

ENVIRONMENTAL AND PUBLIC FINANCE ASPECTS OF THE TAXATION OF ENERGY

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This paper reviews potential applications of environmental taxes in the energy sector. Theoretical and practical arguments for using environmental taxes are reviewed, and possible arrangements outlined for levying environmental taxes on energy. In contrast to most environmental taxes, taxes on energy have the potential to raise revenues sufficient to alter the constraints and opportunities in fiscal policy. A carbon tax levied at a rate of £200 per tonne could raise revenues equivalent to about 11 per cent of total UK tax receipts, allowing income tax to be halved, or corporation tax abolished. Inappropriate use of the revenues, or their unnecessary dissipation, can greatly add to the costs of environmental policy. But, environmental taxes are unlikely reduce the overall excess burden from taxation below the current level, and the case for ecotaxes must thus primarily be made in terms of their environmental benefits.

I. INTRODUCTION

‘Ecotax reform’ has become a catchphrase with considerable political resonance in many European countries. In Germany it is championed by a research institute—the Wuppertal Institute—devoted to this topic, and appears to have been one of the major issues in political bargaining over coalition terms between the Greens and the SPD. In the UK, too, the arguments for ecotax reform—in various guises—have been adopted right across the political spectrum: both Conservative and Labour Chancel-

lors of the Exchequer have taken tax policy measures which they justified by using some of the arguments used by the supporters of ecotax reform, and the Liberal Democrats have adopted a more fundamental ecotax programme as party policy.

Part of the impetus for ecotax reform comes from the recognition of the limitations of environmental policies pursued solely through conventional regulatory instruments. Increasingly, there is a recognition that some environmental problems cannot be tackled purely as technical issues, to be resolved straight-

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forwardly through regulations requiring the use of appropriate abatement technologies. To make any serious impact on some of the major environmental problems now facing policy-makers—acid rain, global warming, traffic congestion—environmental policies will need to achieve extensive and far-reaching changes to existing patterns of production and consumption. Achieving the necessary changes will inevitably entail substantial economic costs. The search for instruments capable of minimizing the costs, and capable of achieving behavioural changes across all sectors, has led policy-makers in the last decade to pay much closer attention to the potential for incentive-based environmental regulation, through taxes, charges, tradable permits, and other ‘economic instruments’.

Another part of the impetus for ecotax reform has come from the side of tax-policy-makers and Ministries of Finance, through the recognition that some ecotaxes could have the potential for raising significant revenues. Some countries that have been concerned about the impact—either economic or political—of high taxes on labour income, have considered ecotax reforms in which the revenue raised from new environmental tax measures would permit reductions in income tax rates. Sweden, for example, actually implemented such a reform package in 1991, in which revenues from new environmental taxes on energy were used to finance cuts in labour income taxes. The political attractions of ‘packaging’ environmental taxes and tax reform in this way are, perhaps, obvious. The environmental gains, too, are relatively clear-cut, but the fiscal benefits of this type of tax substitution are much more contentious.

An important ingredient in the discussion of ecotax reform is the scale of the tax changes that would be involved, and the notion that the introduction of new environmental taxes might significantly alter the constraints and opportunities in tax policy-making. In practice, however, many environmentally motivated tax measures that might be contemplated do not have the potential to raise significant tax revenues. The tax bases involved are insufficiently large to yield revenues that significantly alter the overall tax structure. Taxes on certain types of battery, for example, or on plastic carrier bags, or on household purchases of garden fertilizers and pesticides, have all been employed in some European

countries. In each case, they may have appreciable merit as an instrument of environmental policy, but their revenues are negligible in the context of the overall public finances. Even the substantial tax introduced by the UK on the use of landfill sites for dumping waste, which currently yields about £400 million, contributes little more than 0.1 per cent of total revenues. In addition, of course, some environmental taxes may achieve highly elastic polluter responses, eroding the revenue yield. Thus, for example, the tax differential introduced between leaded and unleaded petrol in many European countries has been followed by quite rapid fuel substitution, as consumers have shifted to the lower-taxed fuel.

In practice, significant scope for major tax reform financed by the revenues derived from ecotaxes is only likely to arise in the case of two potential environmental tax bases—taxes on road transport, and on energy. Congestion charges on private motoring could, for example, be a major source of tax revenues, if levied at a rate reflecting the congestion externality imposed by each individual motorist on other road users. In an earlier issue of this review, for example, Newbery (1990) estimated that the congestion cost per vehicle-kilometre averaged some 3.4 pence across the UK. If this was fully reflected in a congestion charge, it would imply revenues of some £18 billion annually at current values, some 6 per cent of total fiscal receipts (or about one-quarter of the revenues from income tax). On the other hand, if congestion externalities are separately taxed, other taxes on motoring may be higher than can be justified in terms of the remaining motoring externalities, and so the overall revenue gain from moving to an efficient structure of externality taxes and changes on motoring would be substantially lower.

The taxation of energy, to reflect the environmental externalities involved in energy use, is the other area with potential to raise major tax revenues. Energy taxes, in the form of a carbon tax, were the main ingredient in Sweden’s ecotax reform, and the European Commission’s proposal for a carbon-energy tax in the early 1990s would have likewise generated appreciable revenues—between 1 and 3 per cent of total fiscal receipts in member states. In 1994, the UK government ended VAT zero-rating on domestic energy as one of a package of revenue-raising measures. The initial proposal to tax energy

at the standard VAT rate of 17.5 per cent would have raised some £3 billion of revenues annually, some 1 per cent of total fiscal receipts, but subsequent modifications have reduced the tax rate to 5 per cent, and annual revenues to around one-third of the original projection.

More recently, the government has been giving serious consideration to the possibility of taxing industrial energy use. During 1998 the Chancellor of the Exchequer set up a Task Force, chaired by Lord Marshall, to consider the possibilities for using economic instruments to reduce energy use and emissions of greenhouse gases by the industrial and commercial sectors. The report of the Task Force, published in November 1998 (Marshall Report, 1998), argued that a 'mixed approach' will have to be taken in order to achieve the UK's current commitments for reductions in greenhouse-gas emissions and to provide clear signals for longer-term emissions reductions beyond those currently agreed. Within this mixed approach, economic instruments would have a role to play. The report investigated the possible uses that could be made of two possible groups of economic instruments—tradable emissions permits and taxes—and concluded that there was a useful role for both as part of a wider package of measures, 'subject to careful design in order to protect the competitiveness of British industry and maximize the environmental benefit' (Marshall Report, 1998, p. 10).

How much revenue would be derived from an industrial energy tax would depend on the rate set, and the argument for a mixed approach implies that, initially at least, the rate might be relatively modest. Concerns about the impact on industrial competitiveness—whether well-founded or not—will obviously constrain the tax rate. Nevertheless, it is reasonable to suppose that in the longer run, if more stringent reductions in energy-related emissions are needed, an increasing role may need to be played by energy-pricing measures, and correspondingly large revenues would be raised.

This paper considers a number of aspects of the taxation of energy for environmental reasons. First, it reviews briefly the arguments for using taxes in environmental policy. These arguments form the backdrop to any discussion of energy-related envi-

ronmental taxes, and neglecting the basic principles they embody could lead to inefficiently designed instruments, or excessive long-run cost. Second, it reviews potential applications of environmental taxes in the energy sector—their purpose, their design, and their revenue contribution. Third, it considers the value of the revenue contribution from environmental taxes on energy. Where would ecotax reform fit into the current pattern of British tax policy, and how far would it alter the constraints and problems which the tax system currently faces? Would an ecotax reform provide a substantial 'double dividend', in the form of a less distortionary tax system, as well as a cleaner environment? How would these arguments be affected by some of the choices that would have to be made about the design and introduction of energy taxes along the broad lines envisaged in the Marshall Report?

