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POLLUTION CHARGES AS A SOURCE OF PUBLIC REVENUE

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IRIS Summary

Paper: Wallace E. Oates, "Pollution Charges as a Source of Public Revenues"

Tax systems typically distort economic decisions with consequent losses in social welfare. In the design of tax systems, we look for ways to minimize these kinds of losses (or "excess burden"). Taxes on pollution are, from this perspective, a very appealing source of revenues, for rather than distorting the market economy, they serve to correct existing distortions and improve resource allocation. The side effects on the economy of pollution taxes are thus positive, rather than negative as with most other taxes.

Pollution taxes are of particular interest to the transitional and developing countries. These countries often have serious environmental problems. Pollution taxes provide a potentially effective policy instrument with which to address these problems. At the same time, they are a means for generating needed public revenues so that rates can be reduced on other taxes that have more inimical implications for economic development.

The existing literature in environmental economics explores the role of pollution taxes as instruments for environmental management. This paper expands the analysis to encompass their potential for improving the overall tax system. It is a straightforward matter to extend the theory of optimal taxation to incorporate such taxes or charges on pollution. Not surprisingly, we find that tax considerations suggest that we rely more heavily on pollution charges as a revenue source than purely environmental considerations would suggest. Does this mean that we should raise tax rates on polluting activities to higher levels than under a purely environmental regime--or lower them? The answer to this question is unclear: it depends on tax elasticity. And the evidence suggests that this elasticity exceeds unity for some pollution taxes and falls below unity for others. So it is unclear whether tax considerations imply more or less in the way of environmental quality.

In a more realistic policy setting, there are important questions concerning the locus of authority for managing pollution taxes. The paper argues that it is probably better to have this instrument under the control of the environmental authority rather than under the aegis of a tax agency. The paper argues further that it is, in general, undesirable to direct the revenues from such taxes into environmental trust funds. Such earmarking of revenues for environmental programs frequently accompanies systems of pollution taxes. It can lead to the undertaking of uneconomical projects (simply because funds are available) and to the failure to use the revenues to reduce reliance on other distorting taxes.

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Revised Draft

Pollution Charges as a Source of Public Revenues

Wallace E. Oates*

The economic theory of environmental regulation revolves around the concept of an externality--a form of social cost that is not borne by the agent who is its source. The theory carries with it a straightforward policy implication: to correct for the misallocation, in this case excessive emissions of pollutants, the regulatory agency can place a charge, a unit tax, on the offending activity that is equal to the marginal social damage. Such a Pigouvian tax serves to internalize the social cost associated with polluting emissions and can sustain an economically efficient level of environmental quality.

All this is well understood. What has received somewhat less notice is the fact that such taxes will generate revenues. This aspect of pollution charges has recently caught the attention of some policy makers. In the United States, for

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example, a bill was introduced in 1987 for a nationwide tax on sulfur and nitrogen oxide emissions. What was of particular interest about this bill was its source: it was not proposed by an environmental contingent of the U.S. Congress--it was rather introduced in the House Ways and Means Committee as a revenue-raising measure to help reduce the deficit in the federal budget! This brings to the fore an interesting and important question: What role do pollution charges have to play as a source of public revenues?[1]

I will suggest in this paper that although there is a straightforward answer to this question in terms of the theory of optimal taxation, the issue is a more complicated one in a realistic policy setting. The basic problem is that we are likely to find ourselves trying to do two things with a single policy instrument: regulate environmental quality and raise public revenues. While the tradeoff between these objectives can be resolved, in principle, by equating net benefits at the margin, this is not so easy in practice when different groups wrestle for control of the policy instrument for one or the other of these two objectives. For this reason, I will initially take up the optimal tax approach--which yields a clear conceptual

[1]A legitimate alternative to such taxes is a system of tradeable emissions permits where the total quantity of permits is set equal to the efficient level of emissions. Such a permit system can also be the source of public revenues if the permits are issued through a public auction. However, this need not be the case: the regulatory authority may choose to distribute the permits without charge to existing sources (or others). See, for example, Baumol and Oates (1988, Chs. 5 and 12).

solution to the problem. I will then proceed to a "public-choice" perspective that suggests some potentially quite troublesome matters--and also some guidelines for the proper use of environmental taxes.

