European Policy, Taxation and the Environment

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Abstract

European Policy, Taxation and the Environment

The eight essays which form this thesis relate to European Community taxation policy and environmental policy.

The first pair of essays develop an economic interpretation of the principle of "subsidiarity", and apply this in discussing the appropriate boundaries for EC action in relation, firstly, to the harmonisation and coordination of indirect taxes (VAT and excise duties), and secondly, coordination of environmental taxes.

The second group of essays consider further the role of taxation in environmental policy. The first surveys existing literature, and identifies a key tradeoff between "linkage" and administrative cost in efficient environmental tax design. The second essay considers the possible use of tax expenditures and other subsidies if the "first-best" policy, relying purely on tax incentives, is not feasible. The third looks at the European Commission's 1991 proposal for a carbon/energy tax, and draws attention to a particular issue in the efficient specification of the carbon tax base.

The third group of essays consider distributional issues raised by the use of environmental taxes. The first essay provides estimates of the distributional incidence of the proposed European carbon/energy tax in the UK and other European countries, and assesses the scope for policy action to offset the regressive carbon/energy tax burden. The second essay considers similar issues in the different context of water charging. It presents estimates of the distributional incidence of various possible water charges in the UK, and draws attention to the possible equity/efficiency trade-offs which arise. The final essay considers the relationship between household energy efficiency, energy taxes and distribution. The paper presents econometric estimates, using UK household micro-data, of the pattern of energy efficiency take-up, and finds indications that market failures relating to household tenure may be a particularly severe impediment to the efficient adjustment of energy consumption to higher energy prices.
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Preface

I am grateful to my Supervisor, David Pearce, and to Richard Blundell and David Ulph, for advice and encouragement.

Earlier papers on which the eight chapters of this thesis are based have been presented at conferences and seminars, and versions of these chapters have been published, as follows:

Chapter 1 was published in the Oxford Review of Economic Policy, Vol 9, No 1 (1993). The published version has one section (Section V) which is omitted here since it covers issues discussed at greater length in Chapter 2.

Chapter 2 was presented at the Fiftieth Congress of the International Institute of Public Finance at Harvard in August 1994, and has been published in International Tax and Public Finance, Volume 2 (1995).

Chapter 3 was published in Fiscal Studies Volume 13 (1992). Some of the material in this paper has been used as the basis for a paper which I wrote for the Environmental Policy Committee and Committee on Fiscal Affairs of the OECD, which has subsequently appeared, with some changes, as sections in their report Taxation and the Environment: Complementary Policies (1993).

The material in Chapter 4 was used as the basis for the second half of a paper entitled "Taxes, Tax Expenditures and Environmental Regulation", co-authored with Najma Rajah, published in the Oxford Review of Economic Policy, Vol 9, No 4 (1993). The material in Chapter 4 is my own work. Chapter 4 was presented at a conference at the University of Urbino in June 1994.

An earlier version of Chapter 5 was published in 1991 as Chapter 4 of an IFS Report, "The European Carbon Tax: An Assessment of the European Commission's Proposals", co-authored with Mark Pearson. Chapter 4, the material used here, was written solely by me.

Chapter 6 is a development of my paper entitled "The distributional consequences of taxes on energy and the carbon content of fuels", which was published in European Economy, Special Issue No 1 (1992), an early version of which was presented at a workshop at the European Commission in September 1991. Some of the material in Chapter 6 has formed the basis for a chapter I have written for an OECD report entitled Implementation Strategies for Environmental Taxes (1996).

Chapter 7 has been published in Fiscal Studies, Vol 14 (1993). It was co-authored with Najma Rajah, who set up the data used in the paper under my supervision; I was responsible for the main lines of argument and analysis in the paper.

Chapter 8 has been published in Fiscal Studies, Vol 15 (1994). It was co-authored with Vanessa Brechling, who set up the data and ran initial versions of the regressions reported in the paper. I was responsible for the initial research design and the main lines of argument and analysis in the paper. I have presented earlier versions of Chapter 8 at the Zentrum für Europäische

I wish to acknowledge the considerable benefit I have received from discussion and comments by participants at the seminars and conferences where these papers have been presented, and from referees and editors of the journals where versions of these chapters have been published.

Family Expenditure Survey data are used in Chapters 6 and 7 by permission of the Central Statistical Office. The data used have been extracted from the files held at the Institute for Fiscal Studies using the FES Extracter written by Graham Stark.

Chapter 6 makes use of the IFS Simulation Programme for Indirect Taxes, which has been developed by Paul Baker, Richard Blundell, Panos Pashardes, Liz Symons and Ian Walker. I am grateful to them for permission to use the programme, and for advice on its operation and interpretation.

The English House Condition Survey data used in Chapter 8 have been made available by the Department of the Environment. An SPSS file containing the data set was prepared by Richard Moore at the Department of the Environment, and set up at IFS by Vanessa Brechling as part of a research project funded by the Department of the Environment.
Declaration

1. No part of this thesis has been submitted to any other university for any other degree.

2. Chapters 7 and 8 of this thesis are joint work with Najma Rajah and Vanessa Brechling, respectively.

STEPHEN ROBERT SMITH
Introduction

The eight chapters which form this thesis concern various aspects of taxation policy and environmental policy, at the European Community level and in member states. The chapters form three groups, with analytical links both within and between the groups. The first group, consisting of the first two chapters of the thesis, develops an economic interpretation of the principle of "subsidiarity", and applies this in discussing the appropriate boundaries for EC action in relation, firstly, to the harmonisation and coordination of indirect taxes (VAT and excise duties), and secondly, coordination of environmental taxes. The second group, Chapters 3-5, considers further the role of taxation in environmental policy, both in general terms, and in relation to the European Commission's 1991 proposal for a carbon/energy tax. The issues given particular attention in this group of chapters concern the design of efficient environmental taxes, and their relationship with other elements of the tax system. The third group, which comprises the remaining three chapters, considers distributional issues raised by the use of environmental taxes. The three chapters consider, respectively, the distributional incidence of the EC's proposed carbon/energy tax, use-related water charging, and the use of energy efficiency policies to promote efficient adjustment to higher energy taxes and to lessen the severity of the distributional constraint on energy taxation.


In both taxation policy and environmental policy the scope and ambition of Community action has expanded greatly over the past decade. This development was given impetus by the Single European Act of 1986 and the subsequent programme of measures to complete the Single Internal Market by the end of 1992. The Single European Act gave the Community, for the first time, an explicit mandate in the field of environmental policy, whilst the completion of the internal market required the Community to look closely at possible impediments to the single market arising from member state policy measures, including both tax and environmental policies.

The role of Community policy in both fields has been the focus for much controversy, and conflict with member states over the extension of the Community's powers and ambitions. The Community's adoption, in the 1992 Maastricht Treaty, of the principle of "subsidiarity" has provided, for the first time, a formal basis on which to define the legitimate scope of Community policy intervention. Making this principle operational has, however, proved less straightforward; it states, essentially that Community action must be justified in terms of the net balance of costs and benefits. The analytical underpinning needed to assess this balance in particular instances requires contributions from a range of disciplinary perspectives. It is, however, the contention of the first two essays of this thesis that the discipline of economics provides analytical principles which help to identify key issues and criteria.
Chapter 1 articulates an economic interpretation of the principle of "subsidiarity", drawing on the theory of fiscal federalism, and illustrates its application to policy on indirect taxation. In the main, existing discussions of the assignment of taxation powers in the context of fiscal federalism have concentrated on issues of benefit taxation and tax base mobility. Here a richer set of considerations are brought to bear on the question of tax assignment, including a number relating to tax administration, tax enforcement and tax-setting incentives, which have received scant attention in the existing literature. Explicit consideration is also given in this chapter to the distinction (which is central to subsidiarity) between coordination (or harmonisation) and assignment.

The Commission's 1987 proposals for changes to the system and rates of indirect taxation were designed to accommodate the abolition of internal frontier controls. They met with stiff resistance from member states, and it was only possible to agree on interim or "transitional" measures before the 1992 deadline. The Commission has continued to discuss possible permanent (or "definitive") arrangements for the European VAT system.

The first issue concerns coordination of the VAT system in member states, specifically with regard to the VAT procedures to be applied to cross-frontier transactions in goods and services within the EC. In essence, the questions to decided are what rate of tax should be borne by goods produced in one member state and sold in another, and how should the tax revenues be allocated between member states?

On the first of these issues, the essay surveys the literature on the economic consequences of different methods of taxing international transactions - "origin" and "destination" bases, and various intermediate positions. It concludes that there are good reasons in principle to prefer destination-base solutions, which are most likely to be consistent with the maximum discretion for member states on the structure and rates of indirect taxes. However, in practice, the case for a destination based approach to value added taxation is weakened, first, by the difficulty of ensuring consistent application of the destination principle to all categories of transactions, including individual and institutional purchases, and, second, by severe problems in the effectiveness of enforcement. Different types of VAT system for cross-frontier transactions have different implications for the control of fraud and evasion, and some of the VAT systems which in other respects may be most desirable are particularly vulnerable to inadequate enforcement. Systems based on some form of revenue redistribution (or "clearing") turn enforcement into a Community-wide public good, and run the risk that inadequate resources will be devoted by member states to VAT enforcement on certain types of transaction.

The chapter draws on a range of existing academic literature on the economics of the EC VAT system. However, it also makes a distinctive contribution, especially in setting out the limits that issues of administration and enforcement incentives place on the feasible range of options for intra-EC VAT. The observation that, under the Commission's 1987 proposals, the arrangements for revenue reallocation would have the effect of undermining enforcement incentives is potentially applicable to a wide range of international tax issues where credit is given for taxes paid elsewhere, and where the costs of this credit are effectively reimbursed.
The second issue concerns the need for some form of Community coordination of the indirect tax rates levied by member states. The essay identifies cross-country policy spillovers, of a type similar to externalities, from the tax rate decisions of individual member states. These spillovers arise from "origin" aspects of taxation, including the excise duties applied to mineral oils used as industrial inputs, and the cross-border shopping of individuals and institutions outside the VAT system. These spillovers are liable to generate a process of fiscal competition, leading to collectively sub-optimal decisions about tax rates. The essay reviews theoretical models of the outcome of fiscal competition, and of various different forms of Community policy rule to limit its extent.

The line of argument on the need for EC coordination of tax rates which is developed in Chapter 1 has been influential in shaping both future academic research and the form of current EU policy. In particular, the distinction which is drawn between the case for instituting a lower bound to member states’ VAT rates in the EC, and the absence of strong grounds for upper bounds to member states’ tax decisions has been reflected in the form of the current EC agreement to stipulate only a minimum rate of VAT to be applied in member states, of at least 15 per cent, whilst placing no restriction on member states’ powers to choose VAT rates higher than this.

Chapter 2 develops similar arguments in the context of environmental taxation. In addition to the discussions since 1987 about the harmonisation of member states’ existing VAT and excise duties, the Commission has also initiated debate on a new Community-wide excise, which it proposed should be levied on the energy and carbon content of non-renewable energy. Various aspects of this proposal are discussed in Chapters 2, 3, 5 and 6 of this thesis.

The Commission’s carbon tax proposal came in the context of discussion about the appropriate Community contribution to a global agreement on limiting greenhouse gas emissions. The need for co-ordination has been much more widely accepted in this context than in the earlier debate on the co-ordination of indirect taxes in general. Since the benefits of reduced greenhouse gas emissions would be global, and individual European countries would gain no appreciable benefit from unilateral emissions abatement, the problem of free riding clearly justifies coordination. Nevertheless, issues remain about the appropriate form that the coordination should take; is it essential that the method of control - in other words, the choice of a carbon tax, instead of alternatives such as direct regulation - should be determined by the Community, and not just the objectives of policy, in the form of agreed emissions limits for individual member states? Also, since the need for coordination goes wider than Europe, what role, if any, is there for the EC to play?

Chapter 2 sets out a number of issues concerning the EU’s role in environmental taxation. One distinctive line of argument in Chapter 2 is that where there are grounds for some measure of coordination of member states environmental policies (as, for example, in the case of regional and global environmental policies) the form of policy matters and not just the level of environmental restraint. Since there is an informational asymmetry between an individual country implementing an agreed environmental policy and other countries with a potential interest in the effectiveness of the measures it takes, agreement on coordinated introduction of carbon taxes may be more credible, and therefore more likely to be implemented, than agreement on quantitative targets.
Part 2. Tax policy and the environment

Part 2 begins with a survey of the existing literature on taxation and the environment. A distinctive theme developed in the survey is, again, the significance for the economic analysis of administration methods and administrative cost. Costs of administration are central to the design and scope of environmental taxes, in two key respects.

Firstly, they place limits on the extent to which use can be made of environmental taxes. The number of environmental problems which might, in principle, be tackled by environmental taxes is almost unlimited. A wide range of inputs, outputs, production processes and consumption activities are associated with pollution or other environmental damage; typically this environmental damage is controlled through "command-and-control" regulations mandating the use of particular technologies, restricting emissions levels, or constraining locational choices. If emissions measurement and administration were costless it would generally be more efficient for economic incentives to be employed in each of these cases. Because measurement and administration has costs, however, the efficiency savings from greater use of economic instruments in environmental policy need to be weighed against the additional deadweight of administration. This will reduce the number of applications where economic incentives will be justified in terms of efficiency gains. It will also tend to suggest greater use of more "broad-brush" approaches, providing generalised incentives to discourage certain damaging types of activities, rather than specific incentives targeted to each individual emission.

Secondly, consideration of administrative costs may identify circumstances where it may be more appropriate to introduce environmental taxes in the form of modifications to the rates and structure of existing taxes (especially existing indirect taxes), rather than in the form of new environmental taxes levied on the basis of measured emissions. Again, if measurement and administration were costless the latter would be preferred, since the incentive could be related precisely to the environmental damage. Use of existing tax bases (often the value of transactions rather than quantity measurements) will depend for its effectiveness on an assumed linkage between the tax base and the environmental damage which the tax aims to reduce; if the existing base is a poor or unstable proxy for the underlying environmental damage the restructuring of existing taxes will achieve less precise targeting of the incentive than can be achieved with purpose-built taxes levied on measured emissions. Problems arise where taxpayers have the opportunity to vary the tax base independently of the amount of pollution (in which case distortions in production or consumption may arise without any corresponding environmental benefit), or where there are important pollution control options which do not affect the tax liability of the polluter. Environmental taxes on inputs to polluting production processes may not induce the most efficient responses by polluters, if pollution can be reduced through end-of-pipe processes (such as filters and other effluent purification). As Chapter 3 observes, cost-effective methods of end-of-pipe abatement are not available for emissions of carbon dioxide from production processes, and so a tax on the carbon content of input fuels will be relatively well-targeted. On the other hand, a tax on the sulphur content of fuels would be less efficient in controlling sulphur dioxide emissions, since in this case end-of-pipe abatement constitutes one of the available control options.
The second essay in the group, Chapter 4, considers the implications of second-best circumstances for instrument choice, in the sense that the attainment of a first-best level for the rate of an environmental tax might be constrained in various ways. It may, for example, be impracticable to enforce a tax at the first-best level; some of the estimates of the level of carbon tax that would be required to achieve given targets for greenhouse gas abatement are so high that extensive evasion might occur. Alternatively, powerful polluter lobbies, or concerns about income distribution or international competitiveness might limit the rate of environmental tax which governments are able to set. Most formal theory has concentrated on the first-best case, in which the rate of environmental tax is unconstrained. In this case some clear prescriptions can be derived regarding the relative merits of environmental taxes and subsidies. Whilst the problems with subsidy should not be underplayed, Chapter 4 argues that in second-best circumstances a combination of pollution taxes and elasticity-increasing subsidy measures (in the form of, perhaps, corporate tax incentives for pollution control investments) may be more efficient than taxes alone.

Chapter 5 considers the carbon/energy tax proposed by the European Commission in 1991, and discusses an aspect of the tax which has received negligible academic attention, namely the specification of the point of taxation. At what stage in the production chain should the carbon/energy tax be levied? It is possible to envisage a carbon tax levied at an early stage in the chain, on primary "unrefined" energy, at the point of extraction or first import. At the other extreme, the carbon tax could be levied on the wider range of final fuel products, at the point at which they are sold to fuel consumers in industry or private households. Either would be expected to have much the same incentive effect, although it is argued that the relative tax burden on different fuels is likely to be more accurate with a carbon tax of the primary type. Both types, however, would be feasible, although there are administrative advantages and disadvantages to each.

Some of the issues are reflections of aspects of the "origin" versus "destination" debate for VAT. In particular, a tax levied on primary energy would result in a very different allocation of revenues between member states compared to a tax levied on final fuel products. And, whilst it would be possible to envisage a revenue redistribution mechanism which allowed the pattern of revenues to be chosen independently of the administrative system, such an arrangement raises similar enforcement issues to those encountered with the VAT revenue clearing mechanisms discussed in Chapter 1.

Part 3. Equity and efficiency issues in environmental taxation

The distributional effects of environmental taxes are discussed in Chapters 6-8. A theme which recurs in each of the chapters is that of linkages between equity and efficiency issues; some of these linkages are more complex than in the conventional notion of an "equity:efficiency tradeoff" in policy.

Not all environmental taxes would be expected to raise significant distributional issues; in many cases the level of an environmental tax and the significance of the tax base either directly or indirectly in household spending will be too low to have any major impact on household living
standards. This is not, however, the case with environmental taxes on household energy spending, where the tax would be levied on a good with the demand characteristics of a necessity, forming a large part of household spending, at rates which could, potentially, be very high indeed. Such taxes could in principle have a significant regressive impact in relation to the distribution of household income or total expenditure.

In the UK, for example, the domestic energy expenditure of the poorest decile of households is about 60 per cent of that of the richest, whilst the total expenditures of the richest are about ten times those of the poorest. Given this pattern of energy expenditures, the impact of a tax on domestic energy would be expected to be sharply regressive. The essay presents estimates for the UK, drawing on data from the UK Family Expenditure Survey, and behavioural simulations using the IFS Simulation Program for Indirect Taxes. Estimates of the distributional incidence are presented, both on a “current income” basis, and using expenditure as a proxy for life-cycle incomes. In contrast to the results of Poterba for the US little difference is found between the two bases; using the life-cycle basis does not greatly reduce the estimated degree of regressivity.

Evidence on household budgets from other European Community countries shows that although household energy spending has the character of a necessity in all member states, levels of spending per household vary across the Community; energy spending is, unsurprisingly, higher in the colder countries of northern Europe than in the Mediterranean areas of the Community. In some member states, a carbon tax (as opposed to a tax on household energy alone) would not be particularly regressive; the additional tax on motor fuels purchases by households would be progressively distributed, and sufficiently large to offset the regressivity of the domestic energy component. (There is also, in principle, the indirect distributional effect of a carbon tax on industrial energy inputs to take into account, acting through its effects on the final goods prices; however, since most carbon taxes implemented to date have largely exempted industrial energy in one way or another this effect may be quite modest). Distributional issues do not, therefore, arise in the same way throughout the EC area, which would suggest that the appropriate response to the distributional effects of energy taxation may be better left to the member states.

In the UK and some other countries a carbon tax, like higher taxes on domestic energy alone, would be liable to have a regressive distributional incidence. The question addressed in the second half of Chapter 6 is whether this regressivity matters. Given that the absolute expenditures on energy of richer households exceed those of poorer households (even though they are less as a proportion of incomes), it is possible in principle to compensate poorer households adequately for the additional tax they pay on energy by a lump-sum return of tax revenues, for example through an increase in income tax allowances and pension and social security benefits. The overall distributional impact of the introduction of a tax on carbon or on domestic energy, taking account of the use of the revenues, would then no longer be regressive. On the other hand, there may be conflicting pressures on the use of revenues; for example, it would be possible to use the revenues to reduce the overall welfare costs of financing public expenditures, by reducing the level of distortionary taxes in the economy. However, in general, this will require reductions in tax rates, and, as the estimates in Chapter 6 show, this will confer little benefit on poorer households.
Indeed, the requirements for effective compensation for the additional burden of the carbon tax may go beyond lump-sum compensation. There may be substantial variation around the average in the adequacy of lump-sum compensation, reflecting the large range of energy spending of the households within each income group. These differences in energy spending may reflect not only differences in preferences, but also household characteristics affecting the need for energy spending. The elderly, for example, may have a need for more spending on heating, both because they are at home more of the day than the working population, and because of their greater vulnerability to the cold. Also, residential accommodation may differ in insulation and thermal efficiency; older houses may require greater energy inputs than new houses to reach the same internal temperature.

Whilst differences between households in energy needs exist, and where needs are regarded as a relevant factor in assessing appropriate levels of redistribution, compensation for the average increases in taxes paid by low-income groups may be inadequate. The essay assesses the extent to which, in practice, there is variation around the average in the adequacy of lump-sum compensation.