II. THE CASE FOR ENVIRONMENTAL TAXES

There is now an extensive literature on the potential for taxes to contribute to more efficient and more effective environmental policy (e.g. Smith, 1992; OECD, 1993, 1996; Bovenberg and Cnossen, 1995; O'Riordan 1997). In comparison with 'conventional' regulatory policies based on technology or emissions standards, ecotaxes may be able to reduce the costs of achieving a given standard of environmental protection (or, alternatively, can achieve a greater environmental impact for a given economic cost). However, environmental taxes are far from being a panacea for all environmental problems. Consideration of their advantages and disadvantages, as compared with other instruments, suggests that there is a group of environmental problems for which taxes, of various sorts, may be the best instrument available. There are other environmental problems which would be better tackled by other approaches, including other 'economic instruments', such as tradable permits, or various forms of command-and-control regulation.

(i) Advantages of Ecotaxes

From the perspective of environmental policy, environmental taxes have attractions for a number of reasons.

'Static' efficiency gains through reallocation of abatement

Where the costs of pollution abatement vary across firms or individuals, environmental taxes have the potential to minimize costs, for one of two possible reasons. Where other policy instruments cannot fully differentiate between polluters with different marginal costs of abatement, taxes can achieve a given level of abatement at lower total abatement cost. On the other hand, where other policy instruments take account of differences in polluter abatement costs, taxes can sidestep the need for the regulatory authority to acquire detailed information on individual sources' abatement costs, and can thus lower costs of regulation from the side of the public sector.

'Static' efficiency gains through performance incentives

Taxes levied on emissions provide an incentive for care and attention in the operation of mandated technologies. In many cases, use of a given abatement technology does not guarantee a precise emissions level; instead, much depends on how the technology is used. Providing businesses with an incentive to cut emissions can be translated into providing individuals within the business with similar incentives, and some individuals may be in a position to take actions which greatly affect the emissions performance of a given technology. The discussion in section III of the Swedish nitrogen-oxides (NO_x) charge shows that a substantial part of the gains from using an economic instrument came from this, perhaps unexpected, source.

Innovation incentive

Regulatory policies, stipulating that polluters must use particular technologies, or maintain emissions below a specified limit, do not provide polluters with any encouragement to make reductions in pollution beyond what the regulations require. Indeed, where regulations are negotiated on a case-by-case basis, polluters may fear that any willingness to go beyond what is strictly required by the regulations will simply lead to the regulator assigning the firm a tougher limit in future. Environmental taxes, on the other hand, provide a continuing incentive for polluters to seek ways to reduce emissions, even below the current cost-effective level. This incentive arises because of the tax payments which are made on each unit of residual emissions, which create an incentive to

develop new technologies, permitting further abatement at a marginal cost below the tax rate.

Robustness to negotiated erosion ('regulatory capture')

An important consideration in choosing between different strategies for environmental regulation is the extent to which efficient implementation of the policy requires firm-by-firm negotiation of individual abatement or technology requirements. As noted above, command-and-control regulatory policies could be operated in a way which requires different amounts of pollution abatement from different firms, in order to achieve a more cost-effective pattern of abatement than under a uniform abatement rule. However, the regulator is dependent on the regulated firms for information about their abatement costs, and to obtain this information is liable to be drawn into dialogue and negotiation with the regulated firms. The regulated firms, in turn, then control a key element in the process by which regulatory policies are set, and may be able to extract a price from the regulator for their cooperation, in the form of less stringent abatement targets, or other changes which work to their advantage.

One key difference between regulatory policies which set differentiated firm-by-firm targets and the use of environmental taxes is that environmental taxes achieve a cost-effective distribution of abatement, taking account of the abatement costs of individual firms, while taking a robust, non-negotiated form. All firms face the same pollution tax rate. There is no need for the regulator to consider the circumstances of individual firms, and there is thus little scope for individual polluters to attempt to negotiate more favourable terms with the regulator. The risk that this process of negotiation would erode the environmental effectiveness of the policy is thus substantially reduced.

Cost-limiting properties

As compared with policy instruments which operate by defining a quantitative limit on pollution, environmental taxes have the attraction that they insulate polluters from the risk that regulatory requirements might involve excessive abatement costs. The tax rate per unit of emissions places an upper limit on the unit abatement cost which will be incurred. If abatement turns out to be more costly per unit than the tax per unit, firms will simply pollute and pay the

tax, rather than paying for costly abatement. By contrast, regulatory policies which set a quantitative limit on emissions may risk requiring that abatement measures are undertaken which are far more costly than the resulting environmental benefits.

(ii) The Limitations of Ecotaxes

Likewise, and again from the perspective of environmental policy, ecotaxes have a number of identifiable drawbacks and limitations, which will in some cases be sufficiently important to rule out their use in particular applications.

Uncertain environmental impact

The level of pollution abatement achieved by an ecotax depends on individual polluters' responses to the abatement incentive that the tax creates. It is not possible to guarantee that an environmental tax will achieve a particular environmental impact; polluters' behavioural responses may be less, or more, than expected. In cases where the precise achievement of an environmental target is a high priority, this may be an important drawback of ecotaxes. For example, some pollution problems may exhibit threshold effects, where environmental damage per unit of emissions rises sharply beyond a certain level of emissions. On the other hand, many pollution problems do not involve an abrupt boundary between acceptable and damaging emissions, and precise achievement of an emissions target may be relatively unimportant. In these circumstances, ecotaxes may be more attractive.

It will be noted that this uncertain environmental effect is the counterpart of the cost-limiting property of ecotaxes noted above. Quantitative instruments like direct regulation (or tradable permits) guarantee a particular impact on pollution, but at uncertain abatement cost, while ecotaxes guarantee an upper bound on marginal abatement costs, but have an uncertain pollution outcome. Which matters more will depend on the environmental problem under consideration, and on whether society would prefer to take risks on environmental quality or on the costs of environmental policy.

Compatibility with firm decision-making structures

Except in very small firms, it will be efficient for many business decisions to be decentralized. Spe-

cialized units or divisions of the firm may be given responsibility for making many decisions requiring specialized expertise or detailed information, subject only to general instructions or guidelines from the centre. This represents an efficient division of labour, but carries with it the implication that not all aspects of the firm's operations will necessarily be taken into account in making a particular decision. The internal organization of the firm needs to be designed so that related decisions are grouped together, while unrelated business decisions are separated.

For environmental taxes to lead to efficient polluter responses, it is necessary for firms to draw together information relating both to technology choice and to tax payments. Firms considering whether to undertake more pollution abatement need to balance the gains, at the margin, in reduced tax payments, against the marginal costs of abatement. This requires a type of interaction that may not otherwise be a high priority in the internal organization of the firm, and may require significant changes to the decision-making structure of the firm, so that tax and pollution-control technology decisions are taken together. Restructuring the firm so that such interactions can take place may be costly, and may well not be worth doing if the tax at stake is small. Firms may not, therefore, respond at all to 'small' environmental taxes, and conventional regulatory measures may be more effective, and—taking decision-making costs into account—more cost-effective, too.

