty payments for the right to extract minerals. Excess profits tax on some resource projects with comparatively advantageous mining-geological and economic-geographical characteristics.	Specific rate tax on agricultural land (75 different rates). Industrial land tax is specific rate and based on land use, location, and number of persons affected by industry. Specific rate tax on forest land use.	...

Table 5 (continued). Selected Countries: Environment-Related Aspects of Taxes on Income and Profits, Property, and Motor Vehicles 1/

Country	<u>Taxes on Income and Profits</u>		Taxes on Property	Taxes on Motor Vehicles
	Individual	Corporate		
Hungary	...	Tax holidays and rate reductions for manufacturing environmental products.	...	...
Poland	...	Environmental fees deductible for income tax purposes. Allowances for purchases of recycled materials, farm investments in environmental protection, and donations of land for environmental protection purposes.	Water supply and sewage collection, and land retaining water are exempt from property tax.	...
Russia	...	Profits from agriculture exempt from tax. Environmental charges and penalties paid out of after-tax profits. Environmental protection equipment excluded from the base of the net assets tax.	Tax on arable land assessed on the basis of quality, area, and location of property. Ten-year tax holidays to encourage recultivation of spoiled land.	Ad valorem excise tax on the purchase of new and used motor vehicles. Annual specific rate tax that varies by horsepower on most vehicles. Public transport and farm vehicles are exempt.
<u>Europe</u>				
Austria	Energy saving measures by private households deductible within limits.	Investment allowance for low noise trucks. Capital tax exemption for enterprises in environment sector.	...	Registration tax on new vehicles. The ad valorem rate depends on average fuel consumption. Annual vehicle tax and road transport duty based on size and presence of a catalytic converter.
Belgium	Commuting expenditures are deductible. Some income tax exemption for commuting expenditure paid by employer.	Investment deduction at 10 percentage points above inflation for investments classified as environmentally favorable or benign.	...	Registration fee on vehicles. Road tax based on power and vehicle weight.
Denmark	...	Equipment and machinery for environmental improvement on small farms is deductible.	...	Vehicle registration tax and annual weight tax.

Table 5 (continued). Selected Countries: Environment-Related Aspects of Taxes
on Income and Profits, Property, and Motor Vehicles 1/

Country	Taxes on Income and Profits		Taxes on Property	Taxes on Motor Vehicles
	Individual	Corporate		
Finland	Benefits of employer-provided vehicle and fuel subject to income tax. Commuting expenses are deductible above a threshold income level.	Accelerated depreciation for investment in air and water pollution control.	...	Ad valorem vehicle excise. Company vehicles taxed at higher rates. Vehicles with low emissions subject to lower tax. Annual tax on diesel vehicles.
France	...	Plants for treating industrial waste water and reducing atmospheric pollution can be expensed. Accelerated depreciation for energy saving equipment.	Local "Habitation" and "Developed Land" tax bases are increased by a good quality environment. "Nondeveloped" land tax must be paid even if land is in its natural state.	...
Germany	Deductibility of work-related travel expenses by ceiling.	Tax rate on hydroelectricity is half normal rate. Accelerated depreciation for pollution reducing and energy saving equipment.	...	Annual vehicle tax that is dependent on vehicle size and pollutant emissions. Incentives for vehicles that are transportable by rail or whose cargo is so transported. But, some other incentives favor trucks.
Ireland	...	Limit on deductibility of commercial vehicle expenses and a ceiling on capital allowances for vehicles. Capital allowances for land drainage and reclamation as well as for contribution to local authority effluent control. Accelerated allowance for control of farmyard pollution. Income from commercial management of woodlands exempt from tax.	...	Annual road tax based on cylinder capacity.
Italy	...	...	...	Registration tax based on size. Annual tax based on cylinder volume.

Table 5 (continued). Selected Countries: Environment-Related Aspects of Taxes on Income and Profits, Property, and Motor Vehicles 1/

Country	Taxes on Income and Profits		Taxes on Property	Taxes on Motor Vehicles
	Individual	Corporate		
Netherlands	Deductibility of commuting expenses and tax exemption for reimbursed transportation expenses is greater for public transport than for other transport.	Accelerated depreciation for pollution prevention and energy saving equipment.	...	Ad valorem sales tax that depends on vehicle size and presence of catalytic converter. Annual vehicle excise duty levied on weight and type of fuel used.
Norway	...	...	...	License tax and import duty based partly on vehicle weight. Annual kilometer tax--electric and gas vehicles exempt.
Portugal	Personal expenditure on renewable energy forms are income tax deductible.	...	...	Annual vehicle excise duty based on cylinder capacity.
Sweden	Value of company car not taxable and all expenses are deductible.	...	...	Sales tax based on environmental considerations. Annual vehicle excise based on weight, type of fuel, etc., and kilometer tax for diesel vehicles.
Switzerland	Commuting expenses are tax deductible. Reduction of individual taxable income for expenditure on energy efficiency.	Accelerated depreciation for energy saving and other resource saving equipment.	...	...
United Kingdom	Vehicle and fuel provided by employer subject to tax.	No special provisions. Profits and expenses from forestry are excluded from the tax base.	...	Special wholesale sales tax. Specific rate annual vehicle excise with higher rates for trucks based on size and type of vehicle.
<u>Middle East</u>				
Egypt	...	Tax exemptions and holidays for industrial investments.	Ad valorem tax on rental value of agricultural property.	Differential rates for cars based on engine size.