Chapter 7 discusses the equity and efficiency aspects of household water charges. Given that households face a single supplier of piped water, and have little or no opportunity to decline to purchase water from that supplier, household water charges have characteristics very similar to those of taxation. In the UK, indeed, water charges have been levied on a property-value base, “rateable value”, which until 1990 was shared with the local government tax, domestic rates. Since the abolition of domestic rates, water companies have been looking for alternatives to rateable value as the basis for charging water supplies to new properties (for which official rateable values do not exist), and the use of rateable values for water charging beyond the end of the century has been prohibited by law. One possibility would be to move to volumetric charging, where household bills would be based on metered consumption of water; however, alternative quasi-tax charging bases could also be used, such as charges based on the number of household members, or a flat-rate charge per household.

The equity implications of an extension of volumetric charging have been a prominent feature of public debate on water charges. Chapter 7 presents estimates, based on data from a water consumption survey and the UK Family Expenditure Survey, that compare the distributional incidence of water charges levied on a number of possible bases, including volumetric charging. It is shown that across income groups there is surprisingly little difference in the pattern of household payments between any of the possible alternatives to water rates. However, although in this sense volumetric charging would not be significantly more regressive than water rates, there are potentially issues concerning the effect on households of different sizes, within any given income group. Similar issues then arise concerning distributional incidence in relation to need as were encountered in the previous chapter.
Equity and efficiency issues are found in Chapter 7 to be linked where policies of selective water metering are considered. Installation of water meters involves a deadweight cost which in many cases exceed the efficiency gains (in terms of more efficient water use) which would result from volumetric charging. Ideally, the deadweight cost of metering should only be incurred where it will lead to significant reductions in water consumption. Chapter 7 argues that, unless the alternative non-metered charge proxies (unmetered) water consumption, it may induce an inefficient pattern of metering take-up, with households choosing for or against metering largely on the basis of the difference between the metered and unmetered tariffs, at existing consumption. If the option of volumetric charging is to be available to households, this will tend to constrain the choice of non-metered tariff to those that are reasonable proxies for water consumption, whatever the equity implications of these charges.

Chapter 8 considers household investments in energy efficiency. Most Community countries have, since the oil crises of the 1970s, employed policy measures to encourage greater household investments in domestic energy efficiency. Initially, the objective of these measures has been set out in terms of the balance of payments, but more recently energy efficiency policies have been seen as a complement to - or substitute for - incentive measures to reduce energy use and carbon dioxide emissions.

The economic rationale for policies to promote energy efficiency must be seen primarily in terms of market failure. To rely solely on pollution taxes on domestic energy will not be an efficient way of reducing domestic energy use if there are significant market failures (arising from poor information, credit market failures, or other sources) in the energy market which prevent economically efficient projects for investment in energy efficiency from being carried out. In addition, as Chapter 6 has argued, differences in the energy efficiency of dwellings may be a source of differences in household needs for energy spending - and that whilst these persist, differences between households in the level of energy spending cannot necessarily be considered as a matter of public policy indifference. Chapter 8 looks for evidence that would indicate the existence of significant market failures in domestic energy efficiency investments.

The chapter sets out the various possible forms of market failure that might arise. Whilst these have been discussed before in the literature on energy efficiency policies, this discussion has not been informed by any empirical evidence on their quantitative significance in the UK. This chapter uses data from the 1986 English House Condition Survey to model the pattern of possession of three energy efficiency measures - loft insulation, double glazing, and cavity wall insulation. The results indicate significant tenure-related market failures, but little clear evidence of income-related market failures, such as those that might reflect credit market failure. This suggests that public intervention in this market may need to focus on tenure-related problems, and that means-testing of public measures, which has in practice been common, may not be warranted.
Chapter 1

"Subsidiarity" and the co-ordination of indirect taxes in the European Community
Chapter 1
"Subsidiarity" and the co-ordination of indirect taxes in the European Community

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1. Introduction

Few parts of the programme of measures set out in the Commission's 1985 White Paper to complete the Single Market by the end of 1992 have proved as contentious or as difficult to resolve as those concerning indirect taxation - the proposed administrative changes for VAT and excises, and the harmonisation (or "approximation" in the White Paper's words) of tax rates. Although a package of measures was eventually agreed and implemented by the member states, it is very different from the measures originally proposed in the White Paper, and has been seen by many as merely a temporary and transitional compromise, sufficient to permit frontier controls to be abolished on schedule, but inadequate as a permanent solution to the problem of indirect tax coordination within the EC. Almost immediately after the introduction of the new arrangements, debate reopened on the possible introduction of more fundamental changes to the system of cross-frontier VAT from 1997, and on the need for more extensive coordination of member states' indirect tax rates.

This paper reviews the theoretical basis for the European Community's involvement in indirect taxation, and the theoretical and practical arguments relating to the various policy options for the coordination of member states' tax systems, structures and rates. Many of the arguments are close echoes of those which were reviewed thoroughly when the Tinbergen Committee and the Neumark Report first considered the form that indirect taxation should take in the Community, and of those raised in public discussion of the Commission's 1987 proposals (see, for example, Lee, Pearson and Smith, 1988). But there are also substantial new elements in the debate. One is the new emphasis within the Community on the principle of subsidiarity, as a guide to the nature and limits of the Community's role in policy; another is the British government's espousal of tax competition as a substitute for ex ante harmonisation. In addition to these new aspects of the political debate, important new developments have been made in the theory of tax co-ordination, too, such as the literature on tax competition with cross-border shopping which has developed following Mintz and Tulkens (1986), and the literature on Pareto-improving tax harmonisation, following Keen (1987). This paper aims to reassess the need for Community coordination of indirect taxation, in the light of these new developments in policy and theory.

Following this introduction, the paper is in four main parts. The first (Section 2) sets out a general framework for identifying appropriate limits to the extent of Community policy in the field of indirect taxation. This develops an interpretation of the principle of "subsidiarity" in terms of the economic theory of fiscal federalism. The principle of subsidiarity has begun to play a prominent role in political debate over the powers of the Community; what, if anything, does it imply in the context of tax policy coordination within the EC?

Sections 3 and 4 review the main issues of theory which are relevant to the harmonisation or coordination of indirect taxes in the European Community, and consider their application to the policy choices which the Community now faces.
1. Co-ordination of Indirect Taxes

Section 3 considers the choice between "origin" and "destination" bases for indirect taxation in the Community; put plainly, should goods be taxed where they are produced or where they are consumed? What are the implications of choosing one or other approach for economic efficiency, for the scope which member states can be permitted to choose their own rates of VAT, and for administrative effectiveness?

Section 4 considers whether the Community needs to become involved in the matter of indirect tax rates. Conventional policy rules for the structure of indirect taxation are likely to recommend different tax structures in different member states - reflecting differences in income levels and the pattern of individual preferences. There may however be reasons for some amount of Community action. One group of theoretical issues concern the efficient structure of indirect taxes in the Community; here there are both positive and negative reasons why the Community might wish to influence member states' tax structures. One positive reason that has been suggested is that there may be circumstances under which a move towards a harmonised tax structure for member states could be strictly welfare improving. Negative reasons for intervention include the possibility that member states could use the tax system as an indirect means to improve the terms of trade, or to protect particular sectors. Another group of theoretical issues concerns the impact of unrestricted movement of goods between member states on the phenomenon of cross-border shopping. This may lead to tax competition between member states; under what circumstances is unregulated tax competition between member states likely to lead to outcomes that are clearly inferior to those that could be attained through Community coordination or regulation?

Some brief conclusions are then drawn from the analysis regarding the appropriate scope of the Community's future role in indirect tax policy.

2 Subsidiarity and Tax Policy in the EC

What implications is the application of the principle of subsidiarity likely to have for tax policy in the EC? Does it provide any useful guidance as to the extent of the Community's interventions in the tax systems of member states - or indeed to the legitimacy of any Community intervention in this area at all? This section discusses the general conditions which might be implied by the application of the principle of subsidiarity to the issue of the "assignment" of responsibility for tax policy between the Community and its member states.

A useful starting point is the definition of subsidiarity incorporated in the Treaty on European Union agreed at Maastricht:

"In areas which do not fall within its exclusive competence, the Community shall take action, in accordance with the principle of subsidiarity, only if and insofar as the objectives of the proposed action cannot be sufficiently achieved by the member states and can therefore, by reason of the scale or effects of the proposed action, be better achieved by the Community" (Article 3b of the Treaty on European Union).
The principle of subsidiarity thus embodies a presumption in favour of decentralisation: transfer of government functions to the European level should only take place where there are good reasons for such an assignment. The Treaty definition also echoes the two possible "good reasons" identified in the 1977 report of the MacDougall Committee for the assignment of particular policy areas to the Community - the existence of economies of scale, and the existence of cross-country spillover effects from national policy. These are important ingredients of the economic theory of "fiscal federalism", which analyses the appropriate assignment of responsibility for areas of public policy between levels of government in a system of multiple tiers of government. We discuss each of these aspects in turn, before considering how the role played by the Community may in some respects differ from that of other levels of government.

2.1 The case for decentralisation

The main argument for decentralisation in government is that it may help to ensure that the decisions taken by government adequately reflect local preferences and interests. In the area of indirect taxation, the optimal structure of tax rates may tend to reflect the pattern of individual preferences for different goods and services; if different goods are necessities and luxuries in different member states, the optimal structure of indirect taxes may differ. Also, member states of the Community will be likely to have different requirements for budget revenues from indirect taxation, both because public spending choices differ, and because differences in income levels imply different rates of taxation in different member states even if all member states chose the same bundle of public services. This is a key difference between tax policy assignment and the assignment of responsibility for other areas of government policy. The assignment of taxes between levels of government has implications for government decision-making in other areas of policy, since it affects the terms on which financial resources are available. Although fiscal imbalances between the revenue resources and spending needs of different levels of government can be handled by financial transfers between levels of government, this is rarely without a cost to the recipient tier of government in terms of reduced decision-making autonomy.

2.2 Economies of scale

Economies of scale may be an important consideration in determining the appropriate location of responsibility for tax administration and enforcement, if not for tax policy-making.

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1 This rather vague statement conceals the considerable practical difficulties in obtaining general decentralisation theorems for public decisions. Except in cases where public decisions can be taken unanimously, public choices will involve compromise; not everyone can have the outcome they wish. Changes in the structure of government will thus typically result in gainers and losers, and this will usually be true of decentralisation. Only where decentralisation manages to separate the population into homogeneous sub-groups is it possible to prove that decentralisation leads to a Pareto-optimal outcome; in all other cases, the case for decentralisation must contend with the fact that the greater diversity in government decisions which will result from decentralisation may not be to everyone's liking (see Hughes and Smith, 1991, for further discussion).
1. Co-ordination of Indirect Taxes

The extent of economies of scale in tax administration is likely to vary between taxes and between the various aspects of tax administration and enforcement, depending on the type of operations involved. Administrative economies of scale arise from the interaction of two opposing influences. On the one hand, centralisation allows more specialisation, and hence, gains from the division of labour. On the other hand the problems of communication and control will generally increase more than proportionately with the size of the organisational unit. (Arrow, 1974). Generally speaking, the larger the information content of policy implementation - for example, about local needs and circumstances - the greater will be the case for decentralisation, often to levels below those of national governments (Helm and Smith, 1987). Although evidence from the US suggests that tax administration is an activity characterised by some economies of scale (Netzer, 1974), it is unlikely that this can be directly transferred to the EC situation, where both language differences and differences in legal systems and corporate structures are likely to reduce quite sharply the potential for administrative savings from EC-wide tax administration.

Considerations of economies of scale would seem to indicate that tax administration should remain at the national level; the gain in going further to the EC level is likely to be small, whilst many of the costs of greater scale arise at this point. Whereas in moving from local to national level the scale of operation may increase by a factor of hundreds or thousands, in moving from national to Community level the scale of operation only increases, on average, by a factor of twelve. It is unlikely that the unit cost savings of an increase in scale of this order will be sufficient to warrant the costs of diversity in languages and legal systems that EC-wide administration would have to confront.

This is not to deny that there may be some considerable potential for beneficial administrative cooperation between the tax authorities of EC member states. Much tax evasion is able to take place precisely because the information and powers of national tax authorities decline sharply beyond national frontiers; information exchanges and other forms of administrative coordination may be an important source of gains from EC tax policy (for example, in the taxation of investment incomes), and the coordination of VAT administration on transactions which cross the Community's internal frontiers is one of the main issues in EC VAT policy.

2.3 "Spillovers"

Externalities or policy spillovers provide the main economic efficiency argument for higher-tier assignment (Oates, 1972). Where the actions of each national government have consequences which are felt outside its territory, it is unlikely that policy decisions taken by national governments will fully reflect all the costs and benefits of particular policy choices; in particular the interests of non-residents are unlikely to be given adequate weighting. Olson (1969) argues that assignment of policy responsibilities between levels of government should reflect a principle of "fiscal equivalence"; the government unit responsible for a particular government function should cover a sufficiently large area to include within its boundaries all those likely to be significantly affected by its policy decisions.

Inter-country spillovers in taxation may take a number of forms.
1. Co-ordination of Indirect Taxes

(i) the structure and rates of tax of a member state may have effects on private sector decisions which extend beyond its national boundaries. In some cases the spillover effects on other member states may be clearly beneficial or damaging, as for example, when a particularly generous scheme of investment incentives attracts new investment away from other member states. In other cases the balance of costs and benefits associated with the spillovers may be less clear-cut. As an analogue of the concept of fiscal neutrality which has proved useful as a yardstick for evaluating the tax policies of national governments we may define a concept of "cross-country fiscal neutrality" - where the differences between member states' tax systems do not induce an allocation of economic activity and resources between member states that differs from that which would be encountered in the absence of tax differences. As with other notions of neutrality, it is clear that cross-country neutrality should be regarded as a yardstick or tool for policy analysis and not as an objective in itself. Whether it is desirable that the tax system should have a neutral impact on any particular set of transactions may be affected by the existence of distortions elsewhere in the economic system; "first best" solutions may be inappropriate in a "second best" world.

(ii) inter-country spillovers may also be encountered in revenue allocation. To the extent that private sector decisions are affected by differences in tax rates, the distribution of the tax base between member states may change, leading to a redistribution of revenues between states. For example, smaller states may be able to benefit substantially from the inflow of economic activity if they reduce their tax rates, and these gains may more than offset the revenue losses from lower taxation on their domestic residents.

In addition, where the tax systems of member states give credit for taxes already paid elsewhere, the tax rates levied by one member state would be liable to affect the net tax receipts of other member states. Such inter-country spillovers in revenue allocation can arise in various systems of corporation tax and VAT; depending on the interface between the tax systems of different member states, a rise in corporation tax or VAT rates in one state can increase the amount of credit that another has to give.

(iii) these cross-country linkages in tax revenue may also mean that there are inter-country spillovers from the tax enforcement activities of individual member states. Better enforcement by one member state may give rise to externalities benefiting others, as a result of more effective enforcement of claims to be credited for taxes paid elsewhere, preventing low-tax states becoming "tax havens" for those seeking to evade taxes in their own country, and by preventing taxable economic activity evading tax altogether.

The scale of cross-country externalities arising from the effects of taxation on private sector decisions are likely to be a function of, the one hand, the extent to which member states' tax systems differ, and, on the other, the extent of integration of different markets (for labour, goods and services, capital, etc.) within the Community economy.

There are marked differences between member states, both in absolute per capita tax revenues, and in tax revenues as a percentage of GDP. These differences reflect different underlying policies towards the level of government spending (and, in the short term at least, different attitudes towards
state borrowing). For as long as national governments have different priorities in public spending, or economies differ in levels of income and other aspects of the tax base, differences in taxation will be inevitable. Thus, whilst a completely uniform tax system would eliminate the potential for tax-induced distortion of industrial competitiveness and location decisions within the Community market, this conclusion is of little interest. For the foreseeable future, the question is not how to avoid all sources of tax-induced distortion within the Community, but simply to reduce the most serious distortionary effects whilst causing the least disturbance to member states' revenue raising powers.

The degree of market integration is a key factor determining the location of significant cross-country effects from taxation. Where large numbers of economic agents are making decisions across a range of alternatives located in different member states, the potential arises for taxation to influence the pattern of outcomes across countries. The process of European integration in different markets has been very uneven, and even after 1992 will remain so. Thus, the market for goods is already highly integrated within the Community, and, after 1992, the remaining institutional barriers to goods market integration should, it is intended, have been eliminated. Major steps will also be taken towards full integration of the capital market. However, even with the removal of a significant number of institutional barriers to labour mobility, it is likely that the labour markets of member states will remain only weakly integrated, segmented by language barriers and cultural differences that may take many years to erode. This differential integration determines where the cross-country effects of taxation are likely to be of significance, and where, over time, new cross-country issues are likely to arise.

2.4 Assignment versus Coordination

However, assigning responsibility for taxation to the Community is not the only possible response to policy spillovers, and may not be the appropriate choice in many cases. Often it may be possible for the interests of other countries in the policy decisions taken by national governments to be reflected in an agreement between the countries concerned, specifying the way in which policy will operate.

Indeed, the EC plays a mixed role - part government, part forum for international negotiation. It therefore provides scope for a range of possible degrees of constraint on national policy-making, ranging from ad hoc negotiation over the key distortionary aspects of member states' tax systems, to the comprehensive takeover of member states' responsibilities for a particular area of taxation. The current emphasis on subsidiarity and decentralisation implies that the former route is to be preferred wherever possible. When, however, is minimal coordination, of this form, likely to suffice?

Gatsios and Seabright (1989) discuss the circumstances in which agreements on policy coordination or harmonisation will be adequate to deal with the problem of cross-country policy spillovers. They argue that the main gains from actually handing over responsibility for an area of policy with large cross-country policy externalities to the Community arise in the form of greater credibility of central operation. Where it is difficult to monitor compliance with international agreements (for example, where their implementation requires a large amount of judgement, based
on more information than other parties to the agreement are likely to possess), signatories to an international agreement to implement national policy taking international externalities into account may not have confidence that the other signatories will comply. Where this is the case, compliance is likely to become an increasingly unattractive strategy, for the usual "prisoners' dilemma" type reasons.

The key issues in deciding the functions that need to be assigned to Community level are thus those of information and monitoring. Those functions which the Community itself needs to exercise are those where there are substantial cross-country policy externalities, and where compliance with agreements between national governments cannot easily be monitored by national governments. Amongst the various categories of cross-country spillover set out above, it may be comparatively straightforward to negotiate credible agreements to limit the extent of the spillover in the case of some, such as the impact of tax rates on private sector activity, where the compliance of member states' can be easily observed. In other areas, however, the information needed to monitor member states' compliance with any agreement may be harder to obtain - for example, where spillovers arise from member states' tax enforcement activities. Even here, however, it may be possible to maintain a substantial degree of decentralisation. As an alternative to the unattractive option of transferring tax administration responsibilities to the Community, it may be possible to devise measures which would enhance the credibility of agreements about the conduct of member states' tax enforcement activities, for example by the institution of a Community mechanism for auditing member states' tax enforcement practices and procedures.

3 Origin versus Destination Bases for Indirect Taxes in the EC

3.1 Theory

Prior to the introduction of a VAT system in the European Community, there was considerable discussion of the basis on which trade flows between member states should be taxed. Much of this focussed on the choice between two general systems of indirect tax treatment - taxation according to the origin basis or the destination basis. At first sight it would appear that indirect taxes levied on the origin basis (ie in the country where goods are produced) would inevitably distort the pattern of industrial competition between member states of the Community unless levied at the same rate in all member states, whilst indirect taxes levied on the destination basis (ie in the country where the goods are consumed) would not distort competition between producers located in different member states, even if the member states levied different tax rates.

However, in some simple models it is clear that the two principles are equivalent. Thus, where two countries are trading in goods produced using a fixed stock of immobile factors of production, and where either the exchange rate or price levels are perfectly flexible, then the relative prices of the two goods will be unaffected by the choice between the destination and origin principles for indirect taxation.
A completely general tax applied to all production (ie levied on the origin basis) will have the same effects on real income levels and the pattern of consumption in each country as a tax levied on all consumption (ie on the destination basis), because the exchange rate (or domestic price levels) can adjust to offset the higher tax-inclusive prices at which goods are traded between the countries. The goods which are traded, and the volume of trade, will be the same in both cases, and the use of the origin principle will thus not lead to any competitive disadvantage (Shoup, 1954; Grossman, 1980). Since the origin and destination principles lead to equivalent outcomes, harmonisation of tax rates is no more required where a general sales tax is levied at the rates ruling in the country of origin than where it is levied at the rates ruling in the country of destination. Either system is, in this situation, compatible with full national discretion over tax rates (Whalley, 1979).

There has been some discussion about which of these features of the simple model are of critical importance in leading to the equivalence result. In this model, where factor supplies are assumed to be fixed, the choice of tax basis merely affects the relative prices of domestically-produced and imported goods, and indirect taxes therefore do not distort, for example, the choice between goods and leisure in either country. Similarly, the assumption of factor immobility rules out various possibilities for distortion at other margins of decision. In addition, further conditions are implied by the assumptions made - for example, the two-country assumption guarantees initial trade balance, whilst the simplicity of the model rules out the existence of capital flows between countries.

Shoup (1954) argues that the conditions required for the equivalence theorem to hold are so strong that it would be unwise to rely on it as a justification for applying the origin principle. In addition, Cnossen and Shoup (1987) place considerable weight on how the tax system is perceived by market participants; although the origin principle may not disadvantage domestic producers if a higher tax rate is applied in their country than in the other country, the origin principle may be perceived as less fair than the destination principle.