Lack of experience

In the past, the lack of experience with environmental taxes may have been a significant obstacle to their adoption in any particular practical context. A novel policy instrument is only likely to be employed in preference to one which is familiar where the conventional instrument has clear, and widely recognized, defects. Increasingly, the objection that environmental taxes are untried and untested is untrue. Many studies, such as those of the OECD, document the extensive international experience with ecotaxes which is now available, and there is increasing evidence evaluating their effectiveness.

Administration and enforcement costs

Both environmental taxes and conventional command-and-control regulation require mechanisms

for administration and enforcement. The relative costs of these arrangements should be taken into account in choosing between the different instruments available, and it is difficult to generalize.

However, excise taxes on inputs may be an inexpensive way of regulating polluting processes which use these inputs. Unlike other forms of environmental regulation, there is no need for direct contact between the regulator and polluters, and the number of polluting sources does not, therefore, affect the costs of administration and enforcement. The incentive is transmitted through the excise tax levied on the production or sale of the input. If there is only a small number of producers, this will be comparatively cheap to operate. The excise duties levied on mineral oils are a case in point; there is a small number of petrol companies, and their activities are tightly controlled and well documented.

Geographical differences

Where pollution damage varies depending on the source of the emissions, policy based on a uniform pollution tax applying to different sources will be liable to result in inefficiency, and source-by-source regulation may be able to achieve a more efficient outcome. However, an environmental tax need not be constrained to applying the same tax rate to all sources, and could thus achieve the efficient outcome through appropriately differentiated tax rates. However, once the tax rate has to be set individually for each source, the tax may become more exposed to lobbying influence from the regulated firms. Also, some possible forms of environmental tax may be constrained to set uniform tax rates, even where damage is known to differ between locations. Thus, for example, ecotaxes based on the taxation of pollution-related inputs to a polluting production process may be unable to differentiate between sources, because of the difficulty (or the costs) of preventing resale of inputs taxed at a low rate to polluters with more-damaging emissions.

(iii) The Balance of Costs and Benefits

The implications of the above are that environmental taxes are likely to be particularly valuable where wide-ranging changes in behaviour are needed across a large number of production and consumption activities. The costs of direct regulation in these cases will be large, and in some cases prohibitive. In

addition, where the activities to be regulated are highly diverse, it is likely that considerable gains could be made from allowing the required changes in environmentally damaging activities to be achieved in the most cost-effective manner.

Private-sector energy use cannot realistically be regulated through source-by-source regulation. There are too many energy users—both businesses and individuals—and their opportunities for abatement are too diverse. The available options boil down to indirect techniques—either those that operate by restricting or widening the range of available technologies (e.g. regulations requiring standards of energy efficiency from appliances, or subsidies to promote the introduction of low-energy technologies), or incentive mechanisms such as energy taxes. In the long term, given the scale of changes that would be needed in household and business energy consumption to maintain or reduce global energy-related greenhouse-gas emissions (despite rapid industrialization outside the OECD area), it is almost inconceivable that an effective climate-change policy could be pursued without significant use of energy pricing measures, such as carbon or energy taxes.

On the other hand, the analysis above suggests plenty of areas of environmental policy where advocacy of ecotaxes would be misguided. There is little to be gained from over-sophistication in the tax structure, through the introduction of finely-graded tax differentials to reflect the environmental characteristics of commodities with little environmental significance. Complex tax structures are liable to be costly to operate, and the tax ‘boundaries’ between products subject to higher and lower rates of tax are always open to costly and socially wasteful litigation, and consequent erosion. Moreover, insufficiently large tax incentives may achieve little change in behaviour. As argued above, it may not be worthwhile for firms to take account of tax incentives in making environmental technology decisions if the tax incentives are too small to justify the costs of changing established decision-making structures. It is perhaps an over-generalization to suggest that environmental taxes should be large, or not be imposed at all. However, the costs of complexity and the risk that minor environmental taxes will simply be ignored should both caution against too much environmental fine-tuning of the fiscal system.

(iv) Decision-making Obstacles

In the decision-making process, factors other than objective costs and benefits may well play a major role in the choice between environmental policy instruments. Different actors in the process may have divergent interests, and these may affect the policy finally chosen.

For example, it is often suggested that ecotax policies may encounter opposition from some of the 'stakeholders' in the existing regulatory process who would be liable to lose some of the control and influence that they exert within the current regime. This is in effect the counterpart of the 'regulatory capture' argument above. Negotiated firm-by-firm regulation gives significant influence to the regulatory agency and firms, and this would be simply bypassed with a policy based on a uniform ecotax.

A second possible influence on instrument choice is that some participants in the decision-making process may perceive costs and benefits which differ from the overall costs and benefits to society.

From the perspective of firms, ecotaxes impose costs in terms of tax payments that may outweigh the efficiency savings achieved through a more efficient pattern of pollution abatement. These tax payments are not, of course, costs to the economy as a whole, but simply transfer payments, having as a counterpart the revenue flow to government. Nevertheless, taking firms as a group, and assuming that the revenues are not channelled back exclusively to the tax-paying firms, environmental taxes result in substantial burdens. Only if the efficiency gains from a more efficient distribution of abatement across polluters are very large would it be possible for environmental taxes to result in net gains to polluters as a group. This implies polluters will not select environmental taxes if given the choice, and policy-making mechanisms that accord a significant or dominant voice to polluting firms in the choice of policy instrument are unlikely to result in tax-based policies being adopted.

In addition to these possible influences on the decision whether or not to employ ecotaxes, both objective considerations and political pressures may influence the scale of environmental taxes that can be

introduced. As discussed by Rajah and Smith (1993), there may be a number of restraints on the rates of environmental tax that can in practice be applied, that may lead policy-makers to combine environmental taxes, set below the first-best level, with other, 'second-best', policy instruments (such as, for example, abatement subsidies or quantitative regulation). The first-best rate of an environmental tax may, for example, present an excessive incentive for evasion, and may consequently involve excessive costs of administration and enforcement; setting a lower rate for the tax may keep the level of evasion, and the costs of enforcement, within more acceptable bounds. Another possibility is that the first-best environmental tax rate may have undesirable consequences for distributional objectives; if it is impracticable to offset this impact fully through adjustments elsewhere in the fiscal system, it may then be preferable to levy a lower environmental tax, and to supplement it with other measures (such as subsidies to increase the elasticity of behavioural responses). Third, the tax rate that can be set may be constrained by the perception of adverse effects on the international competitiveness of industry. The adverse impact of energy taxes on energy-intensive industry (although balanced by corresponding gains elsewhere) attracts enormous policy attention; the European Commission's proposed carbon/energy tax attempted to 'buy off' these objections through sectoral exemptions, and the Swedish carbon tax was drastically revised under pressure from energy-intensive industry. It is noteworthy, too, that the Marshall Committee report pays great attention to these effects, and that they figure prominently in its conclusions and recommendations. Whether justified or not, concerns about competitiveness are likely to place severe restraints on the ability of governments to set energy taxes at the first-best level, and other instruments will need to be employed in parallel.

III. ENVIRONMENTAL TAXES IN THE ENERGY SECTOR

Environmental taxes could be employed in the energy sector, either as taxes on emissions, or in the form of excises or other sales taxes on energy consumption. Taxing emissions potentially links incentives most accurately to the underlying environ-

mental problems, though it will generally require emissions measurement and firm-by-firm administration, which may be costly. Energy excises depend for their environmental effectiveness on an assumed linkage between energy inputs and environmental impact; only if this linkage is relatively tight will the taxation of energy use be a good proxy for the taxation of emissions. On the other hand, energy excises may be relatively cheap to administer, and can build on the existing system for administering mineral oils excises.