Before turning to the optimal tax problem, I want to return briefly to the theory of environmental regulation. The role of a Pigouvian tax as a corrective device is firmly imbedded in microeconomic theory. Although little is typically said about the precise disposition of the revenues from these taxes, there is one proposition that does flow out of the theory: the revenues should not be used to compensate victims of the pollution [Baumol and Oates, 1988, Chs. 3 and 4]. The victims of environmental insults (or other forms of externalities) often have at their disposal "defensive activities" through which they can mitigate the effects of the pollution. Victims may, for example, be able to locate themselves away from the sources of the pollution or to employ cleansing devices. If, however, such victims are compensated for whatever damages they absorb, they will not have the proper inducement to engage in these defensive activities. Compensation, from this perspective, distorts the set of incentives required to induce the proper response to pollution: it results in excessive abatement by sources and too little in the way of defensive activities by victims. This is a point to which I shall return later in the paper.[2]

[2]This may seem a harsh dictum--one we may feel that, under certain circumstances, should be overturned on equity grounds. Particularly where individuals suffer damages from pollution over

1. An Optimal-Taxation Approach to Pollution Charges

From an optimal-taxation perspective, effluent fees become one of a set of potential revenue instruments. The objective is to design a system of taxation that produces the requisite level of revenues at the least cost to society. If we focus our attention on an efficient tax system, then the problem becomes one of choosing a set of tax rates for the various bases such that the excess burden (or deadweight loss) of an additional dollar of tax revenue is equated across all revenue sources.

More formally, our problem is to determine a set of tax rates $\mathbf{t}=(t_1,t_2,\ldots,t_n)$ applicable to the set of tax bases $\mathbf{b}=(b_1,b_2,\ldots,b_n)$ so as to:

$$\text{Min } D(\mathbf{t}) \quad \text{s.t. } \mathbf{tb}=R, \tag{1}$$

where R is the required level of revenues and D is the level of excess burden associated with the revenue system. The solution to this problem gives us the result:

$$D'(t_i)/b_i = D'(t_j)/b_j \text{ for all } i,j, \tag{2}$$

where D' denotes the partial derivative--or, in short, that the marginal excess burden from a dollar of revenues should be the

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which they really had no control, we may wish to offer compensation in spite of its adverse effects on defensive measures. This is, however, a tricky issue. Where individuals choose to subject themselves to various forms of environmental damage (e.g., by locating near a smoky factory or a noisy airport) in return, perhaps, for lower rents on housing, the case for compensation is much less compelling. There is a further qualification of a different sort to the no-compensation argument. As Martin Bailey has shown, in instances where compensation becomes capitalized into local property values, it will not have any distorting effects on behavior by victims [On this point, see Baumol and Oates (1988, pp. 230-4)].

same for all revenue sources.

The interesting and important aspect of introducing pollution charges as a revenue instrument is that, over some range at least, they have negative excess burden: they improve, rather than distort, resource allocation. This suggests that by substituting revenues from pollution charges for those from distorting taxes, we can improve the efficiency properties of the overall revenue system. An efficient tax system thus should, in principle, encompass taxes on activities that impose external costs on the environment.

David Terkla (1984) has actually developed some measures of the potential efficiency gains from pollution taxes. In a study of a hypothetical set of nationwide taxes on particulate and sulfur oxide emissions from stationary sources in the U.S., Terkla has estimated the gains that would result from using these revenues to replace partially those from either the federal income tax (on labor income) or the corporation income tax. He finds that the potential gains from a more efficient overall tax system range from $630 million to over $3 billion in 1982 dollars. These estimates, of course, rely on a set of specific assumptions concerning the scope and rates of pollution taxation. A broader set of pollution taxes could generate yet larger reductions in the excess burden of the tax system. There is, incidentally, an ongoing study at the U.S. Environmental Protection Agency of the revenue potential of taxes to contain carbon dioxide emissions. Such taxes could both provide a

powerful incentive to reduce emissions of greenhouse gases and produce annual revenues running into the tens of billions of dollars.