In practice, systems of indirect taxation with a single national rate applied to all production, or to all consumption, are rare. Most indirect tax systems differentiate between different goods and services, for a variety of reasons (economic efficiency, distributional reasons, the administrative infeasibility of taxing certain services, etc). Where the coverage of the tax base is incomplete, or where different tax rates are applied to different categories of goods and services, the equivalence between the destination and origin principles no longer applies. The exchange rate adjustment can only offset the average origin tax burden, and not the differences between the burden on different categories of goods and services.

Shibata (1967) has observed that in practice the choice for an integrating economic area may include other options besides the simple choice of destination and origin bases for all transactions. He discusses a third possibility, the "restricted origin principle", under which members of the fiscal union apply the origin principle to their internal trade, and the destination principle to their trade with countries outside the union.
Cnossen and Shoup suggest that the fiscal union might wish to choose the restricted origin principle because it would enable them to avoid border controls between members. This would certainly be a valid reason if the tax were a sales tax to be applied to an economy where there was only a single stage of production. However, where a VAT of the "credit" type is used, some form of border adjustment will be needed to achieve either an origin or a destination outcome; merely the form of the border adjustment will differ.

What would be the implications of choosing the restricted origin principle in place of either the general origin principle or destination principle? The discussion has been unclear, partly because of differences in the assumptions and terminology used.

One issue which affects the conclusions reached concerns the tax treatment of imports to the customs union from countries outside the union. Shibata (1967) points out that if the customs union permits imports from outside the union to be taxed on a destination basis at the point of import, and then taxed on subsequent movements within the union according to the origin basis, it will be worthwhile (in the absence of transport costs) for importers to source all of the union’s imports through the member state with the lowest tax rates. These imports can then be sold throughout the union without any subsequent tax adjustment being applied. Evidently if this type of “tax deflection” occurs, then the tax rate ruling for imports to the union will be the minimum of the tax rates of its members, and the only member state to collect revenues on imports from outside the union will be the lowest-tax member state. Moreover, as Georgakopoulos (1989) shows, the tax deflection can in itself help to reduce the tax distortions under the restricted origin principle; effectively uniform tax rates are levied in the union, since only the lowest rate applies.

On the other hand, members of the fiscal union will generally wish to avoid a situation where substantial trade deflection occurs, since this will lead to large differences in the tax revenues accruing to union members. Trade deflection could be dealt with by applying rules of ultimate destination to imports from outside the union, or by levying a "common external tax" on imports. Neither may be entirely satisfactory solutions, however; the enforcement of rules of ultimate destination might be difficult and costly, whilst the common external tax would lead to distortions between imports and domestic production, if different tax rates were levied on domestic production in each country.

A second source of confusion has been in the choice of terminology to describe the impact of tax differences under the restricted origin principle and the two general principles. Whalley (1979) argues that under the restricted origin principle "any tax rate, either uniform or non-uniform, will usually distort trade in the sense that trade flows between member countries.. cannot be the same as in the no tax situation". The only exception to this conclusion, he notes, is the case where trade is bilaterally balanced (ie member states of the union are in trade balance with each other, and

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2 This is quite independent of the issue of the way in which such border adjustments are made; as Cnossen (1983) argues it is quite feasible to operate a destination based VAT system in which physical frontier controls play no part at all in the operation or enforcement of the tax.
also in trade balance with the rest of the world. The intuition of his argument for this conclusion is simple: under the restricted origin principle exchange rate adjustments have to compensate for the geographically-discriminatory tax, and can only do this if trade is bilaterally-balanced.

Berglas (1981), however, objects that Whalley's reference to "distortions" is inappropriate. In the cases where the member states of the union levy the same tax rate, the no-tax equilibrium can be restored if a set of lump-sum transfers accompanies the introduction of the restricted origin principle. Berglas concludes that these are cases where the outcome simply involves redistribution rather than distortion. Distortions in the conventional sense still arise under the restricted origin principle when member states levy different tax rates.

Georgakopoulos and Hitiris (1992) suggest some further reasons besides the possible administrative gains for choosing the restricted origin principle. Basing their argument on an interpretation of the restricted origin principle where trade deflection occurs, so that the tax applied to imports is the same in all members of the fiscal union, they show that the impact of trade deflection under restricted origin principle may compensate for other sources of distortion, in the form of excessive initial trade tariffs, or inefficient differential taxation of different goods and services. For example, in the case where there is a pre-existing tariff causing inefficiency in the form of unduly high domestic production and inefficiently low domestic consumption in the union countries, the application of the restricted origin principle with trade deflection will reduce the relative price of importables to the exportable commodity, and shift production to the latter - thus offsetting the initial distortion.

In conclusion, the balance of the arguments discussed in this section depends both on the various general and specific economic efficiency arguments, and - probably to a greater degree - on the view taken about the administrative costs - or practicality - of operating different VAT systems.

It is clear that countries levying general destination-based taxes are not unambiguously at a competitive advantage, or exposed to less fiscal distortion, than countries levying general origin-based sales taxes. The economic efficiency case for choosing the destination basis is therefore less overwhelming than a superficial analysis might suggest - although the equivalence between origin and destination-based indirect taxes does break down in a range of likely circumstances, which would generally tend to favour the destination basis.

The administrative arguments appear more clear-cut. Most of the theoretical papers assume, in effect, single-stage sales taxes in a world without intermediate goods, or a system of genuine taxation of value-added; these are cases where it is relatively easy to define how an origin-based indirect tax would be applied. It is more difficult to see how an origin-based system of VAT would work with the types of invoice-based ("credit" type) VAT operated in practice by the EC and most other countries. A further key administrative issue implicit in the above discussion is whether general destination-based systems can be made to work, especially within the EC once internal frontiers have been abolished. Proposals to move to the restricted origin principle basically aim to

3 Grossman (1980) makes a similar observation.
make the best of a situation where the type of fiscal adjustments which the destination system requires cannot in practice be made on transactions within the EC. It is however far from clear that this corresponds to the real situation. There are administrative ways of overcoming some of the economic difficulties, and also further economic issues raised by the choice of different systems which in the end count against the restricted origin principle. We discuss these further issues in the next section, structuring the discussion around an account of the development of VAT procedures within the EC.

3.2 Procedures for intra-EC VAT

Whatever the theoretical arguments for and against destination and origin bases for indirect taxation, VAT in the European Community has been operated in a way that is explicitly designed to ensure that the incidence of the tax reflects the destination principle; in other words, that goods and services subject to VAT bear the VAT of the country where they are purchased by final consumers, rather than that of the country (or countries) where they were produced.

Under the arrangements established when the Community VAT system was introduced, this was achieved by zero-rating goods exported from one member state to another, and imposing VAT on import (in a variety of equivalent ways) on the full value of imported goods (Figure 1). Danish bacon sold in UK shops thus bore the UK VAT rate of zero, rather than the higher Danish rate, and, as far as VAT was concerned, competed on an equal footing with produce from member states with lower VAT rates.

The application of VAT zero-rating on intra-EC exports had a number of implications. Similar VAT procedures applied to intra-EC transactions and to trade with countries outside the Community. Also, VAT revenues accrued to the member state where the goods were sold for final consumption, rather than the member state (or member states) where the goods were produced.

Customs procedures played a central role in the operation of VAT on goods traded between member states. From the point of view of VAT enforcement, the vulnerable point in the arrangements was establishing the export of goods which had been zero-rated, and preventing the diversion of such goods, untaxed, back into domestic consumption. Customs procedures and customs documentation provided the possibility of enforcing export zero-rating, and although most member states did not require routine customs documentation as a prior condition for claims for export zero-rating, customs documentation provided one of the most effective methods of investigation and enforcement.

The precise administrative arrangements for levying VAT on import varied between member states, but in many member states the customs authorities were used to identify the import of goods subject to VAT, and to levy the appropriate tax. This, however, was a considerably less critical operation within the system than supervising export zero-rating. Even if goods which should have been subject to VAT on import were not taxed, there would not necessarily be any revenue loss, since at any subsequent stage at which VAT was due, the VAT paid on import would be deductible.
against "output" VAT liability. The BENELUX countries, which operated a form of "postponed accounting system" for VAT on imports, implicitly relied on this subsequent stage to ensure that VAT was levied on imports.

As far as VAT administration and enforcement activities were concerned, the role of each member state’s national VAT administration ended at its geographical boundary. Since goods bore no VAT at the point at which they crossed from one member state to another, there was no need for national VAT administrations to be concerned with the past VAT "history" of the goods in other member states, and little need for legislative congruence between the VAT systems of different member states. Co-operation between national VAT administrations was largely unnecessary, and consequently the experience of such co-operation was rare and limited in scope.

In the years following the introduction of VAT in the Community, the Commission expended enormous energy on a series of initiatives to harmonise the VAT systems and rates of member states. A series of Directives was proposed which aimed to harmonise the base of the VAT in member states; of these, by far the most significant was the Sixth Directive, which governs much of the basic structure of member states’ VAT systems. The motivation for such harmonisation

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4 This is a reflection of the so-called "self-enforcing" character of VAT, by which it is meant that if an intermediate good is not taxed, this will merely result in a reduction in the "input" VAT which can be deducted at the next taxable transaction; business purchasers therefore have little interest in purchasing from suppliers who fail to charge VAT.
efforts has been mixed. One important consideration appears to have been the ultimate intention
to turn VAT into a tax to be used to finance the EC's own budget, levied on a harmonised basis
across all member states. In practice, however, the VAT contributions made by member states
have always been related to a hypothetical, and fully-harmonised, base, and in recent years the
role of VAT in financing the EC's activities has been reduced in favour of greater GNP-based
contributions from member states. Judged purely in terms of the efficiency of operation of member
states' VAT under the system of export zero-rating, most of the progress towards harmonisation
of the VAT base and other aspects of VAT legislation in member states has been largely
unnecessary.

The 1987 proposals for VAT administration

The proposals of the European Commission, made in the 1985 Commission White Paper
"Completing the Internal Market", to abolish internal frontiers within the Community, created a
requirement for new VAT procedures to replace the role that had been performed by frontier controls
in the operation of VAT zero-rating. The Commission took the view that without frontier controls
to establish the validity of claims to zero-rate goods for intra-Community export, the existing VAT
treatment of cross-frontier trade within the Community would be unworkable.

In proposals published in 1987\(^5\), the Commission proposed that zero-rating for trade between
member state should be abolished, and instead the chain of VAT payment-and-refund, which
applied to transactions within each member state, should be extended to cover cross-frontier
transactions. Goods would then be traded between member states bearing the exporting country's
VAT, and the importing company would then be able to offset this VAT against its output VAT
liability. The VAT paid on imports would thus be refunded to the importing company at the next
taxable transaction, in just the same way as with goods bought from domestic suppliers; the credit
would be given at the full amount of the VAT that had been paid, so the importing company would
again be indifferent regarding the member state from which it bought its supplies (Figure 2). The
"neutrality" of the EC VAT system (in the sense of the conformity of the final incidence of VAT with
the destination principle) would have thus remained unchanged.

The new arrangements were designed to meet two requirements. Firstly, and crucially, they would
have established a VAT system for intra-EC trade which allowed the elimination of fiscal checks
at internal frontiers, and would therefore have eliminated one of the principal obstacles to the
abolition of internal border formalities. The elimination of these formalities was seen as a key aspect
of the White Paper's programme of measures to complete the Internal Market of the Community
by the end of 1992; quite apart from the psychological impact of the abolition of internal frontier
formalities, it was believed that they significantly increased the costs of intra-EC trade, and could
be used, deliberately, by member states to protect domestic producers against imports.

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\(^5\) Commission (1987a); see Lee, Pearson and Smith (1988) for a discussion.
1. Co-ordination of Indirect Taxes

Figure 2.

White Paper proposals for VAT on intra-EC transactions.

Secondly, the proposed system would have treated trade between member states in a way which followed as closely as possible the VAT treatment of transactions within each individual member state, particularly with regard to the procedures which traders were required to follow, and the burden of documentation which they would have to provide. Besides removing the need for frontier controls at internal Community frontiers, the proposed system would thus have contributed in a second way to the objectives of the completion of the internal market of the EC, by equalising as far as possible the VAT compliance burden on business in transactions between member states, and internally within each member state. The costs of "tax bureaucracy" would be broadly the same on both types of transaction, and would thus provide no disincentive to the development of intra-EC trade.

From the point of view of traders, therefore, the new system was intended to involve no greater compliance cost than on domestic transactions subject to VAT, and thus would in general be expected to reduce compliance costs below what they would be with export zero-rating. In practice, there was considerable scepticism from business groups about the extent to which the new procedures would achieve this objective, and the compliance costs involved in certain aspects of the proposals were the subject of extensive discussion.
From the point of view of the revenue authorities of member states, however, it is clear that the proposals to extend the chain of VAT invoices across national boundaries would have involved major changes in operation. The focus of enforcement activity on ensuring the validity of claims for VAT zero-rating for export would obviously come to an end. The convenient administrative separation which the zero-rating system permitted between the concerns and responsibilities of national VAT administrations would cease. Each national tax administration would have had to handle claims for input VAT credit from purchases arising in all of the other member states. Since an important part of VAT enforcement within the chain of invoices is ensuring the validity of invoices, arrangements would have had to be established to ensure cooperation between member states' tax authorities in the cross-country validation of VAT input claims.

These potential problems of administrative coordination were partly simply a problem of transition - insufficient time was available to establish the necessary degree of administrative coordination between member states. But there were also longer-term concerns, which centred on a further feature of the system proposed by the Commission in its 1987 scheme, the proposal for a Clearing House for the re-allocation of VAT revenues between member states. The particular problems this would have created for the long-run effectiveness of VAT administration and enforcement are discussed in the next section.

As a result of these various administrative obstacles, the member states of the Community proved unable to agree on the Commission's proposals for reform of cross-frontier VAT, and, with the deadline of 31 December 1992 rapidly approaching, decided instead on a limited programme of modifications to the existing VAT zero-rating system, designed to ensure that it could continue even after the abolition of frontier controls (Aujean and Vis, 1992). The essence of this new scheme was that the various control possibilities previously available at frontiers should be replaced by controls in the form of audit and administrative supervision of the traders at each end of a cross-frontier transaction. In addition, any VAT previously paid on import from another Community member state should now be levied on the importing company; the timing of import VAT payments would change, but their amounts, and the net impact of VAT on any transaction, would remain the same.

From a theoretical point of view, the system achieves the same neutrality objectives as the existing VAT treatment; it also involves no redistribution of revenues between countries compared to the existing VAT scheme. The main difficulties with operating cross-country VAT in this way concern enforcement. Firstly, is the loss of the scope for control at the border liable to lead to increased VAT evasion, in the form of zero-rated goods being diverted to the shadow economy in member states? Secondly, to the extent that it is possible to devise effective administrative and audit procedures for cross-frontier transactions to prevent greater VAT evasion, how far will these procedures increase the compliance costs for cross-frontier trade, relative to the costs of transactions internal to a single member state? After all, the objective of the whole exercise had been to reduce the deadweight costs of cross-frontier transactions, and if the outcome of the process has been simply to shift the location of these costs inland, the abolition of fiscal formalities at frontiers would have made no contribution to stimulating the development of a more integrated internal market in the Community.
1. Co-ordination of Indirect Taxes

It is certainly possible to devise watertight administrative procedures which will keep the risk of the diversion of zero-rated goods to the untaxed sector to a minimum. Proposals made by the French government during the course of 1989 would have required exports from one Community country to another to be accompanied by multiple copies of a special administrative document. Entitlement to zero-rate intra-EC exports would have been established by the eventual return of one of these copies, certified by the importer’s tax office, to the exporter’s tax office. This system would clearly have kept the risk of greater VAT evasion to a minimum, but at substantial compliance cost; in particular, the cost of “tax bureaucracy” would have been much higher on intra-EC transactions than on purely domestic transactions.

3.3 Revenue allocation

When goods traded between Community member states are zero-rated for VAT purposes, the level of net VAT receipts in each member state is determined by its tax rates and the pattern of consumption of its residents. VAT-inclusive invoicing for intra-Community trade, as proposed by the Commission in 1987, would have changed the pattern of net tax revenues, because member states would be required to give credit for the VAT on imported goods. In the transaction shown in Figures 1 and 2, the zero-rating system allocates all of the tax revenue to the importing country, whilst VAT-inclusive invoicing for intra-Community trade leaves the exporting country with the VAT collected on its exports, and reduces the net VAT receipts of the importing country by this amount. Compared with the zero-rating system, the reform proposed by the Commission in 1987 would have resulted in an increase in overall VAT revenues in member states with above-average VAT rates, or with a surplus in trade with other EC members, and corresponding reductions in VAT revenue elsewhere.

In some cases, the revenue changes would have been substantial; Commission estimates made at the time indicated that the proposed change in the VAT treatment of intra-EC trade would have reduced revenues in Greece by more than one per cent of GDP, and would have also involved large revenue losses in Denmark, Portugal, France, the UK and Ireland. Germany would have been a substantial revenue gainer. In response to the political difficulties that a revenue redistribution of this magnitude would have created, the Commission devised a "Clearing House" scheme, designed to restore the pattern of VAT revenues to what they would have been if the VAT zero-rating system had continued in operation.

The effect of the Clearing House scheme was that member states would be refunded the total VAT credit given on imported goods, but would, in return, forfeit their VAT receipts from exported goods. The scheme would operate through a central Community account, rather than bilaterally between member states. The information needed to operate the system would have been obtained by requiring traders to report the totals of VAT claimed on their imports from other member states,

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6 Commission (1987b), Annex A.
and VAT paid on their exports to other member states, and each member state would then determine its own net VAT position, by adding up the import and export VAT amounts on its traders' intra-Community trade.

As each claim for VAT repayment in one country should have been matched by a VAT payment in another, the Clearing House should have been able to break even. Indeed, since some exports would have been to unregistered and VAT-exempt traders and private individuals, who would be unable to reclaim the VAT paid, the Clearing House ought to operate at a small surplus. However, as Lee, Pearson and Smith (1988) observed, there were reasons to doubt that this would be achieved, because of an important enforcement asymmetry in the system. Under the Clearing House system, member states would have been reimbursed the cost of input VAT claims relating to imported goods, and may thus have perceived little incentive to spend resources on controlling dubious and fraudulent claims for input VAT. The Clearing House serves to make the enforcement of input VAT claims into a Community "public good", and, as with all public goods, there is a presumption that too little of it will be provided.

A number of possible responses might be made to the enforcement problems within the Clearing House system. A limit to the enforcement slackness - or outright misreporting - of member states would have been provided by the availability of external information on the pattern of trade flows between member states. Indeed, it would have been possible to base the revenue adjustments on these statistics, rather than on information provided by individual traders to the VAT authorities of member states. However, once frontier formalities were abolished, information on trade flows would have to be obtained from surveys of traders, and information obtained from trade statistics would then have been less independent of traders' VAT declarations than it might at first sight have appeared. A second possible response would have been to simply to accept the revenue redistribution arising from the new VAT system, or to agree in advance a pattern of compensation that was not to depend on the actual trade flows observed in practice. The amount of revenue redistribution that would have arisen if the new system had been applied to existing trade flows could have been calculated without the same risk of systematic misreporting, might have formed the basis for agreement on lump-sum revenue compensation flows. A third line of response would have been to develop effective Community-level systems for the supervision and monitoring of member states' VAT enforcement, recognising the principal-agent problem that arises when the Community-wide benefits of tax enforcement are provided by decentralised tax administrations at the level of individual member states.

3.4 Future policy options

Severe enforcement problems were envisaged from the Commission's 1987 proposals, both in establishing the necessary degree of administrative coordination between member states' tax authorities before the deadline of the end of 1992, and in preventing gradual erosion of the enforcement "integrity" of the Community VAT system. However, the decision which has been taken to retain the existing cross-frontier VAT system based on export zero-rating, with administrative mechanisms replacing border formalities, has been presented as merely a temporary
solution, pending agreement on a more durable reform. By 1997 the intention is that the Community should move to a new VAT system for intra-EC transactions, based on an "origin" system (Aujean and Vis, 1992). However, there has been some confusion about the precise meaning of this commitment.

It is clear that the UK interprets this as merely a proposal to move to the system of administration proposed in the White Paper - in which the effective incidence of the VAT system would remain on a destination basis, but in which the tax adjustments necessary to achieve this would be made by extending the VAT chain across frontiers. But there have been suggestions that a more fundamental commitment has been made to eventual adoption of the restricted origin principle - which, in a VAT system, is by no means the same thing as abolishing zero-rating on flows of goods across the Community's internal frontiers.

Moving to genuine implementation of the restricted origin principle would almost certainly need to be accompanied by a move to an accounts-type VAT system. Whilst it would, in principle, be possible to define the level of input VAT credit in the importing country which would achieve an origin-basis effect this would require a complex computation of the VAT that would have been charged on the tax-inclusive price of the imported inputs if the importing country's VAT rates had applied (Genser and Hauffler, 1996). The restricted origin principle would increase neutrality between cross-border shopping and trade transactions within the EC - but if it requires an accounts-based VAT has much wider implications. Enforcement of an accounts-type VAT depends on the same source of information as the enforcement of profits taxes, and one source of independent information is lost to the tax system. To the extent that the existing VAT is seen as having a "self-enforcing" character, this would be reduced if an accounts-based VAT were introduced.