Generally, because of the importance of end-of-pipe technologies in abatement of sulphur emissions and the significance of combustion conditions in determining NO_x emissions from industrial processes, environmental taxes to control acid rain would have to take the form of direct emissions taxes. Section III(i) below reviews the operation of one such system, the NO_x charge applied to large industrial plant and power generators in Sweden, to highlight some of the issues involved. Taxes to control greenhouse-gas emissions may, by contrast, be more efficiently implemented as energy excises. In particular, emissions of the most significant greenhouse gas, carbon dioxide, are directly related to the carbon content of input fuels to the combustion process, and commercially viable end-of-pipe abatement opportunities are negligible.

Substantial excise taxes are already levied on motor fuels, and rather lower rates of excise duty apply to certain other mineral oil products. These existing excises were created for purely fiscal reasons, but they offer scope for changes in the rates or structure of the excise to reflect current environmental concerns. Changes to the overall level of mineral oil excises will affect the incentives for fuel choice as between those fuels subject to the excise duties and those which are currently untaxed. In addition, the relative tax rates applied to different taxed fuels may be altered to differentiate between those that are more and less environmentally damaging. A number of measures of this sort have already been taken in the UK. In particular, there has, since 1997, been a tax differential between leaded and unleaded petrol, designed to reduce levels of airborne lead in the environment, and to encourage the take-up of catalytic converters. More recently, attention has focused on the environmental implications of the

duty differential between petrol and diesel fuels, and on the fiscal treatment of new vehicle fuels such as liquefied petroleum gas (LPG). There are further possibilities for differentiation: Sweden, for example, has introduced a sulphur tax on mineral oils, designed to encourage substitution to lower-sulphur fuels.

More dramatically, the large duty differential that currently exists between mineral oils used as motor fuels and those used for other purposes cannot be justified in terms of differences in environmental impact. Instead, it has the effect of concentrating incentives for carbon emissions reduction excessively on the transport sector, while providing negligible incentive for more efficient energy use and reduced carbon emissions from industrial processes.

Beyond these possibilities for differentiation within the structure of existing excises, there are possibilities for extending the scope of excise duties to tax energy sources hitherto outside the duty regime. In particular, an extension of energy excises to natural gas and coal, perhaps accompanied by a tax structure which reflected the relative carbon content of each fuel, would broaden the range of activities facing incentives for better energy use and reduced carbon-dioxide emissions, and would encourage fuel substitutions in the direction of lower-carbon fuels. Extension of existing energy excises to fuels currently untaxed would require additional administration and enforcement activities, but since relatively few energy suppliers are involved, these additional costs of administration will probably be quite limited. Section III(ii) reviews the issues that would arise in extending the scope of excise duties to embrace fuels which are currently untaxed, so as to create a coherent tax structure, with tax rates systematically related to their greenhouse-gas potential.

(i) Direct Emissions Charging: NO_x Emissions Charge in Sweden

The nitrogen oxides charge in Sweden, introduced in 1992, is levied on measured NO_x emissions by a relatively small group of large industrial plants and power stations. This system provides an example of an environmental tax levied on the basis of direct

measurement of emissions, rather than input or output proxies for emissions. The need for direct measurement arises in this case because there is no stable relationship between input characteristics or activity levels and the amount of NO_x emitted. NO_x emissions are greatly affected by the precise operating conditions in the combustion process, which govern the extent to which NO_x is produced through interactions between atmospheric nitrogen and oxygen. Use of a tax based on direct emissions measurement is thus able to target the incentive more precisely than a tax based on an emissions proxy.

The costs of emissions measurement per source are high, and have had a significant influence on the way the system has been designed. The annual costs of measurement, including the costs of inspecting and checking the equipment, are estimated at around 300,000 kronor (some £30,000) per plant (SMENR, 1994). In order to limit total measurement costs, the NO_x charge was confined to a relatively small group of large sources, for whom measurement costs were likely to be low, relative to the potential abatement cost saving. Initially the charge applied to a total of some 185 plants, having an output of at least 50 GWh/year, which accounted overall for around 40 per cent of total NO_x emissions from Sweden's energy sector. The qualifying threshold has subsequently been lowered to 25 GWh/year.

The tax rate is set at SKr 40 per equivalent kilogram of nitrogen dioxide. It is calculated on the basis of measured emissions, or using 'presumptive' emissions levels of 250 mg/MJ for boilers and 600 mg/MJ for gas turbines. Plant operators are able to choose to pay the charge on the basis of presumptive emissions levels instead of installing measuring equipment, although in general the presumptive emissions levels are substantially higher than actual emissions, so measurement will generally be preferable. The presumptive levels also apply where the measuring equipment is faulty (Lövgren, 1993).

To avoid distorting the pattern of competition between the large sources which are subject to the NO_x charge and their smaller competitors (and possibly introducing incentives for inefficient substitution towards uncharged smaller boilers), the system is operated so that almost all of the charge revenues are returned to the participating sources,

in proportion to their final energy output. Thus sources with high emissions relative to their energy output are net payers to the scheme, while sources with low emissions relative to energy output are net recipients. Despite this revenue-neutrality, there is some evidence of tax-induced distortions in activity close to the qualifying output threshold for the system; a significant 'cluster' of plants appear to be maintaining emissions levels just below the level at which they would have to participate in the scheme (SMENR, 1994).

During autumn 1993, after the system had been in operation for some 20 months, a commission examined its operation. A reduction in aggregate NO_x emissions of some 8,700 tonnes had been achieved, about 55 per cent of initial emissions (SMENR, 1994). A wide range of different techniques had been employed to reduce emissions, at a range of marginal costs per tonne of NO_x abatement from SKr 4,000 to SKr 52,000; the average cost of abatement was about 10,000 SKr/tonne. In addition, it was found that changes in operating procedures for a given plant could have a substantial impact on the level of NO_x emitted, without any change in the technologies employed. Decisions made by individual employees responsible for the operation of the plant thus had a major influence over its emissions level. In order to encourage emissions-conscious behaviour by these employees (and hence savings in tax payments), some plants had introduced wage bonuses relating to the emissions reductions which the plant achieved.

(ii) Environmental Excise Taxes on Carbon or Energy

A 'first-best' tax structure for an excise tax to reduce carbon-dioxide emissions would tax fuels in proportion to their carbon content. Different fossil fuels would be therefore be taxed at different rates per unit of energy. Fuels with a higher carbon content per unit of energy (such as coal, for example) bear a higher tax burden than fuels with a lower carbon content per unit of energy (such as natural gas). Such a tax structure, combined with tax rates set at the first-best level, would encourage efficient responses, of two sorts. By raising the price of energy relative to other industrial inputs, and relative to other household spending, the carbon tax would

act to discourage energy use in general. In addition, by raising the price of fuels differentially, in proportion to their carbon content, the tax would encourage substitution away from high-carbon energy sources towards lower-carbon fuels. Both the reduction in overall energy use and the substitution towards lower-carbon fuels would have the effect of reducing carbon-dioxide emissions.

Where the overall level of energy taxation is, for some reason, constrained below the first-best level, it may, however, no longer be appropriate to tax fuels in proportion to their carbon content. The direction in which the relative taxation of fuels should then depart from the 'carbon yardstick' will reflect the nature of the constraints. Constraints on the aggregate burden of energy taxes, for example, will imply that the tax structure should be designed to maximize the environmental impact from the relatively low environmental taxes that are feasible. This would require the tax structure to be shifted in the direction of taxing relatively more heavily those fuels where consumption responses are price-elastic, and taxing less heavily those fuels in more inelastic demand.