The analysis thus suggests that from an optimal taxation perspective, we want to push the role for pollution taxes beyond that of solely an instrument for environmental regulation. From this broader perspective, the efficiency condition for effluent charges is no longer that marginal abatement cost (MAC) equal marginal social damage (MSD)--we now must set pollution taxes to account not only for environmental benefits and abatement costs, but also for the reduction in excess burden associated with reduced reliance on other taxes. As Dwight Lee and Walter Misiolek (1986) have shown, our new theorem says that, in an optimal taxation setting, MSD must diverge from MAC by an amount equal to the reduced excess burden from other taxes. Put more formally, we have that:

$$B'(E) - C'(E) = D'(R)R'(E) \qquad (3)$$

where B is the benefits from reduced emissions, C are abatement costs, and $\bar{E}$ is the level of waste emissions. If the tax rates on pollutants are set so as to satisfy (3), then the net cost to society of another dollar of public revenues will be equated across all revenue sources.

This raises the interesting question of how pollution tax rates in an optimal-taxation setting compare with these rates under a purely environmental regime. One's first inclination is to assume that this will require that rates of pollution taxation

be set higher than they would be for purposes solely of pollution control. However, as Lee and Misiolek show--and as a little reflection suggests--this is by no means necessarily the case. An optimal tax approach may well require that we set pollution tax rates lower than the level for which marginal social damage equals marginal abatement cost.

To take a polar case, suppose that MSD equals MAC just at the point of complete abatement. The environmental literature would thus have us set an effluent fee just sufficient to reduce waste emissions to zero. But such a tax would raise no revenues and would thus forgo the potential gains from substitution of these revenues for those from distorting taxes. The optimal-tax approach would, in this instance, have us reduce the pollution tax somewhat so as to generate some revenues from this source.

The basic point is that optimal-tax considerations require more revenues from taxes on pollution than under a purely environmental regime. But this may call for either an increase or a decrease in the tax rate depending on tax elasticity. If the elasticity at the environmental optimum (i.e., where MAC=MSD) is greater than unity, so that a reduction in tax rates on emissions leads to an increase in revenues, then the optimal tax rate on pollution will be lower than the rate for purely environmental reasons. In contrast, if tax elasticity is less than unity, then the optimal-tax rate on pollution is the higher of the two. Finally, in the special case of unitary tax elasticity, the rates under the two regimes are the same.

Lee and Misiolek draw on the existing empirical literature on pollution control to develop some estimates of the tax elasticity of pollution "demand." Interestingly, their elasticity estimates across a wide set of air and water pollutants exhibit considerable variation: some are well below unity, while the upper range for most reaches well above unity.[3] Their interval estimate, for example, of the tax elasticity for the emission of particulate matter from U.S. electric utilities is (0.99-1.34), suggesting that the rate on this source of emissions would, under an optimal-tax setting, likely be less than the "pure" environmental charge. It thus appears that there is no general prescription here: an optimal-tax approach is likely, in some instances, to require higher tax rates than a purely environmental regime--and, in other cases, lower tax rates.[4]

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[3]These estimates of tax elasticity are based on a variety of different empirical studies of air and water pollutants. Some are based on elasticity estimates of pollution demand in the neighborhood of the conventional pollution target, while others represent the tax elasticity of pollution demand in the region where estimated marginal benefits equal estimated marginal abatement costs.

[4]The question arises here as to whether, as we move in the direction of greater stringency of environmental control and begin to climb the more steeply ascending portions of marginal abatement cost curves, it becomes more or less likely that optimal-tax considerations will point to higher rates for pollution taxes. I present a consideration of this issue in a brief appendix to the paper. There appears to be no general presumption on this matter.

2. A Public-Choice Perspective on Pollution Taxes

The optimal-taxation view of our problem produces a specific result, a first-order condition that must be satisfied for the optimal tax rate on each form of pollution. And this involves a basic tradeoff between the efficiency gains from environmental cleanup and from reduced excess burden in the revenue system. Each pollution tax would have to be set such that the divergence of abatement costs from benefits at the margin from a cleaner environment (per dollar of revenues) equals the marginal excess burden from revenues from other taxes. While this result may be unimpeachable in principle, it is much less compelling in a realistic policy setting. To implement the optimal-tax result, we would need a very well informed public decision-maker whose interests transcend competing environmental and revenue pressures--a benevolent agent in a position to weigh environmental concerns against revenue needs.