4 Community Rules and Member States' VAT Rates

The Commission's 1987 proposals had included substantial limitations on the rates of indirect tax that member states could levy. Under the proposals, member states would have been restricted to a two-rate system of VAT, with a standard VAT rate in the range 14-20 per cent, and a reduced rate of 4-9 per cent, to be applied to a list of "basic" goods and services (food, domestic energy, public transport, books and newspapers). Uniform excise duties were to be applied throughout the Community, at rates which generally represented the average of the rates applied in member states7. The proposals for VAT bands were principally aimed at restricting the amount of cross-border shopping by individuals (and by small businesses and other entities not registered for VAT), which would, the Commission argued, have reached unacceptable levels if tax-induced

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7 The reasons for seeking wholly uniform excise duty rates had to do with the difficulty of enforcing different rates of excise duty once frontier controls were abolished. Large-scale cross-frontier commercial movements of duty-paid goods were anticipated, if rates of duty differed between member states after 1992. The issues of excise enforcement and control in the Single Market are not discussed in detail in this paper; see Smith (1988) for a discussion, and some suggestions of mechanisms which would have allowed some scope for duty rates to differ between member states.
price differentials were to be greater than about 5 per cent. It is clear that the proposed changes in member states' tax rates would have had substantial implications for member state tax revenues\(^8\), and for the rates of tax on certain socially and distributionally sensitive goods.

Much of the argument over the Commission's 1987 proposals focussed on the proposed VAT bands, and subsequent decisions have watered down considerably the rules on tax rates which apply to member states after 1992. For some member states (including the UK) the agreements reached permit the retention of all or nearly all of the existing VAT structure; others such as Germany have, for domestic budgetary reasons, already made moves which bring their VAT structures closer into line with the new requirements. Under the June 1991 agreement on VAT rates, member states must now levy a standard rate of VAT of at least 15 per cent, and can apply one or two reduced rates of at least 5 per cent to a limited list of goods and services. Existing rates of VAT below 5 per cent (including zero rates) can be retained, and transitional arrangements allow an intermediate rate of at least 12 per cent to be applied for a period to goods which member states had previously taxed at reduced rates, but which no longer qualified for the reduced rate (Aujean and Vis, 1992).

How far are these requirements governing member states' tax rates justified, and consistent with the criteria for subsidiarity that we outlined earlier? One aspect of the debate, which we leave to one side, has been the assertion that control over tax rates is an essential component of national sovereignty. Other arguments advanced have maintained that there are various potential economic costs and benefits associated with the coordination of indirect tax rates in the Community, which may warrant some level of Community control. We consider these arguments in subsequent parts of this section.

### 4.1 Co-ordination of Indirect tax structures

There is an obvious Community interest in the indirect tax structure of member states; excise taxes, or other non-uniform indirect taxes, can effectively operate as tariffs on goods that are predominantly imported. Friedlaender and Vandendorpe (1968) show how a country with a degree of monopoly power in international trade can improve its welfare at the expense of its trading partners by imposing taxes either on production or consumption to approximate the effects that would be obtained by an optimal tariff. Except where a country faces an infinitely price-elastic foreign demand for its exports (the small country case), it can improve its welfare by taxing the domestic production of exportables and subsidising the domestic production of importables, or, with a similar effect, by subsidising the domestic consumption of exportables and taxing the domestic consumption of importables.\(^9\)

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\(^8\) For studies of revenue and other effects of the proposed tax rates in member states see, for example, Symons and Walker (1988) and Brugiavini and Weber (1988).

\(^9\) Vandendorpe (1972) extends the results to include conditions for the appropriate taxation of a non-traded good in a three-commodity model. Rose (1987) follows the "optimal tax" literature in making the assumption that lump-sum transfers are not available, and derives results for the optimal structure of consumption tax rates in a single member state and the optimal structure of consumption tax rates to apply to the Community as a whole, which are broadly similar in general outline to those obtained by Friedlaender and Vandendorpe.
Recognising the potential for indirect protection through the indirect tax structure, the Community has, for example, tried to harmonise the taxes levied on alcohol in member states, believing that the higher taxes on wine than beer in the UK constituted indirect protection of UK-produced beer, relative to wine imports. Similarly, efforts have been made to harmonise taxes on cigarettes; the balance of specific to ad valorem taxes has segmented the Community market into two groups - countries where specific taxes predominate, and where high-quality brands dominate the market, and countries where ad valorem taxes dominate, and where lower-quality brands are more competitive (Kay and Keen, 1987).

In addition to these arguments for coordination of the tax structure in member states to eliminate covert protection, it has been argued that there are also potential welfare gains from greater convergence of the indirect tax systems in member states. Keen (1987), for example, presents a model in which the convergence of the indirect tax rates in member states towards the weighted average in all member states can reduce the aggregate welfare costs of raising fiscal revenues in the Community as a whole. The essence of the argument is that the welfare costs of raising tax revenues are not linear in the indirect tax rate, but rise more than proportionately with higher tax rates. Reducing the revenues raised in high-tax member states, whilst simultaneously increasing revenues in low-tax member states can raise the same revenue at lower aggregate welfare cost. Of course, it raises revenues from different countries, and greater distortionary costs are, in general, borne by those member states raising their tax rates. Nonetheless, the aggregate gain means that there is, in principle, scope for the member states which lose to be adequately compensated, through some form of revenue transfer mechanism.

In practice, of course, the required revenue transfers may be difficult to agree. Without them, are there any circumstances in which the form of harmonisation discussed in Keen (1987) would still be desirable? Keen (1989) shows that there are, and that they may well correspond to the actual situation in Community countries. Where member states have designed their indirect tax structures so as to favour their own domestic producers, Keen argues that a move to the weighted average of member states' tax rates may be actually Pareto-improving, without the need for revenue transfers between countries.

**4.2 Cross-border shopping and tax competition**

The main arguments for Community control over the tax rates levied by member states have to do with the possibility that, without Community control, tax competition between member states may take place, and that this competition would prove damaging.

Fiscal competition in the taxation of goods and services can arise in a number of contexts. The type of fiscal competition which has been the main concern of the theoretical literature has been fiscal competition to attract cross-border shopping; that is, purchases of goods and services in one country by residents of another. As we have observed, this is a phenomenon which can be expected

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10 Turunen-Red and Woodland (1990) extend the approach taken by Keen to consider general multilateral tax reforms by a group of countries which apply distortionary tariffs to their international trade.
to have increased as a consequence of the abolition of intra-Community frontier controls at the end of 1992 (Bos and Nelson, 1988; Boiteux, 1988). Since then, Community residents have, in effect, faced a hybrid system of indirect taxation, with the destination principle in force for commercial movements of goods across internal Community frontiers, and the origin system for individual cross-frontier purchasing (Sinn, 1990; Haufler, 1991b). The possibility that tax competition could arise in this situation has been discussed by, amongst others, Lee, Pearson and Smith (1988) and Keen (1993). Member states might, for example, be tempted to try to attract cross-border shopping, and hence extra tax revenue, by reducing the rate of indirect tax they levy, in the hope that it would induce a sufficiently large increase in tax base to compensate for the reduction in the tax paid on each existing unit of cross border shopping. Theoretical models of processes of tax competition based on cross-border shopping have been set out by Mintz and Tuikens (1986), de Crombrugghe and Tuikens (1990), Kanbur and Keen (1993), Lockwood (1993), Christiansen (1994) and Haufler (1996a, 1996b). The papers differ in various aspects of the institutional setting they describe, and in the modelling assumptions made. However, taken together, they provide a corpus of important new results on the consequences of tax competition, and on the effectiveness of various types of policy response.

Under what circumstances is cross-border shopping likely to arise, and what will govern its extent? The costs of cross-border shopping are crucial, and so is the tax system in force. Assuming that cross-border shopping by individuals is always more costly than importing by businesses, cross-border shopping will only arise where different tax provisions apply to cross-border shopping and domestic purchases. In a purely origin-based tax regime, there is always the possibility to purchase goods taxed at the foreign country’s tax rate from businesses located in the domestic economy. Also, the structure and level of cross-border shopping costs determines how much cross-border shopping would take place for a given pattern of tax rates. If cross-border shopping is costless, then any difference in taxes will result in all purchases being made in the lowest-tax economy. On the other hand, if cross-border shopping entails fixed costs, then some tax differential may be possible without any cross-border shopping taking place. Intermediate situations, where some cross-border shopping takes place, but some purchases are still made in the domestic economy, require some form of convexity in the costs of cross-border shopping. One natural source of such convexity will be travel costs; if travel costs rise with distance (fuel costs, time) then a given tax differential may be sufficient to induce cross-border shopping by customers living near the border, without affecting the pattern of purchases of those living further away.

Empirical evidence on cross border shopping on the border between Northern Ireland and the Irish republic (Fitzgerald, Quinn, Whelan and Williams, 1988) found a sharp decline in the amount of cross border shopping with increasing distance from the border. 46 per cent of households in the six counties of the Irish Republic closest to the border with Northern Ireland did some cross border shopping, compared to only 8 per cent of households in other parts of the Republic. The average cost of a shopping trip by households in the six border counties was £6.48, of which two thirds was the cost of travel; this compared with average spending per trip of £41.50. Travel costs appeared to have a major influence on the amount and frequency of cross-border shopping. Regression analysis on data for households in the six border counties showed that distance from
the border and car ownership together explained over one third of the variance in the number of trips made. Time costs too may have been important. The money saving which households said they required to make a trip worthwhile increased by on average £0.42 for each extra mile from the border, and the level of savings required to justify a trip appeared to be positively related to household incomes.

Mintz and Tulkens (1986) discuss the range of possible outcomes that can take place in a model of cross border shopping, reflecting the pattern of cross-border shopping costs and the difference in tax rates between two countries. Five possible "regimes", in the sense of different patterns of production and cross-border shopping, could arise, depending on the pair of tax rates \((t_i, t_j)\) levied in the two countries (Figure 3). Where the difference between tax rates is very small, the costs of cross-border shopping may prevent any cross-border transactions taking place (Regime 1 in Figure 3). At the other extreme, a very large difference in tax rates will lead to all purchases taking place in the lower-tax country (Regimes 4 and 5). In between, there are two "mixed" regimes in which some cross-border shopping takes place, but where some shopping takes place in each country (Regimes 2 and 3). In Regime 2, for example, tax rates in \(j\) are higher than tax rates in \(i\), and some cross-border shopping by residents of \(j\) takes place in \(i\); \(i\) "exports" taxes to \(j\).

Where, within this range of possibilities, would the countries choose to place themselves? This depends on the objective function with which the government operates, and the structure of taxpayer responses, as summarised in Figure 3; it also depends on their assumptions about the likely response of the other country.

Mintz and Tulkens observe that interjurisdictional fiscal externalities of two types may arise in this situation. One, which they term the "public consumption effect" is a beneficial externality felt by country \(i\) from an increase in the tax rate of \(j\). If \(j\) increases its tax rate, this increases the tax revenues of \(i\) and hence the level of public goods provision that \(i\) can sustain, for any given tax rate that it might choose.

The second fiscal externality, the "private consumption effect" is a negative externality experienced by country \(i\) from an increase in \(j\)'s tax rate; this arises where \(i\)'s citizens are buying goods across the border in \(j\), and reflects the reduction in the real income of residents of country \(i\), through the higher price that they must pay for cross-border purchases when \(j\) increases its tax rate.

These fiscal externalities depend on the regime which applies. For example, in Regime 1, neither applies. In Regime 3, where country \(i\) is both producing and importing, both the public consumption and private consumption externalities are present. The sign of their overall effect depends on the relative importance of public and private consumption in the utility function of country \(i\)'s residents; where residents have a strong preference for public consumption, the beneficial externality from an increase in the other country's tax rate will dominate.
Mintz and Tulkens describe as a "non-cooperative fiscal equilibrium" the Nash equilibrium which results from the tax and spending decisions of the two countries in the above model. The existence, however, of such an equilibrium appears problematic, since, as Mintz and Tulkens show, the "fiscal reaction functions" which show each country's best reply, given the tax rate decision of the other country, are discontinuous, with a downward jump. The jump occurs because there is some level of the foreign tax rate at which the home country finds itself indifferent between one of two choices:

• to levy a high domestic tax rate, putting itself in an autarkic or mixed equilibrium, but allowing it to finance a high level of public goods provision

• to levy a lower domestic tax rate, putting the other country in a mixed equilibrium; this offsets the welfare loss from a lower level of provision of public goods by increased revenue from foreign cross-border shoppers, and a reduced distortionary cost of domestic tax revenues.
1. Co-ordination of indirect Taxes

Mintz and Tulkens do not define the full-cooperative equilibrium, but instead ask how the outcome from a process of fiscal competition of this sort would be likely to compare to Pareto-efficient fiscal choices. Firstly, they demonstrate that in regimes where some cross-border shopping takes place (regimes 2 and 3), the non-cooperative fiscal equilibrium and the Pareto-efficient fiscal decision will differ, because of the operation of the two types of fiscal externality set out above: in the non-cooperative equilibrium, country i makes its fiscal decisions without taking into account the welfare losses that its taxes impose on cross-border shoppers from the other jurisdiction, and without taking account of the effect on the standard of public goods that the other country can provide.

Secondly, they show that Pareto-improving fiscal changes would never reduce the tax rates of both countries; in other words, fiscal competition which leads to equilibria with partial cross-border shopping never involves tax rates which are too high, relative to the Pareto-optimal level, in both countries. The country whose residents shop abroad will always set tax rates which are too low, relative to the optimum (since the only fiscal externality from its choice is on the ability of the other government to finance public spending); the other country, however, may set taxes which are either too high or too low, reflecting the fact that the public consumption and private consumption externalities from its decisions may pull in opposite directions.

Kanbur and Keen (1993) focus on one particular aspect of fiscal competition - the effects of differences in size between countries. They note that tax havens tend to be small countries, and set up a model of fiscal competition in which systematic differences in the interests and strategies of two countries are found to be related to their relative size.

Kanbur and Keen show that the fiscal reaction functions of the two countries, representing each country's best reply, given the tax rate set by the other, depend on the relative size of the two countries.

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11 This conclusion is based on an analysis which considers the revenue and income implications of cross-border shopping only. As Lee, Pearson and Smith (1988) note, however, cross-border shopping gives rise to a range of externalities, including the resource costs expended by cross-border shoppers as well as the revenue externality. Observing that in the Nash equilibrium with cross-border shopping, countries trade off higher revenues against the resource costs of cross border shopping at the margin, de Crombrugghe and Tulkens (1990) are subsequently able to prove a stronger result - tax rates are too low in both countries.

12 The objectives of the countries are represented as simple revenue-maximisation (which Kanbur and Keen suggest might be interpreted as the case where each country places a very high priority on supply of a tax-financed public good). Consumers are assumed to have a reservation price for purchasing a single unit of the taxed good; these reservation prices are assumed uniform with each country, but can differ between the two countries. This produces a more tractable model of Nash competition than in the Mintz and Tulkens paper, but means that for some of the other cases the optimal policy is trivial and of little practical interest. Without the possibility of trade, for example, the optimal policy in each country sets tax rates equal to domestic consumers' reservation prices (defined net of the costs of supply) for the taxed good; there is no trade-off between tax revenue and consumer welfare. It is also possible to define the full-cooperative outcome, but this likewise is of limited interest, given the assumed government objectives. In the full cooperative outcome it continues to be the case that one country, at least, would set tax rates equal to its consumers' reservation prices. In some circumstances this may also be the optimal policy for the other country, if the effects of cross-border shopping are small relative to domestic revenues in both countries. Alternatively, the cooperative solution may involve either tax harmonisation at the higher of reservation prices in the two countries (which would mean that there would be no sales to consumers with low reservation prices, but this would be more than offset by the preservation of maximum revenues from the consumers with high reservation prices), or a pattern of taxes where tax is charged at the reservation price in the low-valuation country, but some reduction in tax is made in the high-valuation country, to reduce, but not eliminate, cross-border shopping. Which of these patterns of tax rates is optimal in the full-cooperative case will depend on the difference between consumers' reservation prices in the two countries, their relative size, and the costs of cross-border shopping per unit distance.
For the smaller country, there is a discontinuity in the reaction function. At very low rates of foreign tax, the small country would not find it worthwhile to undercut the foreign tax rate; it would forego the opportunity of substantial revenue from its own citizens, whilst the revenues it could raise from attracting cross-border shopping would be trivial. At higher rates of foreign tax, however, it becomes worthwhile for the small country to switch to undercutting the high tax rate of the larger country; it will attract more than enough revenue from large numbers of cross-border shoppers to compensate for the lower tax revenues it gets from its own citizens.

The fiscal reaction function of the larger country, on the other hand, exhibits no discontinuity - the tax rate which maximises revenue is strictly increasing in the foreign country's tax rate, and there is no point in which a sudden switch to tax undercutting becomes worthwhile.

Given the discontinuity in the small country's fiscal reaction function, the existence of equilibrium is again problematic. Assuming that an equilibrium exists\(^{13}\), the small country is found always to set a lower tax rate than the large country; "undercutting" always takes place. Per capita revenue is higher in the smaller country than in the large country. Compared to a situation in which cross-border shopping could not take place, tax revenue in the larger country is lower, and so are total tax revenues. The direction of the effect on tax revenues in the smaller country is unclear, and depends on the balance between two effects: opening the border restricts its ability to extract surplus from its own citizens, but allows it to attract revenues from cross-border shopping; the latter dominates if the small country is sufficiently small relative to the large. Fiscal competition through cross-border shopping will thus work against the interests of larger countries, but countries which are sufficiently small may be able to improve their situation compared to a situation in which no cross-border shopping could take place.

**4.3 Future policy options**

Cross-border shopping to benefit from lower taxes in other member states has economic costs, like any other activity carried out purely for fiscal reasons. These economic costs include the time and travel costs of cross-border shoppers, the loss of trade suffered by businesses located on the high-tax side of the border, and the loss of tax revenue to the national exchequer. It has been suggested by a number of authors that the existence of these costs warrants some form of Community limitation on the VAT rates levied by member states (Boiteux, 1988; Guieu and Bonnet, 1987). Similarly, the 1987 Commission proposals justified the width of the proposed VAT bands by arguing on the basis of US experience than VAT differences of up to 5 per cent would not lead to excessive cross border shopping by individuals.

Others, including Lee, Pearson and Smith (1988) have maintained that it is the existence of fiscal externalities between member states that warrants Community action to control cross-border shopping, and that there is an important asymmetry between member states wishing to set tax rates above those ruling elsewhere in the Community, and member states wishing to undercut the VAT rates in other member states. In the former case, the externality on other member states is

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13 Kanbur and Keen show that the conditions required are quite weak.
1. Co-ordination of Indirect Taxes

generally a positive one, and there is no obvious reason why member states should need to restrict the freedom of other member states to choose to set higher tax rates if they wish. On the other hand, where member states wish to set tax rates below other member states, they generally impose a negative externality on other Community countries. The models of fiscal competition discussed in the previous section suggest that there will be a general tendency for such competition to drive tax rates downwards, below the levels they would be without the fiscal externality. Community policy might appropriately aim to increase the rates of tax levied in member states, to counter the downward tendency arising from the process of fiscal competition.

Perhaps the most appropriate form of Community rule, which would reflect the general tendencies observed in the models of fiscal competition, without requiring complex judgement in implementation, would be for the Community to place a "floor" below member states' VAT rates, to restrict the extent to which fiscal competition can drive down the rates of tax which member states levy. This will not, of course, lead to an optimal outcome; the fiscal externality will still constrain national fiscal policy-making at tax rates above the Community VAT floor. Nonetheless, it appears likely to improve matters, and to be preferable to the outcome that would result from unrestricted fiscal competition between member states. Kanbur and Keen, for example, examine the effects of such a policy in their model, and find that it would lead to a Pareto-improvement over the initial situation. In their model, even the smaller country, which had been levying a low tax rate and maximising its revenues by undercutting the tax rates of the larger country, is found to benefit from the imposition of a floor to the VAT rates that can be levied.

The type of agreement on VAT rates that has ultimately been reached would thus appear to reflect a substantial improvement on the initial 1987 proposals. Although the requirements are now weaker than in the earlier plan for VAT bands (for example, no maximum VAT rate is now specified), this weakening of Community control appears likely to be justified by the direction of the externalities involved. Some control is, however, clearly warranted. Without frontier control, member states face a choice between a restriction of the tax rates they can levy through the pressures of competition, and restriction by agreement within the Community. Unrestricted fiscal competition would tend to lead to downward pressure on the tax rates levied by member states, preventing member states pursuing the tax policies they would choose. The requirement that member states should set their VAT rates above the 15 per cent Community floor would appear likely to limit the costs of fiscal competition, whilst imposing only a small constraint on member states' freedom of action in tax policy.