In the European countries (Sweden, Norway, Finland, The Netherlands, and Denmark) which have actually introduced carbon taxes, these have taken the form of extended systems of fuel excises. Rates of tax are defined separately for each fuel, in terms of fuel quantities, and relative tax levels on different fuels are set so as to equate the implicit rate of tax per unit of carbon across fuels. This requirement is not, however, always observed; in Denmark and Norway, for example, some fuels are not subject to the carbon tax. Also, the level of tax can vary across types of energy user; in Sweden and The Netherlands, for example, much lower rates of tax apply to industrial energy users than to energy use by private households. However, the basic principle has been to extend fuel excises to cover all relevant fossil fuels, and to structure the relative tax rates on these fuels (for the carbon tax component of the excise) according to the relative carbon content.

Likewise, the carbon/energy tax proposed in 1991 by the European Commission would most probably have been implemented by adding to the rates of existing fuel excises, and extending the scope of fuel

excises to cover fuels previously untaxed. This proposal was, in fact, not for a pure carbon tax, but for a two-part tax, reflecting both the carbon and energy content of fuel. Fossil fuels such as gas, coal, and oil would have borne a tax comprising two components, one related to their carbon content, the other related to their energy content. Non-renewable forms of energy other than fossil fuels (mainly nuclear power) would have been subject to the energy-related part of the tax, but not the carbon component. The tax rates per tonne of carbon and per joule of energy would have been set so that on a barrel of oil the carbon and energy components would have been weighted 50:50.

As Pearson and Smith (1991) discuss, the logic behind introduction of the energy component to the proposed EC tax was unclear and poorly justified. It would have reduced the strength of the incentive to switch from high-carbon to low-carbon fuels compared with a tax of the same overall scale levied purely on carbon content. One possible explanation for including the energy element in the tax base was to avoid giving undue preference to nuclear power, or to avoid giving an undue competitive advantage to those member states (France, especially) which already generate a substantial proportion of their electricity from nuclear sources.

An alternative to implementing a carbon tax as an extension of existing excises would be to levy a 'primary' carbon tax, which would take the form of a new excise levied on primary fuels (e.g. crude oil, coal, and gas) where they are mined, extracted, or imported. Pearson and Smith (1991) discuss the merits of this approach compared with the extended excise approach, under which carbon tax would be levied on final fuel products (such as coke, anthracite, four-star petrol) sold to industrial users or households. Although there are advantages and disadvantages associated with each form of carbon tax, the 'primary' carbon tax has two significant attractions. The first is that it would involve fewer taxable individuals than a 'final' tax, and no need for fiscal supervision of the energy chain beyond the first point; administrative costs would be expected to be low, and there would be scope for tight supervision to prevent evasion. The second is that it would be better able to tax the full contribution of individual fuels to carbon-dioxide emissions, taking

account of emissions during fuel processing as well as their carbon content when finally sold. A carbon tax in the form of excises on refined fuels has to make assumptions about carbon-dioxide emissions during processing; these can vary greatly between different refining technologies, and using 'average' values for these processing emissions can be a poor approximation.

It will be noted that levying a 'primary' carbon tax at an earlier stage in the production chain would not necessarily imply that it would have different economic or environmental effects from an equivalent excise-type carbon tax, levied on refined fuel products. The incidence, for example, of the carbon tax on fuel consumers could be largely invariant to the stage at which tax is formally incident; some part of the burden of a primary carbon tax would be passed on in the prices of fuel products according to their carbon content, so that the prices of fuels purchased by industry and consumers would be much the same as if an equivalent excise-type carbon tax had been levied.

Similar issues arise in the choice of arrangements for the taxation of electricity under a carbon tax. Electricity can be taxed either by taxing the fuels used in electricity generation, or by exempting fuels used in electricity generation from the carbon tax and taxing sales of electricity at a rate reflecting average fuel inputs. Generally, it will be more efficient to take the former route; taxing electricity at a rate reflecting average carbon emissions during generation provides no incentive for generators to use low-carbon fuels for generation. However, in considering how the European carbon tax might operate, the Commission was strongly tempted by the second approach. One reason for this is that if electricity is traded between member states, the excise approach makes it easier to attribute tax revenues to the country of final sale. Another possible reason might again be to avoid giving any fiscal advantage to electricity generated from nuclear power.

IV. PUBLIC FINANCE ASPECTS OF ENERGY TAXES

How much of a difference could environmental taxes on energy make to UK fiscal policy? Table 1

summarizes the current pattern of UK tax revenues.

(i) Some Orders of Magnitude

Table 2 presents some very unsophisticated estimates of the potential revenue yield from an environmental tax on energy, to illustrate the broad orders of magnitude involved, assuming that the tax was imposed at two different possible rates on today's pattern of energy use. The calculations assume, throughout, that there is no behavioural response to the imposition of the tax, and thus will tend to overstate the revenues that would in practice be obtained. However, presenting the results in this way makes it relatively straightforward to assess the revenue implications of different assumptions about the scale of behavioural responses in energy consumption.

Revenues are calculated with two alternative tax rates. The first is a carbon tax of £60 per tonne of carbon, which is roughly equivalent to the carbon tax of \$10 per barrel of oil proposed by the European Commission in 1991. The second is a carbon tax of £200 per tonne of carbon, roughly equivalent to the carbon tax which Burniaux *et al.* (1991) estimate would be required in the OECD area in order to keep aggregate global emissions of carbon dioxide at 1990 levels over the period until the year 2020. Two different assumptions are made about the base of the tax. The first case applies the carbon tax to all energy consumption, including energy used in industry, for transport, and by the household sector. The second case restricts the base of the carbon tax to industrial and commercial energy use alone (some 46 per cent of total energy use). It is assumed in both scenarios that no adjustments are made to other energy taxes (such as those already imposed on motor fuels), and that no sectors of industry are exempted from the tax (except for industrial processes which use energy for non-fuel purposes).

The revenues obtained from the tax would range from some £4 billion, for the lower of the two tax rates, applied to industrial energy alone, to some £30 billion, if the higher rate of tax were to be levied on all energy consumption. As a percentage of total existing fiscal receipts, the revenues would range from about 1.5 per cent of existing revenues, to some 11 per cent of revenues. Placed in relation to

Table 1
UK Fiscal Revenues, 1997–8

	£billion	Percentage of total revenues
Income tax	76.7	25.9
Corporation tax	30.5	10.3
Other Inland Revenue taxes	10.2	3.4
VAT	51.0	17.2
Excise duties: petrol	19.1	6.5
tobacco	8.3	2.8
alcohol	5.7	1.9
Other Customs and Excise	5.7	1.9
Business rates	14.7	5.0
Council tax	11.1	3.7
National insurance (NI) contributions	50.5	17.1
Vehicle excise duties	4.6	1.6
Other miscellaneous taxes	8.1	2.7
Total taxes and NI contributions	296.1	100.0

Source: HM Treasury (1998, Table B9 General government receipts, estimate 1997–8).