This is a demanding institutional requirement. Pollution taxes are likely to be introduced in either of two forums: by an agency concerned with environmental management, or by those whose primary responsibility is budgetary management and who are seeking additional sources of revenues. In such cases, we are unlikely to get the kind of "weighing" of alternative costs between environmental and revenue objectives that is envisioned in the optimal-tax theorem.

This suggests that we turn to a public-choice perspective on the problem to see what insights this can provide. Suppose, for

example, that the public revenue authority, the "Treasury" or "Legislative Tax Committee," were assigned the responsibility for determining the scope and level of pollution taxation. What might we expect? To take the extreme, Brennan and Buchanan (1980), in the public-choice literature, have argued that we can view the public sector as a revenue maximizer, a "Leviathan" that seeks to extract from the economy the most in public revenues that it can. For this polar case, we would expect to find a broad set of pollution taxes with rates set to maximize the inflow of revenues--rates determined so as to get us to the peak of the so-called Laffer Curve. In Figure 1, such an outcome is depicted by tax rate t_m, the revenue-maximizing rate.[5]

How would such a single-minded pursuit of revenues influence the effectiveness of these taxes for environmental management? Some environmentalists have expressed the concern that in the quest for revenues, the tax authority would set tax rates that were too low from an environmental perspective--rates that would not provide an adequate incentive to polluters to reduce waste discharges. After all, if the rates were set at a high level,

[5]In a somewhat similar vein, Adam Smith in The Wealth of Nations noted the potential peril in granting the revenue authority the control over tolls on the "turnpikes." Smith observes that "...if the tolls which are levied on the turnpikes should ever be considered as one of the resources for supplying the exigencies of the state, they would certainly be augmented as those exigencies were supposed to require...The facility with which a great revenue could be drawn from them, would probably encourage adminstration to recur very frequently to this resource...But the turnpike tolls being continually augmented in this manner, instead of facilitating the inland commerce of the country, as at present, would soon become a very great encumbrance upon it" (pp. 685-86).

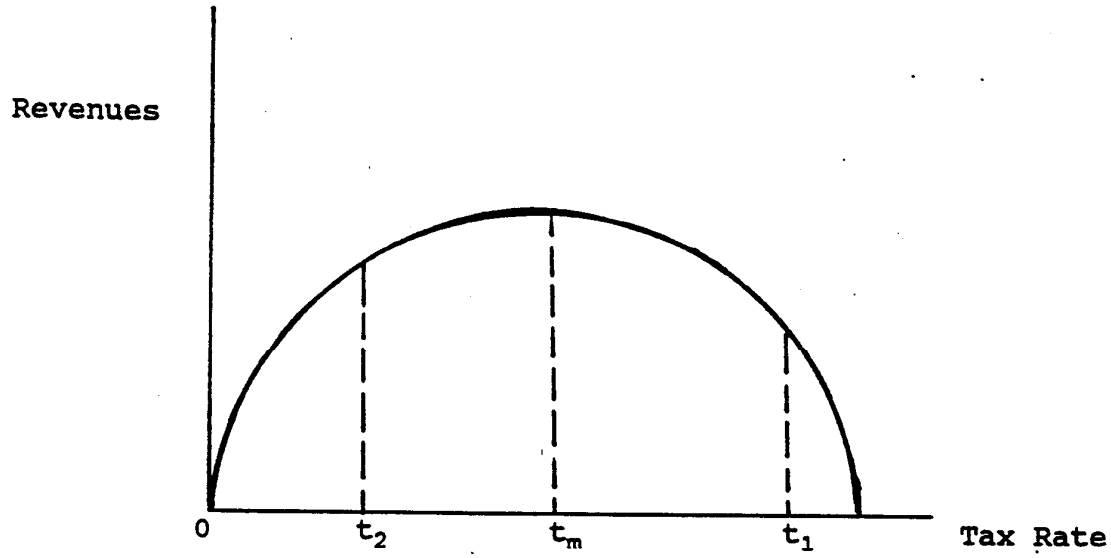

Figure 1

they would tend to kill off the tax base! Such an outcome would occur in Figure 1 if the optimal rate on environmental grounds were t_1: the revenue-maximizing tax authority would, in such a case, choose a tax rate below that for which the marginal benefits from pollution control (MSD) equal marginal abatement cost (MAC).