5 Conclusions.

Implementation of the principle of subsidiarity requires criteria to be developed to identify those areas of policy-making where coordinated or centralised policy-making or implementation would be more effective than policy at the national level. Why has defining the appropriate limits for Community policy on taxation proved so intractable?
One reason is that the power to tax is so intimately bound up with political sovereignty. There is a big difference between government units that have the power to raise their own revenues through taxation, and those that are dependent on transfers from other levels of government. National governments are naturally wary of proposals which would severely limit their ability to make their own revenue choices.

A second reason is that diversity in taxation is very probably optimal, even if increasingly difficult to achieve. Differences in the structure of indirect taxation in member states may well be an appropriate response to differences between countries in the characteristics of demand for particular goods. Also, differences in per capita spending levels, or in national tax bases, will almost inevitably require different member states to levy taxes at different average levels. The important issue for Community policy is then not to harmonise all aspects of taxation (which would almost certainly impose large costs in terms of the required changes in member states' public spending policies), but to prioritise for coordination those areas of taxation where diversity is likely to lead to the greatest economic costs. This perhaps suggests that rather more attention should be paid to measures which might reduce distortional aspects of corporate tax systems and the taxation of individual investment income, and rather less attention to the limited remaining differences in indirect taxation.

A third reason why progress has been slow is that agreement is required; the process of negotiation cannot be bypassed. This is not simply because the Single European Act has reserved taxation as one of the few areas in which Community decisions still require unanimity. Agreement is also needed because competition between member states would be liable to result in inefficient tax policy.

In many areas of regulatory policy, institutional competition, as a result of "mutual recognition" of product standards, has allowed the Community to cut through the time consuming business of reaching agreement on coordinated standards. Often, this process may be efficient, in the sense that competition between national standards would lead to the retention of separate national standards only where the benefit outweighs the cost. This argument can, as will be discussed in Chapter 2, justify institutional competition in certain environmental standards. However, institutional competition in revenue-raising taxation is unlikely to be efficient.

Cross-country fiscal policy externalities, in the form of the effects of each country's tax rate and enforcement decisions on private sector behaviour and revenues in other member states, mean that tax competition is likely to result in inefficient outcomes: market-driven tax coordination will be clearly inferior to cooperative policy. Leaving tax policy to a process of tax competition will, for example, generally result in tax rates which are too low. Some coordination (possibly with appropriate side payments) will be likely to improve matters. In particular, the current form of Community policy, under which minimum rates of tax which member states can apply are specified, seems broadly appropriate, in that it should limit destructive tax competition, whilst leaving member states with a degree of freedom to set higher rates of tax if they wish.
Chapter 2

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Introduction

Many European countries are currently discussing - and, in some cases, implementing - environmentally-motivated tax reforms. This paper considers the extent to which such policy initiatives are purely a matter for policy-makers in the member states in the European Union (EU)\(^1\), and the circumstances in which environmental tax policies might require coordination or other action at the EU level. Many of the issues are not, of course, unique to the EU, and are encountered in varying degrees in other federal, or multi-tier, political systems.

The division of policy responsibilities between the EU and its member states is imprecisely defined, and has evolved over time, both as a result of European Court judgements and new agreements between the member states on the development of the Union. Within the field of environmental taxation, policies at the national level are constrained both by the need to avoid measures which protect domestic producers against competition from other member states and by the terms of existing EU agreements on the permissible forms of indirect taxation in member states. Furthermore, policies at the EU level have been heavily constrained by the concern of some member states, notably the UK, to prevent any extension of the Union's mandate in the field of taxation\(^2\).

The principal proposal for environmental taxation made in the EU countries in recent years was the carbon/energy tax proposed by the European Commission in 1991 (Commission, 1991; Pearson and Smith, 1991). The proposed tax formed part of a programme of measures to contribute to the objective of stabilising CO\(_2\) emissions at 1990 levels by the year 2000, a target that the EU member states accepted at the Rio Convention in 1992. The tax was to be levied on the carbon content of fossil fuels and the energy content of all non-renewable forms of energy, at an initial level equivalent to $3 per barrel of oil, rising in stages to a level of $10 per barrel ($88 per tonne of carbon) in the year 2000. The Commission's original plan was for the tax to be introduced during 1993; however, discussion of the original proposal was protracted, and the initial proposal for a substantial, uniform, EU-wide tax now seems unlikely to be implemented. Although member states endorsed the principle of fiscal instruments as a means of controlling CO\(_2\) emissions, some opposed the proposal because of concern about a possible adverse impact on industrial competitiveness, whilst the UK was implacably opposed in principle to increasing the EU's powers in taxation. The focus of EU discussion has now turned to a consideration of a possible common framework to govern the structure of a carbon tax in those member states which might choose to introduce one.

Since the signing of the Maastricht Treaty in 1992, the criterion of "subsidiarity" has governed assignment issues in areas not unambiguously assigned by the Treaty to either the Union or its

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1 In conformity with current general practice, this paper uses the term "European Union" to include all activities and functions of the European Community; for simplicity, the term is used systematically throughout the paper, including references to the European Community prior to the Maastricht Treaty, except in direct quotations referring to the "European Community".
2 Unanimity is required in EU decisions concerning taxation.
member states, although the practical implications of subsidiarity in particular areas of policy have yet to be fully tested. The criterion of subsidiarity forms the main organising principle for the discussion in this paper. In Section 1 the paper briefly recapitulates the discussion in Chapter 1 concerning the meaning of "subsidiarity" in the EU and the application of subsidiarity to tax policy. Section 2 considers the application of "subsidiarity" to environmental policy, and, specifically, to the assignment of policy responsibility for environmental taxation between the EU and national governments. Section 3 considers the implications for assignment of the need for integration of environmental taxation with other areas of EU and national policy. Section 4 draws conclusions from the discussion.

1 "Subsidiarity" in the European Union

1.1 "Subsidiarity" as a criterion for assignment

The principle of subsidiarity is expressed in the Treaty on European Union agreed at Maastricht in the following way:

"In areas which do not fall within its exclusive competence, the Community shall take action, in accordance with the principle of subsidiarity, only if and insofar as the objectives of the proposed action cannot be sufficiently achieved by the member states and can therefore, by reason of the scale or effects of the proposed action, be better achieved by the Community" (Article 3b of the Treaty on European Union).

The principle of subsidiarity thus embodies a presumption in favour of decentralisation: transfer of government functions to the European level should only take place where there are good reasons for such an assignment (Padoa-Schioppa, 1987). The main argument for decentralisation in government is that it may help to ensure that the decisions taken by government adequately reflect local preferences and interests.

In its references to "scale" and "effects", the Treaty definition also echoes the two principal "good reasons" for EU assignment identified in the 1977 report of the MacDougall Committee (MacDougall, 1977), which drew on theories of fiscal federalism (e.g., Olsen, 1969; Oates, 1972) to assess the EU's future role in government. This had identified the existence of economies of scale and the existence of cross-country spillover effects from national policy as the two main circumstances in which a higher-tier, EU, involvement in policy would be warranted. Policy areas where economies of scale or policy spillovers across national boundaries are significant will tend to be those where the EU has a justifiable role, and where transfer of responsibility for policy from member states to the EU may be one solution to the inefficiency of national policy.

3 The earlier Treaty revisions under the Single European Act of 1986 had required the subsidiarity test to be applied to the EU's environmental policies.
However, assigning full responsibility for a particular policy function to the EU is not the only possible response to policy spillovers, and may not be the appropriate choice in many cases. Often it may be possible for the interests of other countries in the policy decisions taken by national governments to be reflected in an agreement between the countries concerned, specifying the way in which policy will operate.

Indeed, the EU plays a mixed role - part government, part forum for international negotiation. It therefore provides scope for a range of possible degrees of constraint on national policy-making, ranging from ad hoc negotiation over cross-country effects of member states' policies, to the comprehensive takeover of member states' responsibilities in a particular field. The current emphasis on subsidiarity and decentralisation implies that the former route is to be preferred wherever possible. When, however, is minimal coordination, of this form, likely to suffice?

Gatsios and Seabright (1989) discuss the circumstances in which agreements on policy coordination or harmonisation will be adequate to deal with the problem of cross-country policy spillovers. They argue that the main gains from actually handing over responsibility for an area of policy with large cross-country policy externalities to the EU arise in the form of greater credibility of central operation. Where it is difficult to monitor compliance with international agreements (for example, where their implementation requires a large amount of judgement, based on more information than other parties to the agreement are likely to possess), signatories to an international agreement to implement national policy taking international externalities into account may not have confidence that the other signatories will comply. Where this is the case, compliance is likely to become an increasingly unattractive strategy, for the usual "prisoners' dilemma" type reasons.

The key issues in deciding the functions that need to be assigned to EU level are thus those of information and monitoring. Those functions which the EU itself needs to exercise are those where there are substantial cross-country policy externalities, and where compliance with agreements between national governments cannot easily be monitored by national governments.

1.2 "Subsidiarity" and taxation.

In the case of tax policy, there are some strong arguments for retaining tax policy at national level, except where the gains from coordinated reform would be significant. One reason for this is that the optimal structure of taxation in an economy will generally vary, depending on the preferences and economic behaviour of individuals and enterprises. Also, the optimal level of taxes in member states of the EU may differ because member states have different requirements for budget revenues from taxation. This is a key difference between the assignment of taxation and other policies; the assignment of taxes affects the availability of financial resources, and hence the ability of different tiers of government to carry out other policy functions. In addition to these arguments for diversity, there are also reasons to avoid unnecessary instability in taxation; asset prices and private sector decisions will reflect the existing tax arrangements, and adaptation to a new system could be costly.
Arguments for centralisation or EU involvement in taxation based on economies of scale are likely to be of less importance than those relating to spillover effects from uncoordinated national policies. The unit cost savings which arise from a transfer from the national level to the EU level are likely to be relatively modest, since the national units are already large, and differences in language, legal systems and corporate structures are likely to reduce quite sharply the potential for administrative savings from EU-wide tax administration. This is not, of course, to deny that there may be potential for beneficial administrative cooperation between the tax authorities of EU member states, in ways that fall short of full administrative integration.

Spillover effects from national policies (policy externalities) provide much more substantial reasons for EU involvement in taxation, and may take a number of forms. Inter-country spillovers may arise from national decisions about the rates and structure of taxation, and also from the level and pattern of enforcement activities at national level. The spillover effects may also appear in different ways, as effects on private sector decisions (inter-country distortion, or non-neutrality), and effects on the allocation of tax revenues between member states.

Where national tax policy is liable to have cross country effects on economic activity and revenues, there is also concern that unregulated decisions at the national level may result in sub-optimal outcomes for the EU as a whole. In particular, there has been considerable recent concern that these cross-country effects may place downward pressure on "exposed" tax rates in member states, requiring member states to place undue reliance on tax bases less exposed to international competition. Restricting the ability of member states to undercut each other in taxation may be of net mutual benefit; indeed, there may be circumstances (as demonstrated by Kanbur and Keen 1993) where it would benefit all parties concerned.

As with other areas of policy, there is then a further question about the form of EU involvement in taxation. Should this take place through coordination of national policies (for example through harmonisation of tax rates), or should it involve complete assignment of particular taxes to the EU level? One set of considerations in this choice is of course the impact on the financial resources available to each level of government; assigning taxes to the EU would increase the EU's powers in other areas of policy, whilst reducing the financial resources under the control of member states. Other considerations relate to the adequacy of coordination measures, as opposed to assignment, in dealing with cross-country tax policy spillovers.

Thus, for example, it may be comparatively straightforward to design credible agreements to limit the extent of cross-country policy spillover effects to limit the impact of national decisions on tax rates on private sector activity and the allocation of tax bases between member states, since the compliance of member states with a given set of rules regarding permissible tax rates can be easily observed.

In other areas, however, the information needed to monitor member states' compliance with any agreement may be harder to obtain - for example, where spillovers arise from member states' tax enforcement activities. Even here, however, it may be possible to maintain a substantial degree of decentralisation, which stops well short of the unattractive option of transferring tax administration
responsibilities to the EU. Thus, the institution of a EU mechanism for auditing member states' tax enforcement practices and procedures would help to enhance the credibility of agreements about the conduct of member states' tax enforcement activities, and would thus help to sustain continued assignment of the day-to-day operation of administration and enforcement at the member state level, even where enforcement activities involve significant cross-country externalities.

2 Application of the principle of subsidiarity to environmental taxes

2.1 "Subsidiarity" and environmental policy

The practical development of EU environmental policy has occurred through a piecemeal accumulation of functions, partly in areas where other EU policies raised environmental issues. As other discussions of the implications of "subsidiarity" have argued (eg Begg et al, 1993), some of the EU's most significant environmental policy measures, such as the Directives relating to water quality, are difficult to reconcile with subsidiarity. To a large extent, the EU's involvement in these areas does not reflect a process of considered decision-making about the need for centralisation, so much as political competition between levels of government over individual areas of policy. This inter-tier competition will almost certainly continue to influence the division of responsibilities between the EU and member states, although it has now been constrained by the presence of the subsidiarity criterion in the Treaty. In considering how far the EU will develop new policies on environmental taxation, future developments will be - at least in part - governed by the strength of the "subsidiarity" case for a greater EU role in environmental policy generally, and also with respect to particular environmental taxes.

As with tax policy, the application of subsidiarity to define the EU's role in environmental policy requires a balance to be drawn between the benefits from retaining discretion over policy at the national level, and the benefits from greater coordination at the EU level. There are two main lines of argument against EU harmonisation of environmental policy, where there are no strong arguments for coordination.

One is, again, that diversity in incomes, preferences and economic conditions between member states will typically call for diversity in policy measures. Assuming environmental quality to be a normal good, demand for environmental quality will tend to rise with higher incomes, and richer member states will then, other things being equal, wish to implement more stringent environmental policies than poorer member states. There may, in addition, be important differences in the need for particular environmental policy measures, reflecting differences in the assimilative capacity of the environment in different member states. Where the environmental effects of national policy are confined to the country concerned, different standards of environmental protection would, in these circumstances, appear desirable.
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The second is that there are also some important reasons to prefer the status quo in environmental policy, over the introduction of a new, harmonised, EU-wide approach. Individuals and firms will already have adjusted their behaviour to the requirements of the various existing systems of pollution control and regulation in member states; in some cases these adjustments will have required costly changes in technology, or the sunk costs of industrial relocation. Changing the form of policy, even without any increase in the stringency of policy, could require substantial re-adaptation to the structure of incentives and requirements of the new policy, imposing adjustment costs without necessarily achieving any reduction in pollution.

These arguments amount to a substantial case for avoiding unnecessary harmonisation of environmental policy. Nevertheless, there are a number of important environmental policy problems and policy measures where national environmental policies have either environmental or economic spillover effects affecting other member states, warranting some form of EU intervention. Whilst some of these issues have implications for the coordination of environmental policies in general, there are also specific considerations relating to the coordination of environmental taxes in particular.

The environmental spillover effects arise where environmental problems cross national boundaries, for example through air flows which transport national sulphur emissions and deposit them as acid rain in other countries, or through the impact of national emissions of carbon dioxide on global environmental problems such as climate change. In these cases, which have been the subject of an extensive literature (eg Barrett, 1991; Mäler, 1991, and many of the 1994 IIPF congress papers), coordination of national policies is central to achieving efficient environmental policies, although it is also, as the literature makes clear, extremely difficult to achieve.

The economic spillover effects arise where the policy measures adopted at national level have economic effects which cross national boundaries, and which may in some cases have negative implications for living standards in other countries, or for the welfare of all countries taken as a group. The significance for policy of these economic spillover effects has been controversial, and two aspects of the economic spillovers are distinguished here. Section 2.3 considers economic spillovers from "indirect protection" arising through the form of policy measures adopted at national level, whilst Section 2.4 discusses whether economic spillovers arising from the level of protection adopted at national level give rise to a case for international coordination or control of national policy-making.

In particular policy contexts, the environmental and economic spillovers from national environmental tax policy are likely to vary in relative significance. For certain local environmental problems, the need for EU involvement relates only - if at all - to the regulation of economic spillovers, whilst for regional or global environmental problems it is the cross-country dimension of the environmental problem which gives rise to the greatest need for coordination of national policies.
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2.2 International environmental spillovers.

International bargaining and negotiation has become a key feature of environmental policy, as countries negotiate over how best to regulate international environmental problems. As far as the EU is concerned, such negotiations have both an external and an internal dimension.

With regard to the external dimension, the EU has become a key player in the process of international bargaining over global environmental problems. How far the EU's involvement in international negotiations leads to more efficient bargaining and better outcomes depends, to a large extent, on the relationship between the EU and member states in the negotiation. It is possible that, collectively, the EU may be able to secure a better deal for its members than if each were to participate in international negotiations on its own behalf. Indeed, EU involvement may increase the chances of an agreement being reached at all, by reducing the number of independent participants in international negotiations. On the other hand, in practice, the involvement of the EU in international bargaining has introduced further complexity into some aspects of the process. In some cases, where the EU and member states have joint responsibility in international environmental negotiations, the involvement of the EU increases the number of actors in international negotiation rather than reduces it. Moreover, even were the EU to have a single seat at the negotiating table, the EU's position in negotiation could not be formulated without reference, at some stage, to the member states; this introduces a second layer into the process, and may reduce the flexibility of the European position and slow down the process of agreement.

Internally, the EU faces a number of environmental problems which cross member state boundaries; as in the case of the global environmental problems, there is a need to coordinate the actions of member states, so as to ensure that the cross-country externality is adequately reflected in national policy measures. Whilst such coordination is an important function of the EU, its difficulties should not be under-played; the incentive and information problems which arise in reaching agreement on efficient global environmental policies apply with equal force to decision-making amongst the member states of the EU.

The form of most such negotiations, both globally and amongst the European countries, has been for countries to negotiate over their contribution to global abatement measures, in terms of the proportionate reduction of emissions from some initial baseline. Environmental targets are thus set by international agreement, whilst the measures for implementation are left to individual countries to decide. This division of functions between target-setting and implementation is reflected, as Haigh (1989) notes, in the use of Directives in EU environmental policy, which generally set targets, whilst leaving member states discretion over how these are to be implemented in national legislation. Where cross-country environmental problems are involved, how far is such a division of responsibilities adequate, and consistent with the requirements of subsidiarity?

In some circumstances it would, in principle, be desirable for international negotiations to go further than simply specifying quantitative targets for emissions reductions in individual countries, and for the EU role thus to extend to agreeing the form of policy, as well as its intended outcome. One is that negotiating over tax rates rather than over quantitative emissions targets may in certain
circumstances achieve a more efficient pattern of abatement across countries. For example, where
global pollutants are concerned, agreement on a uniform tax rate to apply in all countries may be
more efficient than agreeing that all countries implement the same percentage reduction in pollution.
Indeed, in some circumstances involving uniformly-mixed global pollutants a uniform tax rate on
emissions across countries would constitute the optimal policy. Hoel (1994a) considers whether
a carbon tax, levied to control climate change problems arising from the accumulation of global
carbon dioxide emissions, should be uniform across countries. Ideally, he finds, the tax should be
uniform. But there are two sets of circumstances in which non-uniformity across countries could
be appropriate. One is where side-payments are ruled out; in this case (which Hoel, however,
argues is hard to justify), non-uniform carbon taxes could be Pareto-optimal. Another group of
circumstances concerns the availability of other tax instruments which can be deployed to tackle
other energy-related externalities, and to tax energy within a structure of optimal revenue-raising
taxes on commodities. Typically, the efficient rates to be set for these energy taxes will vary across
countries; in the first case to reflect differences in abatement costs, the assimilative capacity of
the national environment, and citizens' preferences for environmental quality, and in the second
case to reflect the range of factors underlying optimal tax structures. If separate taxes on energy
were not available, and the carbon tax had to perform these functions as well as reducing carbon
emissions, uniformity in the carbon tax rate across countries would be unlikely to be optimal.
However, since all countries already levy substantial taxes on at least some types of energy, the
case for uniformity across countries in a new coordinated carbon tax would appear to be strong.

Another reason for specifying the form of policy, rather than simply emission reduction targets,
may be the credibility of any agreement; agreeing to introduce a tax at a particular rate may make
it easier for countries to verify that the bargain was being implemented, than where the agreement
was simply to undertake unspecified measures to achieve a quantitative target for emissions
reduction at some future date.

In some cases, therefore, the distinction between the EU's role in target-setting and the role of the
member states in choosing how to meet the targets, is unsustainable. For a number of reasons,
including the "credibility" issues raised in section 1, the EU should have a substantial and legitimate
interest in the form of environmental policy (eg in the choice between environmental taxes and
regulation) as well as in its targets and objectives.

In addition, although the limited administrative resources available to the EU will frequently dictate
a substantial role for national governments in administrative implementation of policies (including
both conventional tax policies and environmental policies), even where the EU has primary
responsibility for the determination of policy targets, there will be a need for this to be accompanied
by facilities for monitoring and audit at the EU level, in order to ensure the credibility of policy.

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4 See also Chichilnisky and Heal (1993), who reach a similar result when side payments are not available.
5 Newbery (1992) also considers the relationship between the optimal rate of a carbon tax and the rates of existing
externality taxes on energy; he concludes that these are generally additive, but points out that in some circumstances
the introduction of a carbon tax may increase the optimal tax rate on motor fuel levied to reflect other traffic externalities
(since in the long run the carbon tax will increase fuel efficiency of motor vehicles, and hence will increase the
non-carbon externality costs per litre of fuel).
2.3 Indirect Protection.