Table 5 (continued). Selected Countries: Environment-Related Aspects of Taxes
on Income and Profits, Property, and Motor Vehicles 1/

Country	Taxes on Income and Profits		Taxes on Property	Taxes on Motor Vehicles
	Individual	Corporate		
Jordan	...	Exemption of agricultural income, tax holidays for qualifying projects.	...	Annual license fee based on engine capacity.
<u>Western Hemisphere</u>				
Argentina	Property tax applies on cadastral value of urban and rural property--rates vary from province to province. Exemption from asset tax and individual property tax for investments in conservation and recovery of productive capacity of the soil. Reduced asset tax rate on rural property.	Rate varies according to fuel consumption. Additional tax on recreational vehicles.
Bolivia	Rural property is taxed differentially by region. Unfarmable land and ecological reserves are exempt.	Annual tax on automotive vehicles, ships, and aircraft.
Brazil	...	Special income tax rate and investment incentives for agriculture. Investment incentives for fishing, afforestation, and reforestation. Accelerated depreciation and depletion allowances for mining. Investment incentives to promote regional development and for pollution control and abatement equipment.	Rural property tax is levied on land used for plant exploitation, agriculture, cattle raising, or agribusiness. Tax is intended to induce rational and intensive land use. Tax base adjusted for intensity of use and productive efficiency.	...
Canada	...	Accelerated depreciation for water and air pollution control as well as energy saving investments.	...	Excise on heavy vehicles. Fuel conservation tax on high gasoline consumption vehicles and rebate on low consumption vehicles.

Table 5 (continued). Selected Countries: Environment-Related Aspects of Taxes
on Income and Profits, Property, and Motor Vehicles 1/

Country	Taxes on Income and Profits		Taxes on Property	Taxes on Motor Vehicles
	Individual	Corporate		
Chile	Commuting expenses are not deductible.	Incentives for irrigation improvements, forestry income, reforestation bonuses, forest land exemptions from land, and inheritance taxes. Tax holidays for forestry income from artificial forests and some natural forests.	Property taxes on cadastral value. Legal and license fees for mining.	Annual fee on motor vehicle permits. Ad valorem tax on used cars.
Colombia	...	Mining and oil depletion allowances. Tax credits and deductions for reforestation. Incentives for investments in agriculture.	Property tax assessed on cadastral value.	...
Mexico	...	Exemption of some agriculture income or lower income tax rates. Investment allowances. Incentives for pollution control equipment.	Agriculture incentives reduce asset tax liability.	Excise tax on automobiles based on purchase price.

Table 5 (concluded). Selected Countries: Environment-Related Aspects of Taxes on Income and Profits, Property, and Motor Vehicles 1/

Country	Taxes on Income and Profits		Taxes on Property	Taxes on Motor Vehicles
	Individual	Corporate		
United States	Commuting expenses are not deductible and the value of employer-provided transportation for work commuting is taxable.	Business energy tax credits for nonconventional fuel sources. Five-year write-off of certified pollution control facilities. Current write-off of 60 percent of current expenses incurred in sinking oil, gas, or geothermal wells. Percentage depletion is available for mineral extraction. The highest depletion rate (22 percent) is available for asbestos, uranium, lead, and mercury which have been associated with environmental damage. There are major restrictions on the current deductibility of future clean-up costs. Nuclear power plants have specific and more generous treatment of clean-up costs.	...	Gas guzzler excise based on estimated gasoline consumption per mile. State and local governments levy annual fees.

Sources: Clark (1992); Coopers and Lybrand International Tax Network (1993); Foreign Tax Law Publishers (1993); Gaines and Westin (1991); Gofman and Gusev (1993); IBFD (1993a, 1993b, 1993c, 1993d, 1993e); various IMF REDs; Jenkins and Lamech (1993); Kallaste (1993); OECD (1993a); Pomazi and Zsikla (1993); and Zylicz (1993).

1/ The table identifies tax provisions which may have direct environmental implications. The table is not comprehensive because of the numerous possible interactions between the tax system and the environment as well as data limitations relating to various tax provisions. Subject to these qualifications, the absence of a text entry in the table indicates that the tax does not have direct environmental implications.