Once again, however, this outcome is not a general one. There are likely to be other cases where just the opposite occurs--where the revenue-maximizing rate is above the socially optimal rate such that the Leviathan outcome actually involves increased environmental protection. Such would be the case in Figure 1 if the optimal environmental rate were t_2.

The outcome again depends on the elasticity of the tax base. But this has to be interpreted with care. In a setting of revenue maximization, we might assume that other tax rates are already determined. Given an existing set of rates, the environmental authority might be expected to set pollution taxes such that MAC=MSD (although this is admittedly not, in general, an optimal decision in a distorted Leviathan setting). If the power to set pollution taxes were then transfered from the environmental authority to the Leviathan tax agent, we would find that Leviathan would either raise or lower pollution tax rates depending on whether or not the elasticity of the pollution-tax base was, respectively, less than or greater than unity.[6] There

[6]Note that the elasticity of the pollution tax base must, in this instance, be understood to be the elasticity in the context of a set of distorted Leviathan taxes on other tax bases. This

really is no general presumption here, other than that it is unlikely that revenue-maximizing rates on polluting waste emissions would coincide with the rate that provides the level of environmental protection for which MSD=MAC. Leviathan, in short, could prove to be either a friend or foe of the environment![7]

Note also that, for our polar case of revenue maximization, pollution taxes generate no added benefits in the form of reduced reliance on other distorting forms of taxation. Leviathan simply uses the new source of revenues to augment the flow of funds into the public treasury. The benefits, in this case, come solely from whatever net gains there may be in terms of enhanced environmental protection.

The Leviathan view with its assumption of pure revenue maximization is, of course, a cynical and quite controversial view of the public sector. More realistically, we might expect even a revenue authority to give some weight to environmental issues (in part in response to lobbying efforts from concerned groups) in determining the rates of pollution taxes. It is interesting in this regard that the recent adoption of "eco

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means that we cannot easily compare outcomes (e.g., levels of pollution tax rates) between Leviathan and optimal-tax regimes because the rates of taxation on other tax bases are likely to be quite different--and the elasticity of the pollution tax base is likely to depend to some extent on the rates of other taxes.

[7]In a related context, Oates and Schwab (1988) have shown that revenue-maximizing behavior can be unambiguously anti-environmental. In a setting of intergovernmental competition for new economic activity, "local" officials, to maximize local taxes, will tend to set excessively lax environmental standards in order to attract new capital and expand the local tax base.

taxation" in Sweden took place in an explicitly revenue neutral setting: existing taxes were, in fact, reduced with the introduction of pollution charges (Barde 1991, p. 7). Likewise, attempts (albeit unsuccessful) to introduce environmental taxes in Austria involved a packaging of the proposed levies with cuts in other taxes. In the United States, there is the potential for such coordination in Congress where "interested" committees have joint jurisdiction over certain regulatory programs. While such instances are encouraging, my suspicion is that they are likely to be the exception rather than the rule: tax authorities are likely to view such taxes primarily as a vehicle for revenues and adjust rates to meet revenue needs rather than environmental circumstances.[8]

In contrast, if the authority for levying and adjusting pollution taxes is vested in an agency responsible for environmental management, then pollution control is likely to be the predominating objective. Whatever revenues are generated by the taxes (with a qualification to be introduced in the next section) will tend to be regarded as a "side effect." The revenues can indeed provide some benefits through reduced reliance on other distorting taxes, but the benefits will be serendipitous--not the result of the calculated tradeoff embodied

[8]Friedrich Schneider has called my attention to another potential difficulty in the management of pollution taxes. He notes that such levies are likely to produce substantially more revenues in the short run, following their introduction, than over the longer term when sources have introduced new abatement technology in response to the taxes. The tax authority should thus be prepared for an "erosion" of the tax base over time.

in equation (3).

In a realistic policy setting, we may well be faced with the choice of placing the determination and administration of pollution taxes with either a tax or an environmental authority. The analysis does not provide any sort of rigorous basis for a preference for one over the other: it would appear very difficult to establish a general proposition that says that the tax rate for which MAC=MSD will result in a higher (or lower) level of social welfare than the revenue-maximizing tax rate.