Table 2
UK Energy Use and Potential Energy Tax Revenues: Orders of Magnitude

Carbon tax on all energy used	
UK energy consumption (million tonnes of oil equivalent)	227 mtoe
Carbon content of UK energy consumption	160m tonnes C
<i>Carbon tax per tonne of carbon:</i>	
(i) EC proposal (\$10 per barrel of oil) = \$88 per tonne of carbon <i>Current sterling equivalent</i>	£59
(ii) Burniaux <i>et al.</i> (1991) = \$308 per tonne of carbon <i>Current sterling equivalent</i>	£206
<i>Carbon tax revenues (assuming unchanged energy consumption):</i>	
(i) Carbon tax of £60/tonne C Revenues as percentage of total fiscal receipts	£9.6billion 3.2%
(ii) Carbon tax of £200/tonne C Revenues as percentage of total fiscal receipts	£32billion 10.8%
Carbon tax on business energy use only	
(i) Carbon tax of £60/tonne C Revenues as percentage of total fiscal receipts	£4.4billion 1.5%
(ii) Carbon tax of £200/tonne C Revenues as percentage of total fiscal receipts	£14.7billion 5.0%

existing taxes, the first case would permit a reduction of some two percentage points in the basic rate of income tax, a relatively minor tax adjustment (especially if it is borne in mind that the energy tax revenues could be eroded by behavioural responses, and by any tax exemptions given to particular sectors). The second case, however, would permit a drastic reshaping of the tax system. Revenues of some £30 billion would, for example, imply that rates of income tax could be almost halved, or corporation tax abolished, while even substantial erosion of these revenues through elastic behavioural responses by energy consumers would still probably leave enough revenue to permit the abolition of business rates.

(ii) Revenue Sustainability

The revenues that would be raised from environmental taxes on particular raw materials or products associated with pollution will be a function of the responsiveness of demand and supply to price. The more effective the tax is in restraining production and use of the taxed good, the lower will be the revenue derived from the tax. In some sense, therefore, revenue issues arise in inverse proportion to the environmental effectiveness of an environmental tax; the tax is paid and revenues obtained only where the good continues to be produced and consumed.

The effects on revenues of an environmental tax are likely to change over time. Since, in general, supply and demand responses to the imposition of an environmental tax are likely to be rather greater in the long run (when taxpayers' patterns of production and consumption can be freely adjusted), than in the short run (when taxpayers' production and consumption decisions may be constrained by existing capital equipment), there may be circumstances where the revenues to be obtained from the environmental tax could decline over time. Where long-run supply and demand responses to the environmental tax are large, reflecting the existence of close substitutes which are less heavily taxed, the opportunities and problems posed by the tax revenues and the burden of additional tax payments will be short-lived.

In practice, forecasting the long-run revenue effect of environmental taxes is unlikely to be a precise

matter. Not only are there likely to be important uncertainties regarding the size and timing of the effects of the tax on production or consumption of the good in question, but also demands and hence revenues will be a function of the overall economic climate and level of economic activity. Economic growth may increase demands for the polluting good, partly (or fully) offsetting the effects of the environmental tax. Where the price elasticity of demand for the taxed good is low, and the income elasticity is high, the increases in demand due to growth are likely to be large relative to the reductions in demand due to the environmental tax. Thus, one concern in considering the use of tax on energy to control environmental problems associated with energy use is that the price elasticity of energy demand is so low, that a steeply rising energy tax would be needed merely to keep energy demand constant in the face of rising incomes.

(iii) A 'Double Dividend'?

From the perspective of fiscal policy, what are the gains from using ecotaxes? Do they have the potential to reduce the overall costs involved in raising fiscal revenues? Some commentators (e.g. Pearce, 1991; Oates, 1991) have drawn attention to a potential 'double dividend' from environmental taxes—the possibility that, in addition to their merits as instruments of environmental policy, they have a second benefit in that the revenue raised from the environmental taxes allows other taxes, with possible distortionary effects on labour supply, investment, or consumption, to be reduced. There are a number of strands to this argument.

'Distortion-correcting taxes are better'

Empirical studies of the marginal distortionary costs (the marginal excess burden) of existing taxes show that these costs can be appreciable. For example, Ballard *et al.* (1985) estimate the marginal excess burden of public revenues in the USA at 20–30 cents for each extra dollar of tax revenue. These costs reflect the fact that most taxes (apart from lump-sum taxes) lead to behavioural adjustments which reduce individual welfare, over and above the value of the actual tax payment by the private sector. Raising the rate of conventional taxes will typically increase these distortionary costs. However, the behavioural adjustments that arise from environmental taxes include some which are posi-

tively desirable, reflecting changes in private-sector activities that reduce emissions. In these circumstances, making use of environmental taxes to raise revenues would appear distinctly preferable to relying on conventional taxes, which generate undesirable distortions in activity. Surely it must be better to raise revenues from taxes that correct distortions, rather than create them?

Starting from a position in which the system of taxes has been designed to minimize excess burden, without any concern for the environmental implications of the tax structure, there would, indeed, usually be gains from shifting the balance of revenue-raising towards greater reliance on environmental taxes. In this sense, the tax system will be more efficient if ecotaxes are used, than if they are neglected. However, there are two key observations.

First, the particular meaning of 'excess burden' in this argument should be noted. Environmental taxes on energy can be said to have negative excess burden (at least over some range) if we include within the definition of the excess burden the environmental benefits from the induced behavioural changes. Ecotaxes, on this argument, may have negative excess burden, but to say that they have this desirable property *in addition to* their environmental benefits involves double counting.

Second, although there will almost certainly be gains from some shift to distortion-correcting taxes, this will be true only up to a certain point. The purely fiscal component of the excess burden, in the form of such things as the reductions in energy consumption and expenditures on energy-saving technologies, will have costs that rise more than proportionately with the rate of tax. Raising the tax rate on energy will initially confer benefits, in the sense that the environmental gains offset the costs of these behavioural adjustments, but as the energy tax rate is further increased, the costs of these behavioural changes will rise more than proportionately, eventually overtaking the additional environmental benefits. As Oates (1991) observes, economic efficiency in raising public revenues requires that the marginal deadweight burden from each revenue source be equal; in other words, that there should not be scope to raise the same revenues at lower deadweight cost by changing the pattern of public revenues. This will imply shifting the pattern of

revenue-raising towards ecotaxes, up until the point where the marginal excess burden of each ecotax has risen to equal the marginal excess burden from other taxes.

The above form of the argument that introducing ecotaxes will lead to more efficient fiscal policy does not establish clear and separate 'environmental' and 'fiscal' dividends from the use of ecotaxes. The environmental benefits form part of the claim that revenues can be raised at lower cost through ecotaxes; there are not two separate 'dividends'.

'Using ecotax revenue to reduce other tax rates reduces excess burdens'

A second strand in the 'double dividend' literature concerns the significance, or value, of the revenues raised from environmental taxes. What, if any, are the benefits from choosing an environmental policy instrument which raises revenues, in preference to one which has similar environmental effects but raises no revenues? If we employ a revenue-raising environmental policy instrument, such as an environmental tax or auctioned tradable permits, do the revenues collected as a 'by-product' of its environmental effects give us a more efficient fiscal policy, compared with the use of an equivalent non-revenue-raising instrument?

The closest comparison that can be made between a revenue-raising environmental policy instrument and one that is otherwise identical but raises no revenues, is that between auctioned and 'grandfathered' tradable permits. Auctioned tradable permits trading at a price x per unit of emissions would provide the same incentive for pollution abatement, and raise the same revenues, as an emissions tax set at the same rate x per unit. The comparison between auctioned and grandfathered tradable permits thus provides a way of thinking through the consequences of two equivalent instruments, differing only in the fact that one raises revenues.