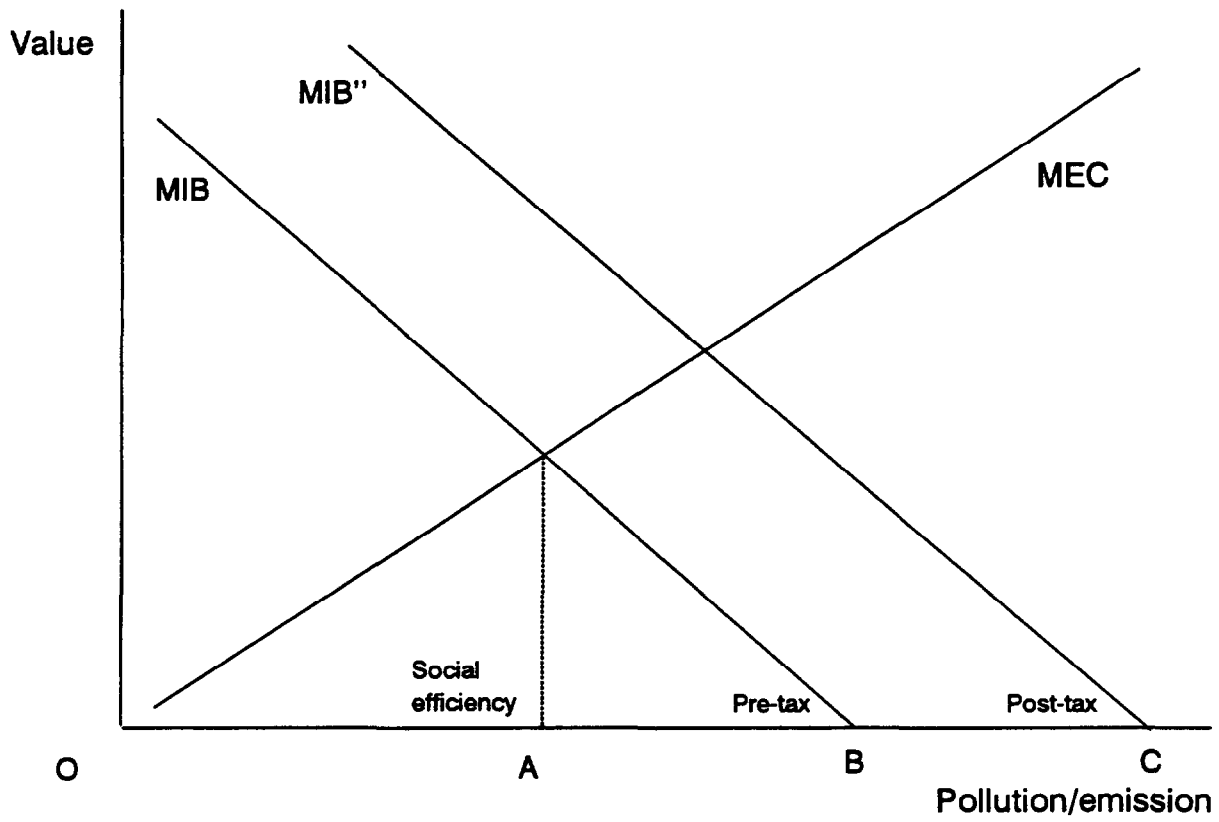
Tax Incentives with Unintended Harmful Environmental Implications

The survey in Appendix I showed that many countries provide tax incentives, such as tax holidays or accelerated depreciation intended to encourage industrial development that may lead to investment in environmentally sensitive areas or activities. Such tax provisions increase the return to producers from the polluting activity. In the framework of the environmental problem shown in Chart 3 (which is similar to the earlier charts), the tax incentive leads to an increase in the marginal internal benefit schedule of the firm to MIB''. The firm now chooses to pollute to the point C compared to B in the absence of the tax incentive. However, the socially efficient level of emissions remains unchanged at point A because it depends on the opportunity cost of adjustment and marginal external cost and not on policy-induced distortions.

Many countries provide rate reductions or tax holidays to the agriculture, forestry, fishing, and mining sectors. Rate reductions and tax holidays are also provided for new investments in regions that may have been undeveloped because of low carrying capacity. There are also examples of provisions in sales taxes or VATs that may encourage consumption or use of environmentally damaging goods. For example, in many European VATs, a lower or zero tax rate has applied to coal. In some developing countries, including Malaysia and Egypt, petroleum products are exempt from the VAT or general sales tax. In some countries, automobile taxes may discourage ownership of new vehicles which are likely to be more environmentally friendly than older vehicles. For example, the rate of the annual automobile levy in Madagascar decreases with the age of automobiles. Other countries, such as Colombia, apply luxury VAT rates to new automobiles. There are also examples of fuel excise taxes that may encourage greater environmental damage. The Philippines, Côte d'Ivoire, and Chile, for example, apply lower tax rates to diesel fuel than to gasoline even though diesel engines have been identified as a significant source of airborne particulate matter.

The sheer number of these potentially environmentally harmful provisions suggests that a critical step in any environment tax reform should be the modification or elimination of such provisions so that they do not contribute to environmental damage. This course of action is consistent with traditional tax reform principles of base broadening and elimination of special incentives and exemptions. These reforms would contribute to both fiscal and environmental objectives, but are in contrast with the use of several environment taxes to address a number of environment problems in a given country. This reflects two sets of circumstances. First, circumstances where the tax provision is the cause of the environmental damage--a case of tax-induced *policy failure*--and second, circumstances where an environment tax is employed to address *market failure*. In the first circumstance, tax-induced environmental damage could be eliminated by reforming broad-based taxes. Resolution of market failure requires use of special environment taxes such as Pigouvian taxes.

Chart 3. Environmentally Damaging Tax Incentives



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