However, I wish to argue that from a policy perspective there are reasons for prefering one locus of authority for pollution taxes to the other. There is, I think, a strong case for placing such taxes under the aegis of an environmental regulator. Pollution taxes are a potentially powerful tool for environmental management--one of the most effective policy instruments available for controlling polluting activities. There is a large theoretical and empirical literature in environmental economics that makes a compelling case for a heavy reliance on economic incentives for pollution control.[9] To take pollution taxes out of the sphere of the environmental authority is effectively to place one of the primary determinants of levels of waste emissions under the management of another public body. This is likely to constrain quite severely the options for environmental management--and to force environmental regulators

[9]See Cropper and Oates (forthcoming) for a recent survey of this literature.

to turn to less effective, command-and-control instruments for pollution control.

Tax authorities, in contrast, have a substantial range of tax bases from which to choose. Revenues from pollution taxes can ultimately finance only a modest portion of the budget. This suggests, it seems to me, that it would make sense for the tax authority to take tax rates on pollution basically as given by environmental regulators. The tax authority would view these funds as largely an exogenous (but welcome) revenue source--and would then determine rates on other tax bases so as to produce the requisite overall level of revenues. The outcome would admittedly diverge from the optimal-tax result described in equation (3), but it is, I suspect, about as good as we can hope to do in the policy arena. I would stress in this regard that pollution taxes, effectively administered for purposes of environmental management, are the potential source of sizeable revenues--and the "side benefits" in terms of a less distorting tax system are likely to be quite substantial. This conclusion, however, is subject to an important qualification to be taken up next.

3. Some Reflections on Environmental Trust Funds

As we have discussed, in the economics literature, pollution taxes have traditionally been addressed as instruments for pollution control, not as sources of public revenues. The basic theorems in environmental economics call for unit taxes on

polluting waste emissions to be set equal to marginal social damages or, in a second-best setting, at a level designed to achieve certain predetermined targets for environmental quality (Baumol and Oates 1971).

Theory and practice have, however, diverged in important ways. Environmental authorities around the world have not made extensive use of pollution taxes for environmental management. But there are some noteworthy uses, especially in Europe. France, Germany, and the Netherlands, for example, have employed effluent taxes for water-quality management. But, interestingly, in all these cases, the revenue aspects of the taxes have been quite important. As Robert Hahn (1989) and others have pointed out, environmental authorities have typically set rates in such a way as to generate the revenues needed for various pollution-control projects and other related costs. They have looked on these taxes as a source of revenues to fund programs for water-quality management, not primarily as instruments for the regulation of waste flows.[10]

This is an important issue in the "political economy" of pollution taxes. I mentioned earlier the legislation proposed in the U.S. in 1987 for a nationwide tax on sulfur and nitrogen oxide emissions. There was in that bill a provision to direct the revenues collected by the taxes into a special "Sulfur and

[10]There are a few instances in which incentive effects have figured importantly in environmental taxes: fees on discharges into Dutch river basins and some of the new "eco taxes" in Sweden on carbon and other airborne emissions. But these appear to be the exception--not the rule.

Nitrogen Emissions Trust Fund" which would be used to assist polluters in meeting their control costs. More generally, there seems to be a strong force that leads to the earmarking of such revenues for environmental purposes.

This is a force to be resisted! If the revenues from pollution taxes are siphoned off into increased spending for environmental projects, then they will obviously make no contribution to the improvement of the overall tax system by reducing the reliance on distorting taxes. The case for pollution taxes as a revenue source rests on their use to replace other taxes. If, as some public-choice writers fear (Brennan and Buchanan 1980), the new source of revenues serves as a means for expanding the public budget, then its role as a revenue source may have perverse results.

Moreover, certain trust-fund uses may themselves have troublesome implications for efficient resource use. In the proposed U.S. bill, a primary use of the revenues would have been to assist polluters in covering their control costs. From the perspective of economic efficiency, this is misplaced assistance. The tax is itself to serve as a signal to polluters to guide decisions on levels of control activities--and rebates on control costs would distort this signal. Over the longer haul, it is important that sources bear the full cost of their abatement activities and pollution taxes so that profits (net of these costs) will provide the right incentive for entry and exit decisions into the industry (Baumol and Oates, 1988, pp. 52-54).