Under a 'grandfathered' scheme, permits are distributed free of charge, according to some system of distribution. Polluting firms may, for example, be allocated permits in proportion to their emissions levels in some past period. The free allocation of permits on the basis of historic emissions levels has a clear opportunity cost to the government. Revenues could have been raised by auctioning the

permits, since they are of value to the firms that receive them, and, instead, the government is making a transfer to the firms, of a value equal to the number of permits allocated, times the price at which they subsequently trade. Aside from the possibility that the number of firms in the industry might be affected if permits are auctioned rather than distributed free, it would be expected that the market price at which permits trade would be identical under the two regimes, and the level and pattern of pollution abatement would be identical. The only difference between the two regimes is, then, that one raises revenues, while the other forgoes the opportunity to raise revenues. The latter case may be seen as equivalent to the case where permits are auctioned, and the revenues raised then transferred back to firms through lump-sum transfers.²

Looking at the above comparison between auctioned and grandfathered tradable permits, the environmental effects are held constant, and the only difference is that revenues are obtained under the former, but not under the latter. Any fiscal policy benefit from the revenues raised can be clearly distinguished from the environmental benefits from the instrument, which are identical across the two cases.

The revenues raised from the revenue-raising instrument do clearly have a benefit in that they reduce the need to raise revenues from other taxes, and reduce the need to incur the distortionary costs involved in raising revenues through these taxes.

In his discussion of the double-dividend debate, Goulder (1995) refers to this case as that of a 'weak' double dividend. Cost savings are made by using ecotax revenues to reduce distortionary taxes, rather than returning tax revenues to taxpayers through lump-sum payments. He points out that the existence of a double dividend, in this sense of the term, is uncontroversial, because 'the idea that swapping a distortionary tax for a lump sum tax has a positive welfare cost is part of the usual definition of *distortionary*'.

The claim of a double dividend in this form is undramatic, but not without policy significance. In making a choice between policy instruments, it implies that—other things being equal—a substantial premium should be placed on selecting revenue-raising instruments, and on then using the revenues raised to reduce the rates of existing distortionary taxes. There are significant costs if the potential revenues from environmental taxes are dissipated or forgone.

Two examples can be drawn from the Marshall Report (1998). First, the Marshall Report pays considerable attention to the idea that the tax revenues derived from energy taxes levied on industry should be returned to firms, rather than used in other ways. The economic arguments which would support this recommendation are considerably less clear-cut than Marshall appears to think. In the long run, it is not at all obvious that reducing taxes on firms would enhance UK firms' competitiveness by more than if taxes on individuals were reduced. However, if we accept Marshall's recommendation that the revenues should be returned to industry, the implication of the analysis above is that it matters how this is done. Efficiency gains will be made if this is done by reducing the marginal rates of other taxes, and arrangements for revenue return which have a more lump-sum character (as with the return of revenues from the Swedish NO_x charge described earlier) will forgo these fiscal gains.

Second, the Marshall Report discusses the relative merits of grandfathered and auctioned tradable permits. The report rightly observes some significant difficulties with grandfathered permits. The basis for allocation may well be controversial, and allocation on the basis of historic emissions would tend to disadvantage firms which had already reduced emissions in the past, and give greatest benefit to the least-dynamic firms. Also, grandfathering may discourage competition, because new entrants to an industry (which have to buy permits) do not compete on equal terms with existing firms (which receive an allocation of free permits). However, the report omits to mention probably the most

² In a one-off, unanticipated, permit allocation, the transfers are lump-sum in the sense that they cannot be influenced by any current decision of the firms. In a repeated, or anticipated, allocation, firms may realize that their current decisions could influence future permit allocations, and grandfathering could be distortionary rather than equivalent to a lump-sum transfer.

serious disadvantage of grandfathering, which is that it simply forgoes the chance of raising revenues. If the estimates of marginal excess burden from Ballard *et al.* (1985) are taken, the cost of grandfathering, in terms of the forgone fiscal gains from recycling the revenues through cuts in the marginal rates of distortionary taxes, is of the order of 20–50 per cent of the forgone revenues.

A corollary of the double-dividend argument in this form is that the optimal level of pollution abatement will not be independent of the environmental policy instrument used (Lee and Misiolek, 1986). Where increasing the rate of the environmental tax increases tax revenue, instruments such as regulation or grandfathered tradable permits which forgo revenue will have a higher total marginal abatement cost (taking into account the marginal deadweight burden of raising public revenues as well as the conventional marginal abatement costs) than environmental tax instruments, which can use the extra revenue raised to reduce the distortionary costs of other taxes. In this case, an efficient policy will set a higher level of pollution abatement if the tax instrument is used than if an environmental policy instrument is employed which does not raise revenues.

'Switching to ecotaxes reduces excess burdens'

There has recently been a spate of theoretical papers which have modelled the conditions under which a double dividend would arise, in a more demanding sense of the term, defined by Goulder (1995) as a 'strong' double dividend. He defines this as the claim that a tax switch which increases taxes on energy and reduces existing non-environmental taxes would have negative 'gross costs'. In gross costs he includes all the welfare costs of all behavioural changes from the tax switch, but *excluding* the environmental benefits. This is an extremely demanding criterion, and will be seen to be a substantially different claim from that being made at the start of this section. A shift towards environmental taxes would have a double dividend only if there were environmental gains (the first dividend), and if the total deadweight costs of revenue raising (including abatement costs in the form of behavioural substitutions to higher energy prices, but excluding the environmental benefits) are negative. The double-dividend argument in this 'strong' sense becomes a 'no regrets' argument; even if the changes

in energy use turn out to have no environmental benefit, achieving them has been costless because the overall fiscal costs of the tax change are negative.

One obvious group of circumstances in which the gross costs of a particular tax switch might be negative are those where existing fiscal policy has not been optimized with respect to purely fiscal considerations. Where existing fiscal policy has failed to set the pattern of tax rates so that the marginal excess burden of each tax instrument is equalized, the aggregate deadweight costs of revenues are not minimized (as noted above). It may be possible to reduce the total excess burden of raising public revenues (and, in other words, to make a tax switch with negative gross costs) by introducing an energy tax and using the revenues to reduce a tax which at the initial pattern of tax rates has above-average marginal excess burden. (Goulder refers to such a case as an 'intermediate form' double dividend.) Although perhaps of interest in the context of practical policy, where inefficiency in the pattern of revenue-raising may well exist and where the introduction of an environmental tax on energy might offer a politically palatable route to a shift to a more efficient pattern of taxation, this case introduces little of theoretical interest.

The more demanding requirement for a 'strong' double dividend, that the gross costs of a tax switch will be negative even where the existing pattern of tax rates is set optimally with respect to fiscal considerations, and equalizes marginal deadweight burdens across all taxes, can be satisfied only in a set of somewhat special circumstances. A series of papers by Bovenberg and co-authors has identified the limited range of possible cases where a double dividend of this form could exist (e.g. Bovenberg and de Mooij, 1994; Bovenberg and Goulder, 1994; Bovenberg and van der Ploeg, 1994; see also Parry, 1995).

Bovenberg and de Mooij (1994) argue that the distortionary cost of taxation needs to be considered in a general equilibrium context, in which the effects of taxes on both goods and factor supplies and demands are taken into account. Taxes on goods, for example, will tend to distort not only the pattern of spending on goods, but will also distort labour supply. Since a uniform tax on all goods is formally

equivalent in a one-period model to a uniform tax on labour income (since both affect the quantity of goods which can be purchased with the income earned from an additional hour's labour), a shift in the pattern of taxation from income tax to a uniform tax on goods would leave the deadweight burden unchanged (i.e. would have zero 'gross cost' in Goulder's terminology). A shift to a non-uniform tax on goods, in the form of a tax on one good, energy, alone, would, in addition, have a distortionary effect on the pattern of spending (if any environmental benefits are disregarded), and would therefore have a higher deadweight burden than the uniform tax on labour; such a tax switch would have a positive gross cost.