Inter-country spillovers from national environmental policy may have an economic as well as an environmental dimension. One aspect of this, which applies both to cases where national policies have cross-country environmental effects, and to cases where purely national (or local) environmental problems are involved, is the risk of indirect protection. Unrestricted policy-making by individual member states carries with it the risk that measures may be introduced by member states in the guise of environmental protection which have their principal rationale in their role as instruments of indirect trade protection. It is possible to think of a range of environmental characteristics of particular goods which could be used to justify the imposition of environmental taxes which would in practice have the effect of protecting the goods supplied by the national producers of member states. "Clean car" incentives for vehicles meeting certain emissions standards have already been a concern of the EU; similarly, heavy taxes on non-recyclable drinks containers would tend to disadvantage importers of drinks relative to domestic suppliers (which have larger market shares, able to bear the fixed costs of systems for returning used bottles, and which would, in any case, have to return the bottles over shorter distances).

Although the sections of the Treaty of Rome which govern the conduct of EU environmental policy explicitly leave room for member states to operate more stringent environmental policies than the EU as a whole, fiscal measures which have the effect of indirect protection conflict with other key objectives of EU policy, especially those concerning the free flow of goods between member states. It is under these provisions of the treaty that the Commission attempted to restrain member states' own measures on fiscal incentives for lower vehicle emissions. There is clearly a difficult balance to be drawn between the requirements of the Single Market, and leaving member states any scope for independent environmental policy-making. Where that balance should be drawn is inevitably unclear, and guidelines for member states' policy are difficult to develop. The least that can be said, however, is that it is surely an issue entirely unsuited to resolution though judicial processes, and work on some form of detailed guidelines is long overdue.

Similar "indirect protection" issues arise in the case of the proposed European carbon tax. The least-cost pattern of abatement would be achieved if all sources of carbon dioxide emissions were to face the same tax. However, there were, in practice, demands that the tax should provide scope for selective exemption of certain categories of industrial energy user which might be adversely affected in international competition with firms outside the EU area, either through exemption of certain energy intensive industries, or through more selective exemption of particular firms facing severe competitive pressures.

Hoel (1995) discusses the circumstances in which such sectoral differentiation would be efficient. He observes that if countries are not able to levy tariffs on trade with non-signatories to an international agreement to restrain carbon dioxide emissions, it may be appropriate to levy differentiated taxes across sectors. Informally, these taxes would aim to offset the competitive advantage that firms in energy-intensive sectors would receive in non-signatory countries, although
the efficient pattern of carbon tax differentiation across sectors would be complex. However, if
countries are able to determine tariff rates without restriction, then tariffs should be employed for
this purpose, and the optimal pattern of tax rates across sectors will be uniform.

Whilst the arrangements for sectoral or discretionary exemption were proposed as part of the
structure of the Community-wide tax, implementation of the exemptions would, inevitably, have
been undertaken by the national authorities, and, especially in the case of selective exemption of
firms, might have provided considerable scope for national authorities to ease the burden on
national producers. Designing the arrangements for exemption in such a way as to minimise the
amount of national discretion in their application is obviously desirable, if they are not, in effect, to
become a route for selective subsidy of certain sectors. Detailed EU coordination of the carbon
tax is then clearly helpful, not only in reducing the need for such exemptions, but also in constraining
the circumstances and form in which they are made.

2.4 "Downward competition".

A second possible source of economic spillovers from national environmental policy relates to the
possibility that cross-country economic considerations might induce countries to set
inefficiently-low standards of environmental protection for environmental problems which are purely
national in character. Might countries be tempted, for example, to tolerate lax environmental
standards in order to attract foreign direct investment, or in order to enhance the international
competitiveness of their existing exporters - a policy sometimes referred to as "environmental
dumping"?

There is, indeed, evidence that environmental policies in the industrialised countries may have
affected the international pattern of economic activity. Hettige, Lucas and Wheeler (1992), for
example, observe that the output of pollution-intensive activities grew more rapidly during the
previous two decades in less-developed countries (LDCs) than in the industrialised countries, and
argue that this may have reflected relocation to LDCs as a result of the tightening of environmental
standards in developed countries. Rauscher (1995) summarises the results of a number of other
empirical studies on the same topic. However, the key issue in assessing the efficiency of policy
is not whether relocation has or has not occurred, but whether, in response to relocation or the
threat of relocation, policy-makers have been induced to set environmental standards which do
not reflect the true willingness-to-pay of their residents for environmental quality.

In an early discussion of this issue Cumberland (1981) argued that economic competition may
induce countries, acting alone, to choose inefficiently-low standards of environmental protection,
and that international agreements should therefore set a floor to national levels of environmental
protection, to prevent considerations of economic competitiveness inducing a process of downward
competition in environmental standards. This line of argument would then imply that there may be
a role for the EU in agreeing minimum standards of environmental protection, even for problems
which involve no cross-country environmental spillovers. However, a growing theoretical literature on environmental standards and international economic competition has emerged in recent years\(^6\), the results of which have substantially undermined Cumberland's policy prescription.

Oates and Schwab (1988), on the other hand, have set out a formal model in which economic competition between independent jurisdictions does not result in excessively-low standards of environmental protection. The model is one in which there is perfect competition, and countries compete with each other for an internationally-mobile capital stock through the standards that they set for permitted pollution levels. By setting less stringent environmental standards the country may be able to attract more investment. The advantage to countries of attracting more capital is the impact of a higher capital stock on wage levels in the country; the disadvantage is the lower environmental quality that the country has to accept in order to attract more investment. The country thus faces a tradeoff between income and environmental quality, and in the first-best case where there are no existing distortions, and where all residents share the same interests, would choose to set environmental standards at the point on this tradeoff where the marginal gain in income from more investment is just equal to the marginal willingness to pay for greater environmental quality. In this case, international economic competition does not induce countries to set inefficiently-lax environmental standards.

Oates and Schwab note, however, that in some second-best circumstances environmental competition might lead to downward pressure on standards. One would be where taxes on the internationally-mobile capital were needed to finance public expenditures. Another would be where residents' interests differed, and where policy-making was dominated by those with greater preference for income than for environmental quality; the opposite outcome would arise where policy was dominated by those with less interest in wage levels than in environmental quality.

Long and Siebert (1991) discuss a similar process of competition in the large-country case, where environmental standards could affect the incomes of mobile factors of production. They conclude that in these circumstances countries will select lax or stringent environmental policies, depending on their interests in the rate of return to mobile factors of production. A capital rich country would tend to keep environmental standards low, in order to raise the rate of return on capital, whilst a capital-poor country would do the opposite. As a result of the attention paid in the countries' policy decisions to the effects on factor returns, the outcome is not Pareto-efficient.

Hoel (1994a) observes that under "ideal conditions", including the absence of any other (ie non-environmental) market failures, there is no need for international coordination of policies towards environmental problems which do not involve international environmental spillovers. However, the presence of various forms of market failure, affecting for example the markets for labour or output, may mean that uncoordinated policy results in inefficient levels of environmental protection being selected. Hoel (1994a) shows an example with a non-clearing labour market where, in order to prevent a fall in employment governments adopt inefficiently-low environmental standards. Barrett (1994) discusses a model where firms have product market power. The model

\(^6\) See the survey by Ulph (1994b).
2. Role of EU in Environmental Taxation

is one of Cournot oligopoly, with each producer located in a different country; the output is sold to a country outside the group of producers. The efficient outcome would be one in which each country set an environmental standard so that the marginal cost of abatement equals marginal environmental damage, but countries instead set standards lower than this, in order to increase the profits of their own producer (by reducing the share of total output produced by the other firms). Changes to the specification of the model, however, result in different conclusions. Barrett shows that if a direct production subsidy is permitted this dominates the degradation of environmental standards as a method of promoting the country's producer's profits. Also if there is more than one firm in each country, there is less incentive to weaken environmental standards, and indeed the country may wish to set inefficiently-high standards.

A number of other papers, including Markusen, Morey and Olewiler (1993, 1995), Ulph (1994a), Hoel (1994b) and Rauscher (1995), consider similar issues in the context of models of non-competitive markets with increasing-returns technologies and endogenous location. Markusen, Morey and Olewiler (1995), for example, model the location decisions of mobile polluting firms with a technology exhibiting increasing returns to scale, and consider the Nash equilibrium resulting from the income and environment choices of competing governments. In this model, the number of firms is endogenous, and the possibility of changes in the number of firms means that the relationship between the stringency of domestic and foreign environmental policy and the domestic country's welfare may be discontinuous at some points. They show that, in contrast to the perfectly-competitive model of Oates and Schwab, the uncoordinated decisions of competing governments could lead to inefficient outcomes. The direction of this effect is not always the same. In some circumstances, the outcome may involve tolerance of excessive levels of pollution. In other circumstances, which Markusen, Morey and Olewiler refer to as the NIMBY (not-in-my-back-yard) case, the opposite can happen, and the equilibrium may involve excessive restriction of pollution, and a smaller number of firms than in the optimum.

To summarise the implications of the above for EU policy, whilst it is possible to find theoretical models (especially models involving imperfect competition) in which member states might apply inefficiently-low standards of environmental protection due to their concern for economic spillovers arising through trade or direct investment, such results are sensitive to the precise specification of the models concerned; in some cases, the opposite effect may even arise. There is not, therefore, a general case for the EU, or international agreements, to specify minimum standards of environmental protection, or minimum levels of environmental taxes, for problems which do not involve cross-country environmental spillovers.

3 Integration with other EU policies

Much of the EU's initial role in environmental policy arose through the environmental aspects of other areas of policy - agriculture, transport, the regulation of the internal market, etc. In particular, policies for the development of the internal market have had considerable influence on the development of environmental taxes within the EU. These have included EU efforts, as discussed in Section 2.3, to limit indirect protection arising through national environmental policies. Also,
removal of border controls within the internal market has constrained the administration and enforcement of certain types of environmental taxes at the national level; the scope for member states to set differing levels of environmental excises on goods is limited by the free movement of goods across borders, whilst fiscal deposit-refund arrangements at the national level may require special controls if they are not to be undermined by cross-frontier movements of goods. A third way in which internal market policy has affected the relative involvement of the EU and member states in environmental taxation has been where the EU has tried to regulate tax competition by setting limits on member states’ tax rates for certain commodities. EU rules on the taxation of motor fuels, for example, have inevitably expanded the EU’s involvement in the environmental dimension of transport taxation.

Over and above these developments, there are important questions about the interdependence of assignment decisions in the future evolution of the EU. Assignment of responsibility for environmental tax policy clearly needs to reflect decisions taken about assignment of other areas of policy. In principle, environmental tax policies need to be coordinated both with other environmental policies, and with other fiscal policies. In an ideal world, the level of environmental taxes would be set with regard to the economic costs and environmental benefits of a particular tax level, and with regard to the marginal excess burden of raising revenue through other fiscal instruments. However, perfect coordination of environmental taxes with both environmental and fiscal policies may not be feasible. Where these are assigned to different levels within the EU (e.g. fiscal policy to the national governments of member states, and environmental policy to the Union, or vice versa), it will be inevitable that the assignment of responsibility of environmental taxes will result in better coordination with one of these related decisions, and poorer coordination with the other. A choice then has to be made, either of poor coordination between environmental taxes and other environmental policy, or between environmental taxes and other fiscal policy.

A similar issue of coordination, discussed by Oates (1991), arises in the single-country context, where a choice has to be made of the government agency to be given responsibility for environmental taxes: should environmental taxes be the responsibility of the Finance Ministry, so that they can be coordinated efficiently with other elements of tax policy, or should they be under the control of an environmental ministry or agency, so that they can be coordinated with other environmental policies? Either assignment is liable to have some costs; Oates recommends a split assignment, in which the determination of the structure and rate of environmental taxes should be under the control of environmental policy-makers, whilst the revenue should accrue to the general exchequer, rather than to the environmental agency’s budget. Oates’ argument rests on the observation that the range of instruments available to fiscal policy-makers for revenue-raising is wide, so that setting environmental taxes without regard to considerations of efficient revenue-raising is unlikely to significantly increase the aggregate excess burden of taxation. On the other hand, the range of alternative environmental policy instruments is smaller, and setting the level of environmental taxes with principal regard to their revenue rather than environmental effects is likely to lead to appreciably sub-optimal environmental policy outcomes. Nevertheless, whilst it may be more efficient to locate responsibility for setting the rate of environmental taxes
2. Role of EU in Environmental Taxation

with the environmental policy authorities, there would be a risk of inefficiency if they derived budget revenues from the environmental tax; the agency’s budgetary needs might encourage it to set an excessive tax rate, from the environmental point of view.

This line of argument might also be used to suggest that priority should be give to assigning policy responsibility for environmental taxes in the EU to the same level as the assignment of environmental policy, so that an efficient balance can be drawn between environmental taxes and other environmental policy instruments; coordination with fiscal policies is less critical. In some cases, of course, where both environmental and fiscal policies are assigned to the national level, the issue does not arise. But in the case of global warming policies, efficient coordination of tax and non-tax instruments demands that the tax rates should not be determined by the national fiscal authorities, but should be determined in conjunction with other environmental policy measures relating to global warming.

As in the EU carbon tax proposal, however, there should be no presumption that the revenue should be assigned to the same level of government responsible for determining the rate of the environmental tax. In general it is probably desirable that the revenue from environmental taxes should accrue to member states rather than the EU, regardless of the assignment of responsibility for the environmental tax rate. Since member states have many other potential revenue sources, they are unlikely to seek to drive environmental tax levels beyond the level which is efficient from the point of view of environmental policy (and general revenue-raising efficiency); the EU, on the other hand, which is highly constrained in terms of budgetary resources, might well be inclined to seek to increase environmental taxes above the efficient level, if the revenues from such taxes accrued to the EU budget.

4 Conclusions

As in Chapter 1, the analysis of this chapter has taken as its starting point the principle of subsidiarity, which now governs the respective roles of the European Union (EU) and the national governments of its member states. It has drawn on the theory of "fiscal federalism", in which both policy spillover effects and administrative scale economies provide grounds for some form of higher-tier involvement. Following Gatsios and Seabright (1989), the discussion has placed greater emphasis than conventional theories of fiscal federalism on the significance of "credibility" and administrative discretion in determining how far policy coordination is an adequate response to spillover effects, and how far higher tier assignment is required.

In applying the theoretical framework to assess the extent to which the EU should become involved in issues of environmental taxation, the paper draws a distinction between the assignment of policy responsibility and the assignment of administrative implementation. One interpretation of the implications of subsidiarity for environmental policy that has had some currency is that the EU may have a valid role in setting environmental targets, but not in choosing the method or details of implementation. The paper has argued that this distinction is unsustainable; for a number of
reasons, including the "credibility" issues raised in section 1, the EU should have a substantial and legitimate interest in the form of environmental policy (e.g., in the choice between environmental taxes and regulation) as well as in its targets and objectives.

Section 3 of the paper has considered the relationship between environmental tax policy and other policy assignment decisions. The paper has argued that environmental tax policies need to be coordinated both with other environmental policies, and with other fiscal policies. Where these are assigned to different levels within the EU (e.g., fiscal policy to the national governments of member states, and environmental policy to the Union, or vice versa), it will be inevitable that the assignment of responsibility of environmental taxes will result in better coordination with one of these related decisions, and poorer coordination with the other. It is argued that the decision about environmental tax rates should be taken by the level of government responsible for other, related, environmental policies, whilst the revenues from environmental taxes should accrue in general to member states in preference to the EU.
Chapter 3

Taxation and the Environment: A Survey
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Introduction

Environmental policies in the UK and other industrialised countries have to address an increasing range of concerns. These include not just the long-standing problems of controlling localised pollution from industrial effluents, but also more recently-recognised problems of international pollution (e.g. acid rain) and global ecological balance, especially the risks of damage to the ozone layer and of an accelerated "greenhouse effect". These new problems call, in many cases, for extensive and - in some cases - costly changes to the existing patterns of production and consumption, and for major new investments in pollution control. The search for policy instruments that can achieve the necessary adjustments at least economic cost has brought renewed attention to the potential benefits of using market mechanisms in environmental policy - incentives to encourage the private sector to make decisions which are less damaging to the environment.

This survey paper reviews the possible contribution that taxation could make to the efficient achievement of environmental policy objectives. The paper is in seven sections. The first section describes the main ways in which tax instruments have been employed in environmental policy, and identifies in particular three types of environmental tax measure - "Pigouvian" taxes on polluting emissions, "approximations" to Pigouvian taxes, and cost-sharing or "mutualisation" taxes. The main issues raised by each of these three types of fiscal instrument are then discussed in turn in Sections 2 to 4. Section 5 surveys empirical studies of the effects of various possible environmental taxes, including the burgeoning empirical literature on a carbon tax. Section 6 then considers environmental taxes in the context of public finance, and surveys the arguments over the distributional and revenue aspects of environmental taxes. In Section 7 some conclusions are drawn, identifying the main areas where the debate in the literature appears to have found scope for a useful fiscal dimension to environmental policy.

1 Types of environmental tax

Within the broad heading of environmental tax instruments, a number of distinct types of measure may be identified.

- Measured emission taxes. This group of market-based instruments are those which involve tax payments which are directly related to metered or measured quantities of polluting effluent. A tax per unit of measured pollution output of this sort conforms most closely to the type of tax envisaged in the early discussion by Pigou (1920) of the correction of externalities. In European countries, a number of instances can be found of taxes on measured polluting emissions; whilst some are set at a very low level, others are levied at rates liable to have a substantial impact on polluter behaviour, and to raise significant revenues (Opschoor and Vos, 1989). In the USA, although a number of

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1 For recent surveys of the case for market mechanisms in environmental policy see Helm and Pearce (1990), Nicolaisen, Dean and Hoeller (1991) and Muzondo, Miranda and Bovenberg (1990).
examples of such taxes can be found, recent policy has tended to make greater use of marketable permits in applications where some form of market-based environmental mechanism could be employed.

Measured emission taxes have generally tended to be considered as an alternative to "command-and-control" systems of pollution regulation, and in section 2 we set out the main considerations identified in the choice between regulatory policies and environmental taxes. Section 2 also briefly considers the merits of emissions taxes in comparison to two other possible market-based instruments, subsidies and tradeable permits.

- use of other taxes to approximate Pigouvian taxes. Changes in the rates of indirect taxes (excise duties, sales taxes, or value-added taxes) may be used as an indirect alternative to the explicit taxation of measured emissions. Goods and services which are associated with environmental damage in production or consumption may be taxed more heavily (e.g. carbon taxes, and taxes on batteries and fertilisers) whilst goods which are believed to benefit the environment may be taxed less heavily than their substitutes (e.g. the reduced taxes on lead-free petrol).

Under this heading we may also include various tax expenditures designed to provide incentives to reduce pollution. For example, the direct tax system, particularly accelerated depreciation provisions in corporate taxation, may be used to provide incentives for the installation of certain types of pollution control equipment etc.

The scope for restructuring of indirect taxes for reasons of environmental policy can be wide. Sometimes, new taxes have been introduced, or other tax changes have been made, to achieve a specific environmental objective, and have been explicitly identified as "environmental taxes". Increasingly, however, policy towards the structure of existing indirect taxes on goods such as energy, vehicles and motor fuels is taking account of environmental concerns, and the evolution over time of the level and structure of existing indirect taxes is being shaped by environmental concerns.

This group of tax instruments where fiscal restructuring is used as an indirect "proxy" for pollution measurement raises a rather wider range of issues than the taxation of measured emissions - including questions of integration and compatibility with existing tax policies and administrative procedures. The debate over these issues is assessed in section 3.

- "Mutualisation taxes". In many cases environmental taxes have in practice been used principally for purposes of revenue-raising, rather than to provide incentives to reduce polluting emissions (Opschoor and Vos, 1989). Where environmental taxes have been employed in this way, it has generally been to raise revenues for particular public expenditures related to environmental protection - for example, to recover the costs of administering a system of environmental monitoring or regulation, or to pay for public or private expenditures on pollution abatement measures. Thus, for example, in France a number of specific taxes on polluting emissions - most notably on water pollution - raise revenues which are earmarked according to a "principle of mutualisation" to expenditures on pollution abatement which benefit the taxpayers of the tax concerned. Similar
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Earmarked pollution taxes are to be found in a number of other countries, with the principal aim of raising revenues for particular purposes; the taxes concerned may or may not also have an incentive effect on the level of polluting emissions.

2 Pigouvian taxes

The need for public intervention to control environmental pollution arises because of the "externalities" involved in pollution - the costs that the polluting individual or firm imposes on other members of society. Without government intervention, a polluter may have no reason to take these external costs into account. Decisions about the level of production and consumption activities which give rise to pollution, about the choice of technology, the use of pollution abatement measures and the disposal of waste products will then all be taken purely on the basis of the "private" costs and benefits to the individual polluter. In particular, the atmosphere and water systems may be treated as free methods for disposing of unwanted waste products, despite the fact that unrestricted pollution of the atmosphere, or of ground water, rivers and seas, may impose costs on other firms or individuals.