An alternative use of such funds is the compensation of victims for any damages they suffer from pollution. But, as we discussed earlier, such compensation also can create undesireable incentives: it discourages victims from engaging in efficient levels of defensive activities.

All this is certainly not to say that important environmental projects should not be undertaken. But they should have to meet the same budgetary and economic tests as other public-sector projects--and should not be undertaken simply by virtue of the availability of some earmarked funds. In short, the revenues generated by pollution taxes should be treated in the same way as other tax receipts: they should make up part of the general fund and other tax rates should be determined in light of the contribution from this source.

This is admittedly a tough stance--since earmarking of revenues has played a central role in many of these programs. There are, for instance, cases where funding is needed for public projects (e.g., waste-water treatment plants) related directly to the emissions of the taxed sources. The "Polluter Pays Principle" can be used to justify earmarking of revenues for the finance of such publicly provided environmental services. In addition, Jean-Philippe Barde has suggested to me that such trust funds can been seen as a kind of second-best measure where the heavy costs of taxes would make their introduction politically infeasible without some earmarking assistance, or as a transitory solution in a setting where charges are raised gradually over

time to the desired level. While such cases can be made, I think that, in general, we do best to discourage earmarking of funds from pollution taxes--and to regard them as a valuable source of general revenues that can be used to improve the structure of the overall tax system.

4. Some Concluding Remarks

Environmental economics has viewed pollution taxes, quite properly, as a potentially effective instrument for environmental management. But such taxes will produce revenues. And, from an optimal-taxation perspective, the design of these taxes should, in principle, consider both their contribution to pollution control and to an improved tax system. While it is straightforward to characterize the nature of this tradeoff and the conditions to be satisfied by an "optimal" tax on pollution, it is more difficult to envision an institutional setting in which the potentially conflicting goals of environmental and revenue management will be effectively coordinated.

This suggests that for purposes of institutional design, we should probably consider two alternatives: placing the responsibility for levying and administering these taxes under either the environmental, or the tax, authority. The analysis indicates that it is impossible to say, in general, which regime is likely to adopt the higher rate structure. But broader concerns of effective environmental management suggest, I think,

a strong case for placing the authority for pollution taxes with an environmental regulator. The revenues from these taxes would then flow into the general fund and provide a special "side benefit" in terms of reduced reliance on taxes that distort the functioning of the economy.

The magnitude of these "side benefits" depends on the excess burden at the margin from existing distorting taxes. There is now a substantial empirical literature in the economics of taxation that attempts to estimate the magnitude of marginal excess burden. While there is far from a consensus on any precise figures, many of these studies produce quite sizable estimates. Charles Ballard, John Shoven and John Whalley (1985), for example, making use of a multisector, computational general-equilibrium model, find that the marginal excess burden of taxes in the United States is large. They estimate that the welfare loss from a one-percent increase in all distortionary tax rates is within the range of 17 to 56 cents per dollar of extra revenue.[11] Such estimates suggest that the "side benefits" from pollution taxes could be quite sizable indeed!

[11]See Don Fullerton (1991) for a helpful attempt to reconcile some of these diverse estimates.

APPENDIX

As Lee and Misiolek have shown, there is no general presumption concerning the relationship between the optimal tax rate on pollution and the rate under a purely environmental regime. What we know is that the optimal tax solution will call for more revenues from pollution taxation (relative to the environmental regime), but this may entail a higher or lower tax rate (and more or less pollution), depending on the tax elasticity at the environmental optimum.

A further question arises here. There now exists a large body of empirical work on the costs of abatement for a wide range of pollutants. Nearly all these studies find that marginal abatement costs (MAC) behave in textbook fashion. After a range of relatively low and slowly rising marginal costs, abatement efforts encounter rapidly rising costs at the margin. Figure A.1 depicts such a prototypical MAC curve.

In this context, we can ask whether or not as we move, say, from a point like G to a point like H, reflecting an increasing stringency of environmental control, tax elasticity tends to rise or fall? The issue here is how optimal tax considerations are likely to affect the levels of the tax rate and emissions as the stringency of environmental regulation rises. Or, put slightly differently, is tax elasticity higher at G or H?