Bovenberg and de Mooij observe that the size of this gross cost will depend on the extent of pre-existing distortionary taxation. The additional distortions to labour supply and other markets from the environmental tax will be greater, the greater the initial degree of distortion in the economy; where an economy is initially highly distorted, the double-dividend argument will then be weaker than where the initial marginal excess burden of taxation was small.

Only a limited range of circumstances is identified in which the strong form of the double-dividend argument holds. Bovenberg and de Mooij (1994) find that it can hold if the uncompensated wage elasticity of labour supply is negative: Goulder (1995) notes that this condition is generally rejected in empirical studies of the labour market. Shah and Larsen (1992) point out that pre-existing, inefficient, subsidies can generate a strong double dividend, if the tax switch helps to counteract the inefficiency arising from these subsidies. A strong-form double dividend is also possible in the model of Bovenberg and van der Ploeg (1994), where involuntary unemployment can arise due to a fixed real wage, and where part of the burden of the energy tax can be borne by a fixed factor other than labour. Since the tax borne by the fixed factor has little distortionary cost, the gross cost of the tax switch can be negative. This model, they observe, may be appropriate to the case of small open economies.

Pearson and Smith (1991) observe that there is a close link between the impact of an environmental tax on the excess burden of taxation, and the

distributional impact of the environmental tax. Where policy-making operates on the basis of a tradeoff in taxation between efficiency and equity objectives, it would generally be possible to reduce the excess burden of taxation by relaxing the distributional constraint. If the distributional objectives are weakened, it will be possible to increase the lump-sum, non-distortionary, element within the tax structure, and this will reduce the excess burden of raising a given revenue. An environmental tax which is sharply regressive would tend to increase the lump-sum, non-distortionary component of the tax system, and this will, in turn, tend to reduce the overall welfare costs of raising revenue. This provides a way in which, in practice, environmental taxes could reduce the distortionary costs of the tax system. However, they would, in part, do so only to the extent that the distributional incidence of the tax system is permitted to become more regressive; if the original distributional incidence is restored, this source of efficiency gains would be eliminated.

V. CONCLUSIONS

Environmental taxes may have an increasingly important role to play in environmental policy, especially in achieving the extensive changes in the energy use of firms and individuals that will be required if global greenhouse-gas emissions are to be held constant, or, still more, reduced. As the Marshall Report (1998, p. 17) has recognized, energy-pricing measures, in the form of energy taxes, would provide a common incentive signal to a wide variety of energy users with different abatement costs and opportunities. This will promote cost-effective responses, reducing the cost of achieving any given level of emissions abatement. In addition, the use of taxes instead of regulation can spread the burden of adjustment efficiently across all energy users, rather than simply concentrating on those most amenable to direct regulation.

Few ecotaxes have the potential to raise revenues sufficient to alter the constraints and opportunities in fiscal policy. Environmental taxes on energy and congestion charges on motor transport are the two areas where ecotaxes could make a major contribution to tax revenues. In both cases the available tax base is broad, demand is inelastic (so revenues will not be greatly eroded by behavioural responses),

and high rates of tax may well be warranted by the environmental externalities resulting from energy use and vehicle congestion.

To illustrate the broad orders of magnitude involved, a carbon tax levied at a rate of £200 per tonne could raise revenues equivalent to about 11 per cent of total UK tax receipts, allowing income tax to be halved, or corporation tax abolished. Even a rather lower carbon tax of £60 per tonne (broadly equivalent to the carbon/energy tax proposed by the European Commission in 1991) could still raise revenues of more than £4 billion, equivalent to about 1.5 per cent of total tax receipts, which would permit a reduction of about 2 percentage points in the basic rate of income tax.

These revenues clearly present opportunities for significant change in the UK fiscal system. The revenues raised from environmental taxes have an enhanced value in the sense that—as with all taxes—the welfare costs of transferring resources to the public sector are high. Estimates of the distortionary costs of taxation in the USA suggest that the marginal welfare costs of existing tax revenues could be of the order of 20–50 cents for each dollar raised (Ballard *et al.*, 1985). If the tax system of the UK has similar costs, then the revenues raised as a by-product of pursuing environmental policy through taxation have a social value some 20–50 per cent higher than the nominal tax receipts. The benefit from these revenues will be maximized if they are used to permit reductions in the marginal rates of existing taxes, and will be dissipated if the revenues are returned to taxpayers as a lump sum, or in equivalent ways. A lump-sum return of the revenues would forgo the opportunity to reduce tax rates, and thus avoid the opportunity to save on the distortionary costs of other taxes. However, it may be unavoidable in some circumstances.

Thus, for example, offsetting the regressive distributional effects of taxes on household energy may require at least some of the revenue to be returned to households in ‘lump sum’ form. Pearson and Smith (1991) note that this will generally mean that maximizing the ‘double dividend’ gains from environmental taxes requires tax revenues to be used in the opposite way to that required to maintain the original distributional incidence of the fiscal system.

Lump-sum revenue return may also be needed where environmental taxes are levied on the emissions of some subset of polluters only. The Swedish NOx charge, for example, is restricted to large firms only, because the high costs of measurement rule out its application to smaller firms. To avoid distorting the conditions of competition between large and small firms, the NOx tax revenues are returned to the participating firms in ‘lump sum’ payments unrelated to emissions levels.

A third case where potential fiscal revenues from an environmental policy instrument are dissipated, in such a way as to forgo the economic gains that could be achieved by using the revenues to reduce other taxes, is where a non-revenue-raising instrument is chosen in preference to an equivalent, revenue-raising, instrument. A case in point is the possible use of grandfathered tradable permits as an alternative to energy taxation. Auctioned tradable permits and ecotaxes are closely similar, both in their environmental and revenue effects. By contrast, grandfathered tradable permits forgo the opportunity to raise revenues, and hence forgo the possibility of reductions in fiscal distortionary costs, by granting the permits, uncharged, to existing polluters. The implication of this is that grandfathered tradable permits are a substantially more costly way of achieving a given outcome than ecotaxes set at an equivalent level. They may appear politically attractive as a way of avoiding tax burdens on industry, but, at the same time, have a higher resource cost, equivalent (if the figures of Ballard *et al.* are used) to some 20–50 per cent of the tax revenues that could be raised.

Achieving reductions in greenhouse-gas emissions through the use of environmental taxes may confer future environmental benefits, but it is highly unlikely to confer fiscal gains in the sense of reducing the excess burden of taxation below current levels. Ecotaxes are likely to involve distortionary costs at least as high as those involved in raising equivalent revenues through existing taxes. If the question is posed whether we would choose to use energy taxes, in preference to existing taxes on labour or other bases, in the absence of any environmental benefits, then the answer is almost certainly that we would not. Energy taxes would be likely to involve just as much distortion of the labour market as

income taxes, and at the same time distort the commodity market. Only if there are expected to be environmental gains can the use of environmental taxes be justified, and the case for ecotax reform must be made primarily on the basis of the environmental gains that would result.

The fiscal aspects of ecotax reform are important, since inappropriate use of the revenues, or their unnecessary dissipation, can greatly add to the costs of environmental policy. But an appeal to the fiscal consequences of ecotax reform cannot justify measures that do not pay their way in purely environmental benefits.

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