Environmental policy needs to draw a balance between the costs of pollution and the costs of controlling pollution. Whilst there may be some forms of pollution which it would be desirable to eliminate entirely, this will generally be the exception rather than the rule. Ideally, pollution should be restricted up to the point where the benefits to society as a whole from further reductions in pollution are less than the costs of controlling pollution through the installation of control devices or the curtailment of polluting activities. In economic terms, therefore, pollution should be controlled up to the point where the marginal cost of further abatement measures just outweighs the gain from reduced emissions.

For a single polluting firm (for example, a firm discharging organic matter into a river) we can draw Marginal Abatement Cost (MAC) and Marginal Damage Cost (MDC) functions as shown. The marginal abatement cost will generally rise (strictly will not fall) with more stringent control, since the MAC curve assumes a ranking of measures, such that the least costly are implemented first. Often the marginal damage cost will also rise with emissions, reflecting a tendency for large amounts of pollution to cause proportionately greater damage to the environment than small amounts of pollution. This might be the case if the environment has some natural assimilative capacity - as in the case of the ability of water systems to assimilate organic matter. In the diagram, E* represents the efficient level of pollution control. At E*, the marginal abatement cost and marginal damage cost are equal, at a level C*.

In theoretical terms, the appropriate level of abatement is achieved where the marginal social cost of reducing pollution by an additional unit is equal to the marginal social benefit of a one unit reduction in pollution. Achieving this level, whether through tax policies or through other measures,
requires information on both the structure of marginal abatement costs and marginal damage costs. As the recent survey by Cropper and Oates (1992) shows, considerable progress has been made in recent years in refining the methods for obtaining the information needed to determine the optimal level of pollution abatement. Extensive research has, for example, been undertaken into the valuation of marginal environmental improvements, using both indirect inference from the market prices of housing and other commodities affected by environmental conditions, and direct survey evidence ("contingent valuation") of the values which individuals place on environmental improvements. Johansson (1990) discusses the degree of convergence of estimates obtained using the range of available methods, and considers explanations for some of the observed discrepancies.

In practice, the context for many environmental policy decisions is already more tightly defined than in the above analysis of "optimal" pollution control. Many countries have already undertaken quantitative commitments to reduce greenhouse gas emissions, for example, and may wish to use environmental taxes to achieve these targets. In these circumstances, the main issue concerns the scale of the response to tax changes, in terms of the price elasticity of demand for the taxed
products. Although there may be considerable uncertainty about the magnitude of these elasticities, measures can always be implemented on a gradual basis, increasing tax rates until the desired quantitative response is achieved.

### 2.1 Market mechanisms versus regulation

In principle, any given pattern of pollution reduction could be achieved either by regulations restricting emissions to a given level, or by use of market mechanisms such as pollution taxes and charges, to provide an appropriate incentive to reduce emissions to the same level. Thus, in Figure 1, a charge of $C^*$ per unit of pollution could be used to reach the optimal level of emissions $E^*$, or regulations could require the polluter to abate emissions to the same level. However, whilst charging mechanisms and regulations can be used to equivalent effect in the context of this simple example, in practice there both advantages and disadvantages to the use of emissions taxes.

(i) Static cost minimisation. The costs of reducing polluting emissions may in practice vary between polluters for a variety of reasons. Different firms may use different technologies, some of which may be more able to accommodate reductions in polluting emissions than others. Similarly, the costs to individual households of reducing their use of particular polluting products may vary as a result of differences in tastes or individual circumstances. An efficient pollution abatement policy would seek to reflect these individual differences in abatement cost, and would concentrate reductions in pollution where they can be achieved at least cost. Empirical studies of the costs of pollution abatement using different abatement rules, summarised by Tietenberg (1990), show that the gains from efficiently allocating emission reductions between polluters can be substantial. In a study of the cost of achieving strict abatement standards for nitrogen oxide pollution in Baltimore, USA, Krupnick (1986) shows that efficient abatement would involve about one sixth of the cost of uniform reductions in pollution imposed using command-and-control. Similar large gains from the efficient pattern of abatement, compared to uniform regulatory requirements, are found by other key empirical studies including Atkinson and Lewis (1974) and Seskin, Anderson and Reed (1983).

The principal argument in favour of emissions taxes or other market-based approaches to pollution control is that they are more likely to achieve an efficient allocation of pollution abatement across polluters than is a policy based on regulation. Extensive information about individual costs and circumstances would be required for a regulatory authority to allocate pollution abatement efficiently across individual polluters, and regulatory policies will tend to have to rely on rules which can only approximately reflect individual circumstances. In contrast, using the price mechanism in the form of a tax per unit of emissions economies on the information needed - those polluters with the lowest abatement costs in effect "select themselves" in response to the signal provided by the tax.

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3 It should be noted, however, that it will not always be possible to use a trial and error process of this sort to discover the information about marginal abatement costs needed to set an environmental tax at the optimal rate, since polluters may respond strategically in these circumstances.

4 In addition, an efficient pattern of response to pollution problems might involve relocation by firms or households; White and Wittman (1982) discuss the possible contribution of pollution taxes to efficient location decisions. It has been recognised that certain types of abatement and defensive measures can complicate greatly the achievement of an optimal level of pollution abatement (Coase, 1960; Shibata and Winrich, 1983).
(ii) **Dynamic incentives for innovation.** In addition to these "static" cost-minimisation properties of emissions taxes, taxes and other environmental market mechanisms may also provide a "dynamic" incentive for the development of further cost-effective methods of pollution control. The source of these dynamic improvements is the fact that, even at the static optimum, the environmental tax continues to be paid on remaining units of emissions - thus providing an incentive to search for technological innovations that will reduce still further the optimal level of emissions (Wenders, 1975; Magat, 1978; Milliman and Prince, 1989).

Emissions taxes\(^5\) will give a greater incentive for such innovations than command-and-control regulations, which merely constitute an incentive for the minimum necessary compliance. However, it is not clear whether emission taxes, alone, can be expected to secure the first-best level of innovation. Carraro and Topa (1991) show a model in which emissions taxation leads to less than the first-best level of environmental innovation.\(^6\)

(iii) **Vulnerability to regulatory failure.** Market instruments such as emissions taxation may be less exposed to the risk of regulatory "failure" than certain forms of quantitative regulation. One important source of regulatory failure is the asymmetry of information between regulators and their subjects (Vickers and Yarrow, 1988). Where a substantial amount of information about the circumstances or characteristics of individual firms is required to implement a particular policy, the firms may be in a strong position to control the flow of information to the regulator in such a way as to significantly affect the way the policy is applied. Although there may be little difference between a uniform rule on emissions levels (e.g. one setting an upper limit to emissions) and an emissions tax in the amount of information required for administration and enforcement, a regulatory policy which sought to take more account of the circumstances of individual firms would be much more vulnerable to regulatory failure. The efficient allocation of emissions abatement between firms depends on the marginal costs of abatement to each firm, and this information can only be obtained by the regulator from the firms themselves.

(iv) **Revenues.** The revenue raised from emissions taxes may be regarded as an additional benefit from their use, in that it may reduce the amount of revenue which has to be raised from existing taxes, and hence reduce the net aggregate deadweight loss from raising public revenues (Terkla, 1984). At the same time, however, as discussed in section 6, there are also issues about the burden of the tax payments on households or firms, and their distribution, to be taken into account.

(v) **Monopoly.** Buchanan (1969) discusses a possible limitation of environmental taxes in circumstances where polluting firms have a degree of monopoly power. Where companies have market power, they may reduce output below that which would occur in perfect competition, in order to maintain higher prices. An environmental tax raises the marginal cost of production and consequently a monopolist will reduce output even further, away from the social optimum. An

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5 Tradeable permits, whether auctioned or distributed free, will also provide a similar incentive for innovation, since the necessary permits have a cost or opportunity cost to any source which continues polluting. However, depending on the rule for permit issue over time, this incentive could be less than with an emissions tax (Maleug, 1989). This result arises because the firm which innovates reduces the aggregate demand for permits, and thus reduces the value of any permits which it holds.

6 There are, of course, well-known "public good" arguments for the subsidy of R&D, especially of fundamental research.
environmental tax set at a level that would lead to an efficient amount of pollution abatement by firms in a competitive industry will typically not be efficient if applied to a monopoly. In an empirical investigation of the significance of this argument, however, Oates and Strassmann (1984) found that the welfare costs of output restriction by monopolies were rather small and the inefficiencies in Pigouvian taxation from this source consequently unimportant.

(vi) **Non-uniform damage.** Where the concentration of pollution, either in particular localities or over certain time periods, is of importance, more complex forms of tax instrument will be needed than where the concentration of pollutant emissions is irrelevant. A straightforward tax per unit of effluent discharge (or, more generally, pollutant emitted) would not discourage geographic or temporal concentrations of pollution, whilst at the same time it could mean that firms in areas where pollution was less damaging might be charged more than the value of the damage created. Where policy is, nonetheless, constrained to use only uniform taxes, there is then a straightforward tradeoff between the efficiency gain from taking into account the diversity of abatement costs, and the efficiency costs of inadequately differentiating between polluters with different marginal abatement benefits (Seskin, Anderson and Reid, 1987). A number of papers have considered the use of zoned taxes or other non-linear tax systems to reflect the fact that pollution in particular localities or at certain times causes greater damage (Tietenberg, 1978; Kolstad, 1987).

One case where determination of the appropriate time profile of tax rates is particularly complex is that of a carbon tax, used to control greenhouse gas emissions. One reason for this is that the problem is one of a stock externality; the damage relates primarily to the total stock of greenhouse gases in the atmosphere rather than to the rate of emissions (Nordhaus, 1991). Also, as Sinclair (1992) observes, the choice of a tax profile is further complicated by the fact that the fuels concerned are an exhaustible resource. Policy measures to regulate the rate at which the resource is depleted will need to take account of the natural changes over time in the pricing of the resource, reflecting its scarcity. Sinclair's conclusion that, in steady state, the optimal carbon tax rate should decline over time is challenged by Ulph, Ulph and Pezzey (1991), who argue that a steady state will in general not arise, and that in many cases the optimal carbon tax will rise initially, and then fall as the exhaustion constraint starts to bite.

2.2 **Pollution taxes versus subsidies**

In principle, subsidies can be used to provide a similar incentive to reduce pollution to that provided by a tax or charge on each unit of pollution. A subsidy, on each unit of pollution abatement compared with the existing situation, would lead individual polluters to reduce pollution by the same level, and make the same choice of technology as they would if faced with a tax at the same level on each unit of pollution.

There are, however, four principal points of difference between the use of incentive mechanisms based on subsidies and mechanisms based on taxes and charges.

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7 Cases where the geographical concentration of pollution is of no concern at all are rare; the emission of CO2 (and its impact on global warming) probably provides the only significant practical example.
(i) Definition of the subsidy baseline. Since the equivalent subsidy has to be paid on each unit of pollution abated, rather than on each unit of pollution emitted, it is necessary to define a baseline level of emissions against which current emissions will be compared. In principle, this requires a complex "counterfactual" assessment of what would have happened in the absence of policy. A more straightforward alternative, using the emission levels at the start of the policy as the baseline may initially be a reasonable approximation, but would become increasingly out-of-date; in addition, as Kamien, Schwartz and Dolbear (1966) point out it could encourage polluters to increase pollution at the outset, to qualify for higher subsequent subsidy.

(ii) Effects on entry and exit. Whilst taxes and subsidies can provide the same incentive at the margin, as Bramhall and Mills (1966) observe they have different effects on the level of profits earned by polluters. This may affect the evolution over time of the industry structure, since the pollution abatement subsidy could reduce the rate of exit from the industry. Whilst the reduction in exits (e.g. bankruptcies) may be seen as having political advantages, it has the unhappy consequence that the level of pollution from the industry as a whole could actually rise, if policy was based on pollution-abatement subsidies rather than pollution taxes.  

(iii) Public expenditure. One obvious difference is that subsidies add to public expenditure, and thus require other taxes to be raised to finance them, whilst pollution taxes raise tax revenue, and thus permit other taxes to be reduced. The potential value of the revenues from environmental taxes is discussed in detail in section 6.

(iv) Concealed protection. One important practical consideration which counts against the use of subsidies in environmental policy is the risk that over time these subsidies may come to constitute a form of protection for the industries concerned. The appropriate level of subsidy to reflect environmental objectives may be difficult to define with any precision, and the appropriate pattern of payment across firms may, as argued above, rest on a number of difficult judgements. In these circumstances, the borderline between justified and unjustified subsidy may be blurred, and it may be relatively easy for protectionist pressures to lead the subsidy to be increased. Such indirect or concealed protection in the guise of environmental policy has been the focus of discussions in a number of international fora. Amongst the countries of the OECD it has been a major reason for the adoption of the Polluter Pays Principle (PPP), which is based on the most readily-verifiable rule, a baseline of zero subsidy in environmental policy (OECD, 1974).

On the other hand, Bovenberg (1992) argues that subsidies may in some circumstances be promising instruments for unilateral environmental policy, since they will lead to smaller changes in the pattern of trade and factor flows than environmental taxes, and will thus involve smaller economic adjustment costs. This argument for the use of subsidies is perhaps strongest in the context of the gradual adoption by countries of policies to control an international environmental externality. For example, the temporary impact of the unilateral introduction of a carbon tax on the...
trade of the country which moves first may be large; a policy based instead on subsidy would reduce the need for trade to adapt to what the "first movers" hope is only a temporary situation, before other countries have adopted similar measures.\(^9\)

### 2.3 Pollution taxes versus tradeable permits

US policy towards market instruments in environmental policy has evolved in a rather different direction to that taken in Western Europe. Little use has been made of emissions taxes in the US, but there has been considerable interest in the use of systems of tradeable pollution permits, including a much-documented river pollution application in Wisconsin (O'Neil et al., 1983), permit trading for lead in petrol, and extensive scope for emissions trading in various parts of the air pollution control systems. There has been some discussion of the reasons why US policy has evolved in this distinctive direction (Burtraw and Portney, 1991), and extensive consideration of practical lessons that can be derived from US experience (see, e.g. Tietenberg, 1990).

The principal theoretical consideration in the choice between taxes and tradeable permits relates to the impact of uncertainty. Where policy can be based on complete information about both the costs and benefits of pollution control, a chosen optimal level of pollution abatement can be attained either using quantity-based instruments (such as tradeable permits), or using price-based systems of regulation (charges or taxes). Important differences emerge, however, between quantity and price-based regulation in how the outcomes are affected by uncertainty about the costs and benefits of abatement (Weitzman, 1974).

A system of tradeable permits guarantees the quantitative reduction in pollution, but at uncertain cost, whilst a price-based mechanism such as an environmental tax has an uncertain impact on the quantity of emissions, but fixes the marginal cost to polluters of emission controls. The choice between the two types of environmental market mechanism, thus turns on whether policy error regarding the costs of pollution control would be more damaging than uncertainty about the quantitative reduction in pollution.

The practical experience of tradeable permits also suggests one other major problem area, which is the efficiency of the permit market. These have tended to be thin, and the supply of permits for trading, in particular, has been small, perhaps because the rules of the schemes have been too vague about the long-term rules for permit allocation, and have imposed various restrictions on permissible trades (Hahn, 1989). Permit trades will also not take place at the efficient level if polluters are large, and can affect the price at which permits are traded (Hahn, 1984; Misiolek and Elder, 1989).

On the other hand, permits have the attraction that they can be introduced without significantly increasing the average financial burden on existing polluters by a system of "grandfathering" - a free distribution of permits to existing polluters. This may, it is suggested, ease acceptance

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\(^9\) Similar arguments can be made for using regulation or "grandfathered" tradeable permits instead of taxes in these situations.
compared with taxes and charges where there may be public scepticism about any commitment
to use revenues to compensate, on average, those industrial or social groups affected by the
introduction of an environmental tax. Issues of tax burden and compensation with environmental
taxes are discussed in more detail in section 6.

3 Approximations to Pigouvian taxes

The environmental tax instruments discussed in the previous section were payments directly related
to polluting emissions - for example the taxes operated by some countries for effluent discharges
into rivers; the tax is directly related to polluting emissions, in the sense that the amount of tax paid
depends on the quantity emitted, and hence on the amount of pollution caused. In this section we
consider an alternative group of environmental taxes based on an indirect relationship between
the amounts paid in tax and the environmental problem which the tax seeks to influence. This
group of environmental tax measures would include, for example, changes in the rates of taxation
on petrol, introduced for environmental reasons. In such a case, the incentive to reduce polluting
emissions takes an indirect form, in that the tax is not levied directly on the quantity of emissions,
but instead is levied on a base which is assumed to be linked in some dependable relationship to
the amount of pollution caused.

Both types of environmental tax have a role to play in environmental policy. The choice between
a tax directly related to emission quantities, and a tax which is more indirectly linked to the pollution
it aims to control will depend on considerations of two sorts, administrative cost and "linkage".
Broadly speaking, as McKay, Pearson and Smith (1990) argue, there is likely to be a tradeoff
between lower administrative cost and better linkage; in many cases, environmental taxes based
on measured emissions will have higher administrative costs than taxes which are levied on some
other base, but will be better linked to the amount of pollution caused, and will thus provide a more
precisely-targeted incentive to reduce pollution. The balance between these two considerations
is, however, likely to differ from case to case.

3.1 Administrative cost

The administrative costs of any new tax will normally be greater, the less scope there is for the tax
to be incorporated in existing systems of administration and control. Where the assessment,
collection or enforcement of the tax can be "piggy-backed" on to corresponding operations already
undertaken for existing taxes, the costs of an environmental tax measure may be significantly less
than where wholly - new administrative apparatus and procedures are required.

The vast majority of existing taxes are levied on transactions - the value of goods and services
sold, the value of incomes paid or received, etc. The scale economies that can be achieved from
administrative integration of environmental taxes are likely to be greatest where environmental

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10 Pezzey (1988, 1992) points out that polluters may believe themselves to have de facto "property rights" in their
current pollution, and that grandfathering may simply reflect this situation.
3. Tax and Environment: Survey

taxes, too, are levied in a form based on transaction values. Thus, for example, the differentiation of the rates of existing taxes (which may be seen as the limiting case of a tax reform closely compatible with existing tax administration) may gain considerably from combined administration. On the other hand, there are likely to be few gains from combining the administration of a tax on measured emission quantities with existing transaction-based taxes.

It is necessary to bear in mind that most administrative piggy-backing is unlikely to be wholly costless from the point of view of the administration of existing taxes. Greater complexity is likely to increase administrative costs in all areas - though the extent of this will depend on the existing degree of complexity in the tax structure.

New environmental taxes based on measured emissions quantities will require, as a minimum, the additional costs to be borne of a system for the assessment or measurement of the emission quantities on which the tax is to be levied. These costs will depend on:

(i) measurement costs per source. This will vary depending on the technical characteristics of the emissions (flow, concentration, stability, etc), the substances involved, and the range of currently-available measurement technologies. Recent scientific and commercial developments in measurement and control are likely to have substantially widened the range of technologies available for monitoring the concentrations and flows of particular substances in effluent discharges, and hence to have increased the range of pollution problems for which charging on the basis of direct measurement is likely to be a feasible and cost-effective option. It is also probable that the future pace of development and commercialisation of such technologies will in part be stimulated by a greater use of direct emissions charging.

(ii) the number of emissions sources. Direct charging for measured emissions quantities will be less likely to be worthwhile, the more separate emission sources there are. An extreme case of this is the case of non-point-source pollution - in other words, where no identifiable pipe, outlet or chimney provides a "point source" at which emissions can be measured. The leaching of agricultural fertilisers and pesticides into the water system are examples of non-point-source pollution; for such pollution problems, direct measurement is likely to be costly and/or highly imprecise.

(iii) scope for integration with normal commercial activities The costs of a system of emissions measurement will generally be reduced, if the measurement of emissions can be integrated with activities that would naturally take place for normal commercial reasons. Not merely does this reduce the additional costs of measurement for tax purposes, but it also tends to reduce the risk of false or misleading information being provided, since there are non-tax reasons for accurate measurement.

Even, if despite the administrative costs, Pigouvian taxes on emissions are still preferred to "approximate" environmental taxes, the existence of significant administrative costs of taxation would be likely to mean that the range of tax instruments employed will be more restricted than would be the case if tax administration were costless. As Yitzhaki (1979) observes, explicit consideration of administrative costs, so that the number of tax instruments is included as a decision
variable in optimal tax analysis, avoids the need to treat optimal taxation as a second-best problem, with arbitrary restrictions on the tax instruments available. Polinsky and Shavell (1982) consider another issue raised by administrative costs in the context of Pigouvian taxation - whether it is desirable to take administrative costs into account in choosing the appropriate rate at which Pigouvian taxes should be levied. They conclude that the answer varies depending on the relationship between administrative costs and the number of polluters; for example, where the administrative costs are a fixed amount per polluter and are borne by government, it may be appropriate to set the Pigouvian tax rate above the level of the external cost, so as reduce the administrative cost, but this rule will not be appropriate where the costs of administration are borne by the polluters themselves.