One's initial surmise may be that elasticity is higher at G, since the steepness of the MAC curve at H indicates that a unit reduction in taxes will not have much influence on the level of

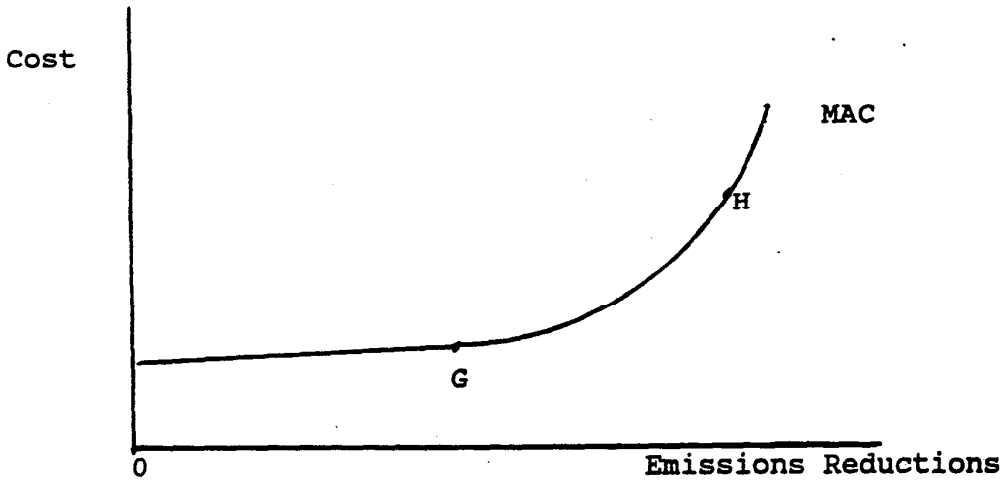

Figure A.1

emissions. But the matter is more complicated. It is also true at H that the level of emissions is lower, so that the relative size of the percentage change in emissions at G and H is unclear.

I will show here that no general presumption emerges from the consideration of a simple case. In carrying out the analysis, note that all that is at issue here is the shape and position of the MAC curve. Cost-minimizing polluters respond to taxes on effluents by setting MAC equal to the tax rate. It is this response to variations in the tax rate that determines whether revenues rise or fall as tax rates are increased.

For purposes of the analysis, I take as a simple representative case a marginal abatement cost function of the form:

$$C = f + gA^2 \qquad (A.1)$$

where C is marginal abatement cost, A is the level of abatement (i.e., reduction in emissions from the uncontrolled level), and f and g are parameters.

The level of revenues (R) from the tax is simply the product of the level of emissions (E) and the tax rate (t):

$$R = tE. \qquad (A.2)$$

Note next that emissions are related to abatement by

$$E = E_0 - A \qquad (A.3)$$

where E_0 is the uncontrolled level of emissions.

Cost-minimizing behavior by polluters implies that marginal abatement cost will equal the tax rate:

$$C = f + gA^2 = t \qquad (A.4)$$

Substituting (A.3) and (A.4) into (A.2) gives us:

$$R = E(f + gA^2) \qquad (A.5)$$

$$= E[f + g(E_0 - E)^2]$$

$$= (f + gE_0^2)E - 2gE_0E^2 + gE^3.$$

Taking the derivative of revenues (R) with respect to the level of emissions (E) yields:[12]

$$dR/dE = (f + gE_0^2) - 4gE_0E + 3gE^2. \qquad (A.6)$$

Examining the right side of (A.6), we see that the first and third terms are positive and the second term is negative, suggesting that the sign of the entire expression is likely to be ambiguous. Taking the second derivative:

$$d^2R/dE^2 = -4gE_0 + 6gE.$$

We thus find that "marginal revenue" is decreasing over the range 0 to $(2/3)E_0$ and increasing from $(2/3)E_0$ to E_0. But this does not permit us to determine, in general, how the sign of the derivative, dR/dE, varies with E. Hence, in terms of Figure A.1, it not possible, in general, to determine whether tax elasticity at a point like G is greater or less than tax elasticity at a point like H.

In short, as environmental measures become more stringent and we move up the MAC curve, it is unclear whether optimal tax considerations are more or less likely to require further increases in the tax rate.

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[12]It is easier to work with the relationship between R and E than between R and t. Since E and t are monotonically non-positively related, we can infer the relationship between R and t from that between R and E.

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