3.2 Linkage

Where the costs of an environmental tax system based on direct charging for measured emissions are high, restructuring of the existing tax system may provide an alternative way of introducing fiscal incentives to reduce environmental damage.\(^{11}\) The effectiveness of changes in the existing tax system in achieving an efficient pattern of pollution abatement will depend on the degree to which the taxation is closely linked to the pollution which it aims to control. If the tax rises, does it encourage taxpayers to seek to reduce this tax burden by reducing the processes or activities which give rise to polluting emissions - or are they, instead, just as likely to find ways to reduce their tax payments that do not change their level of pollution?

This issue of linkage is central to any case for or against using fiscal instruments other than those based on direct charging for measured emissions: where the linkage between tax base and pollution is weak, the tax may fail to have the desired impact on pollution, and may, at the same time, introduce unnecessary and costly distortions into production and consumption decisions.

"Indirect" environmental tax policies depend on the existence of a stable relationship between the tax base and pollution, but relationships which are observed to be stable in the absence of policy measures can turn out to be unstable once a tax is introduced. A good illustration of this phenomenon is given by Sandmo's (1976) account of Norway's attempt to introduce a system of charging for domestic refuse collection by charging for the special sacks which householders were required to use for their refuse. The logic for the system was that the number of sacks used would be a rough proxy for the quantity of refuse collected from each household. Unfortunately, the charging scheme, once implemented, tended to change the relationship between sacks used and refuse collected. Some households tended to economise on sacks rather than to economise on refuse, and responded to the tax by over-filling the sacks, or by dumping refuse, causing environmental problems elsewhere.

\(^{11}\) Plott (1966); Holterman (1976); see also Young (1977).
A number of papers have considered the appropriate structure of taxation where the only administratively feasible policies involve some degree of approximation in the linkage between tax base and pollution damage. The issue of linkage has been represented in these models in two different ways. One group of papers has considered models where administrative limitations require that all individuals causing externalities are taxed at the same rate, but where the externalities from some are more damaging from others. In the context of Pigouvian taxation of emissions, these could be cases where taxing different polluters at different rates, according to the damage from their emissions, required a large element of judgement, which thus tended to expose the system to lobbying or regulatory capture. In the case of conventional product taxes, an example might be the use of a tax on coal to encourage smoke abatement; although smoky chimneys may be more damaging in densely-populated areas, it would be impracticable to tax coal at different rates in different areas, since it would be almost impossible to prevent urban dwellers from buying their coal from rural suppliers.\(^\text{12}\)

Diamond (1973) considers the rate at which such a uniform tax should be levied. In the case where there is separability between the externality and consumption, the appropriate tax rate is simply the weighted average of the marginal contributions to the externality, where the weights are given by the sensitivities of demand for the good which generates the externality. Where the separability assumption is relaxed, so that externalities affect demand as well as utility, calculation of the optimal tax rate is more complex, and "perverse" cases cannot be ruled out, in which it would be appropriate to subsidise the good causing the externality.

Where linkage is poor, it may be possible to improve matters by going beyond taxation of the good associated with the externality; complements or substitutes to the externality causing good may be taxed or subsidised. Like Diamond (1973), Green and Sheshinski (1976) and Balcer (1980) consider cases where individual externality effects differ (and where the optimal Pigouvian tax would therefore be at different rates). However they focus on cases where goods exist that are complements (or substitutes) to the externality-generating good. Depending on the interaction between demand for the complement (or substitute) and the externality, it may be possible to improve on the taxation of the externality-causing good alone, by taxing or subsidising the complementary or substitute good. For example, if the objective is to deal with urban congestion, high petrol taxes might be supplemented by subsidies to urban public transport and taxes on urban parking spaces. Sometimes the appropriate policy rules will appear counter-intuitive. Balcer shows a simple case where a subsidy to a complementary good would be appropriate, and Wijkander (1985) discusses cases where the policy rule is complicated by the cross-effects between various complements or substitutes to the externality-causing good.

Other papers have represented the linkage issue differently. Sandmo (1976) represents the problem as one where goods can be used for two purposes, only one of which generates the externality; this could be a case where some consumption uses of a good cause more pollution than others (e.g. use of petrol in urban and rural areas) or, as in Henry (1989), where the good

\(^{12}\) In practice, of course, market instruments in this case are likely to be easily dominated by a simple regulatory rule, forbidding the use of smoky fuels in urban areas.
causes more pollution in one production use than in another. It is assumed that the good can be
taxed, but that it is not possible to differentiate between its different uses. Again, the analyses
confirm the value of taxing or subsidising complements or substitutes, as well as the good
associated with the externality, and again it proves possible to find counter-intuitive policy
prescriptions. Perhaps the most important advantage of representing the issue in this way is it
focuses attention on the key practical question of how the externalties are generated: What is the
 technological relationship between the taxed commodity and the externality, and is this relationship
likely to be stable?

Where there is a wide range of available techniques which differ widely from one another in the
relationship between tax base and pollution, linkage is likely to be more of a problem than where
the range of technologies is small, and the tax base: pollution relationship broadly stable across
production techniques. Technical data about the range of available production techniques and
their environmental attributes will thus help to assess the practical relevance of linkage problems
for any particular environmental tax.

McKay, Pearson and Smith (1990) observe that a particularly severe problem of linkage arises
where it is sought to influence pollution emissions from a production process through taxes on
inputs, and where significant scope exists for pollution abatement through effluent "cleaning" at
the end of the production process. One case in point is the scope for cleaning the sulphur dioxide
emissions of coal-fired power stations by fitting "scrubbers" (flue gas desulphurisation equipment,
or FGDs). Where effluents can be cleaned in this way, taxes on production inputs will not be an
effective way of encouraging an efficient pattern of pollution abatement. Such a tax (e.g. a tax on
sulphurous coal) may discourage the use of polluting materials in production, but will provide no
incentive to clean up effluents from the process. Although pollution may be reduced, the way in
which pollution reductions are achieved will not necessarily be the most efficient.

Environmental taxes on fuel inputs may thus be more appropriate to deal with carbon dioxide
emissions, where effluent cleaning is not currently a commercially-viable option, than with sulphur
emissions, where important effluent-cleaning technologies are available. However, it should be
noted that what is at issue is not merely the existence of (commercially-viable) alternative
technologies, but also the potential for them to be developed, since an efficient pollution tax will
create an incentive for new technologies, involving less pollution, to be developed. The acceptability
of a carbon tax on fuel inputs instead of a tax on measured carbon emission quantities depends
in part on a judgement about how rapidly such technological developments are likely to take place,
and about how far their future development might be inhibited by the choice of a tax on inputs
rather than on measured emissions.

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13 A number of countries, including Sweden and Finland, have already introduced carbon taxes on fuels (Hoeller and
4 Mutualisation

In practice, one of the common characteristics of environmental taxes has been hypothecation or "earmarking" of the revenues, for example, to expenditures on environmental policy measures, or to be used to raise revenues for environmental agencies or funds. Thus, water charges levied in a number of European countries are earmarked to expenditures on water quality management, and feedstock taxes in the US are earmarked for the "Superfund", which finances the clean-up of hazardous waste dumps. Indeed, as Opschoor and Vos (1989) conclude, most of the initiatives to introduce environmental taxes have arisen because of the need to find revenue sources which can be assigned to finance environmental expenditures, rather than for their incentive value.

This suggests that the issue of earmarking may need to be considered from two angles. Firstly, there is the question of whether there is a case for earmarking the revenues from an environmental tax introduced for incentive purposes. Secondly, there is the question of whether public expenditures on environmental measures should be financed specifically from the revenues of particular taxes; if so, are there reasons to finance such expenditures from eco-taxes, rather than from general tax revenues?

(i) Earmarking environmental tax revenues. In the case of the use of revenues from environmental taxes introduced to correct market incentives so as to reflect the environmental costs associated with polluting emissions or the production or use of particular commodities, the "conventional" view of public economics is that earmarking is a potential source of inefficiency in fiscal decision-making. Whilst the assignment of particular revenue sources to particular expenditures headings may be made in a way that initially allocates tax revenues efficiently across expenditure headings, over the longer term, tax revenues and expenditure requirements can move out of line. Requiring the revenues from environmental taxes to be used for given purposes would mean that the amounts spent on these purposes would change over time according to the trend in the revenues from environmental tax, rather than according to spending needs. Alternatively, earmarking could lead to inefficiencies in the pattern of taxation, as the rates of tax come to be driven by the revenue requirements for the earmarked budget headings, rather than by the balance between the costs and benefits of particular tax levels.14

On this view, there is no reason to believe that "earmarking" the revenues from environmental taxes would lead either to appropriate levels of expenditure on environmental improvements, or to appropriate levels for the environmental tax. These inefficiencies would, moreover, be likely to be magnified over the course of time.

This view of earmarking, however, depends on assumptions about the underlying political and administrative process that may be unrealistic. Earmarking is contrasted unfavourably with a situation where taxes and public expenditures are set "optimally" as the outcome of a process which sets taxes so as to minimise the costs of taxation and allocates expenditures across particular

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14 Oates (1991) discusses a related issue, namely whether the rates of an environmental tax should be determined by the Ministry of Finance or the Ministry of the Environment. He argues that the latter would be preferable, since the Ministry of Finance may allow revenue considerations to dominate environmental policy efficiency.
headings so as to maximise the overall benefits of public spending. In practice, political decisions about taxation and public spending may reflect a wider range of pressures - including, perhaps, bureaucratic pressures tending to the over-expansion of public expenditure programmes (Buchanan, 1963). In these circumstances, public support for new taxes may be weakened by the concern that the revenues could be diverted to undesired purposes. Earmarking of a new environmental tax to some popular expenditure heading may then be a strategy which would generate greater political support for the measure than if the revenues were simply to be allowed to augment the general resources of government. By "ring fencing" the revenues to "desirable" expenditure headings, the measure may command greater public support.

(ii) Financing environmental expenditures. The above arguments reflect the "conventional" debate over earmarking - a discussion of whether it is appropriate for the revenues from a particular tax to be devoted to particular spending headings, or to the general exchequer. However, in practice, the context in which environmental taxes have been introduced has often been rather different to that being presumed here - usually the issue has not been what to do with the revenues from an existing environmental tax, but rather to find revenue sources that would be appropriate to finance environmental expenditures. In this context, environmental taxes are seen not as incentive mechanisms, but principally as revenue-raising devices, to provide revenues for a programme of public environmental expenditures (Hahn, 1989).15

The principal issue is the identification of revenue sources which would be "appropriate" to the expenditures in question. One criterion for appropriateness might be given by the concept of benefit taxation: taxpayers should contribute financially towards the cost of public expenditures in proportion to the benefits they derive from them (Musgrave and Musgrave, 1984, ch 11).

Where the expenditure programmes are general, yielding benefits distributed widely across the population, environmental taxes are unlikely to constitute or approximate benefit taxes. However, the benefit tax argument would seem more applicable in cases where both the expenditure programmes and the taxes were confined to particular sections or groups of the population. These groups may be defined either geographically - in the case of local taxes to finance local environmental expenditures - or they may be defined in terms of a particular sector or industry. Thus an environmental tax might be levied on a particular sector, to finance public expenditures on abatement measures which benefited that sector, or which cleaned up pollution attributable to that sector.

One obvious attraction of the earmarking of an environmental tax levied on a particular sector to environmental spending benefiting that sector is that it may overcome some political opposition to aspects of the policy - either to the use of public revenues to subsidise the costs of a particular sector, or, where the tax has an incentive function, to the sectoral impact of the revenue burden; earmarking of this form provides sector-by-sector "compensation".

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15 This is in practice a particularly important motivation for environmental taxes in developing countries, where other options for raising tax revenues may be very limited.
Linking sectoral spending and revenue-raising also formally complies with the restrictions imposed on subsidy schemes by the OECD Polluter Pays Principle; subsidies that would have been regarded as contrary to this principle if paid for out of general tax revenues are regarded as consistent with the requirements of the PPP if the cost is shared amongst the beneficiaries.

However, despite the formal conformity of such sectoral earmarking with the requirements of the PPP, there are reasons for concern about its extensive application. Certain types of environmental policy measure require public involvement and common financing; those that have the character of "public goods" (e.g. joint effluent treatment facilities, or research expenditures) are unlikely to be provided to an efficient level if they have to rely on the uncoordinated actions of individual firms. However, it is less clear that any justification can be found for public subsidy to measures that benefit one firm alone. Indeed, financing such subsidies from the proceeds of environmental taxes levied on the sector may distort desirable signals about the appropriate level of activity in the sector; they may inhibit exit from the sector (and possibly attract new entrants), leading to a long-run higher level of sectoral activity than would be desirable, and, conceivably, increasing rather than reducing the aggregate level of pollution (Oates, 1991).\textsuperscript{16}

Finally, even in the "public good" case where sectoral expenditures can be justified, it is not obvious that environmental taxes, rather than other levies related perhaps to employment, assets or output, are the appropriate way of sharing the cost of providing the common facilities. If it is felt desirable that payment should be in proportion to benefits received, it is then a purely empirical matter whether the pattern of benefits is more closely approximated by the environmental tax, or by payments of some other tax.

5 Empirical studies of the effects of environmental taxes

A growing literature on environmental taxes has tried to assess the likely scale of responses to environmental tax measures. How large would environmental taxes have to be, and what would be their impact on pollution, and on economic variables, including the level and distribution of incomes, prices, exchange rates and international competitiveness, employment, government revenues, etc? Given the scale of this literature, it is impracticable to provide an exhaustive survey here; this section can merely indicate the range of approaches adopted, and highlight conclusions from a few selected papers.

In practice, whilst policy measures taken in a number of countries have included environmental taxes on narrowly-defined commodities (e.g. taxes on plastic bags, batteries, non-returnable containers, etc), most of the quantitative research has examined more broadly-specified environmental taxes, such as carbon taxes (taxes on energy sources related to the amount of carbon dioxide they will produce in combustion), other taxes on domestic or industrial energy use, and taxes on motor vehicles and motor fuels. Besides the fact that these are the areas where

\textsuperscript{16} Lans Bovenberg has pointed out that the problem of efficient entry/exit may be less severe than is suggested here if tax revenues decline over time, because the long-run elasticity exceeds the short-run elasticity. In this case, part of the subsidy is only temporary, and may not attract new firms.
3. Tax and Environment: Survey

Environmental taxes might be expected to have the most significant impact, the poor availability of data on past spending and prices tends to restrict the scope for more detailed modelling of environmental taxes on narrowly-defined commodities, or on commodities (such as leaded petrol) defined by particular environmental attributes.

With the exception of the literature on the economic effects of a carbon tax, most of the empirical research has focused on estimating the impact of environmental taxes on the use of the taxed commodity, and occasionally on closely-related sectors, and has paid less attention to wider economic effects including macroeconomic adjustment and general equilibrium effects. The studies which seek to estimate elasticities of demand and substitution can be divided into time-series estimates at an aggregate level, and estimates using micro data on individual firms, industries, or households.

(i) Estimates at an aggregate level have included time-series estimates of aggregate energy use by industry, by consumers, or by the economy as a whole, time series models of motor vehicle ownership and vehicle fuel expenditure, of agricultural fertiliser use, etc. The data requirements of such studies are comparatively small, but there are frequently difficulties in distinguishing price effects from other trended variables such as income, output price levels, etc. For the UK, a number of studies of aggregate energy demand are summarised in Hunt and Manning (1989).

Brännlund and Kriström (1991) study the impact of a tax on chlorine effluent from the bleaching process in the pulp industry, using a model which takes into account possible effects on forestry and the sawn timber industry. They found that a tax which increased the price of chlorine by 50% would reduce the quantity of chlorine used by some 14 per cent, but that it would have negligible repercussions for forestry and the timber industry.

The likely impact of a tax on agricultural fertilisers can be derived from a number of studies of the price elasticity of the demand for fertilisers. Burrell (1989) provides a useful survey of this literature. Estimates from linear programming models and from econometric models have tended to diverge widely, with rather higher elasticities being obtained from the latter.

Time-series models can often be particularly informative about the time-scale of likely responses to an environmental tax. One recent study which has generated important new information about the likely dynamics of changes in energy use in response to an energy tax is the paper by Ingham and Ulph (1990), which models the age ("vintage structure") of the capital stock in considerable detail. It points out that the scope for changing energy efficiency is much less with existing plant and machinery than when new machinery is installed, and shows that to achieve quick results, a much higher level of taxation would be required than if energy consumption changes were sought over a longer time period.

(ii) Estimates at a micro level using data for industries or individual firms tend to be seriously constrained by the lack of relevant data. Changes in the classification of industry or trade statistics mean that industry-level data rarely contain an adequate number of yearly observations for robust estimation, and detailed data on individual firms' expenditures on inputs is frequently unobtainable for reasons of commercial confidentiality.
There has been a growing amount of research on the spending patterns of individual households, using data from large-scale household surveys which can be used to assess the impact of environmental taxes on consumer goods. Household expenditure and income data from a number of years of budget surveys are now available for a number of OECD countries, and allow elasticities of demand and substitution to be estimated at a micro-level for a range of goods (e.g. Blundell, Pashardes and Weber, 1989; Decoster and Schokkaert, 1989). Usually the models operate at a comparatively broad degree of aggregation although domestic energy spending and spending on vehicles and petrol are usually separately distinguished. Blundell et al. (1992) provide a comparative analysis of the impact of a "carbon tax" using consumer spending models from five European countries (Belgium, France, Italy, Spain and the UK), whilst other, single-country, studies of energy taxes or carbon taxes using these models have included Johnson, McKay and Smith (1990) and Symons, Proops and Gay (1992). Whilst all of these papers are based on a model which treats domestic energy purchases as a single aggregate, and which cannot therefore model the substitution between household fuels that might occur as the result of a carbon tax, Baker and Blundell (1991) present separate equations for household spending on gas and on electricity, based on micro-data from the UK Family Expenditure Survey.

Wider economic effects have been investigated using economic models of two sorts. As Boero, Clarke and Winters (1991) describe each approach has particular strengths and weaknesses, and these need to be borne in mind in assessing the results obtained.

(i) Simulation using macroeconomic models. Macroeconomic models can be used to investigate the economy-wide repercussions of environmental taxes, by embedding estimated models of commodity demands in a full system of equations representing supplies and demand for all commodities and factors of production, and financial relationships. These models can then be used to simulate the wider implications of environmental taxes and the revenues raised from them - including effects on prices, international competitiveness and the exchange rate, employment, etc. Linked macroeconomic models for a number of countries can be used to investigate how these effects might be altered if policies to introduced environmental taxes were subject to international co-ordination, rather than introduced by a single country acting alone. Linked simulations of the macroeconomic effects of a carbon tax are reported in Demmerman et al. (1991) and Standaert (1992) and a range of international estimates are surveyed in Hoeller, Dean and Nicolaisen (1991) and Bradley and Fitzgerald (1992). Barker and Lewney (1990) use a sectoral macro model of the UK economy to simulate the macroeconomic effects both of a carbon tax, and of the regulation of water quality. Lanza and Scabellone (1991) use a sectoral model of Italian energy demand to simulate the impact on an index of atmospheric pollution of the European Community's proposal to harmonise the structure of indirect taxes (which would require changes to the taxation of petrol and other energy), and Agostini, Botteon and Carraro (1991) simulate the impact of various ad valorem and specific energy taxes on energy-related pollution in Italy.

The principal uses made of most macroeconomic models have been to study and forecast short-run changes in economic conditions, and there is an obvious question about the extent to which they are suitable for simulating the longer-term implications of major structural changes in the economy.
that would be implied by substantial "carbon taxes" for example. Considerable recent research effort, however, has gone into improving the long-run dynamics of a number of models, to allow them to be used for longer-run simulation exercises.

(ii) Simulation using computable general equilibrium models. CGE models are, by contrast, designed to investigate the long-run process of economic adjustments to policy changes, by examining how relative prices of all goods and factors of production would have to adjust to achieve equilibrium in all markets\(^\dagger\). CGE models tend to pay little attention to the short-run dynamics of the economic adjustment process, in contrast to most macroeconomic models. Also, estimation can play quite a small role in the construction of CGE models; relevant elasticities may be gathered from a range of existing sources or simply assumed, and the model "calibrated" so that it is consistent with data for a particular "benchmark" year. As a result, statistical criteria to evaluate the reliability of the models and the precision of simulation results are difficult to obtain; the models, in effect, calculate the implications of policy change, \textit{given} a particular structure of the economy, supply and demand elasticities, etc. Because of their long-run focus, however, CGE models have been increasingly applied to the analysis of major environmental taxes.

This literature has grown explosively in the last two years. Proost and van Regemorter (1990), for example, look at the impact of a carbon tax using a CGE model for the Belgian economy, and Conrad and Schröder (1990, 1991) describe various aspects of the effects of environmental taxes using a German CGE model. Other studies include Glomsrød \textit{et al} (1992) for Norway, Blitzner \textit{et al} (1990) for Egypt, Bergman (1991) on Sweden, and Burniaux \textit{et al} (1992) which discusses the OECD's global CGE model GREEN, in which a number of regions are modelled.

One particular focus of studies based on CGE models of the effects of a carbon tax has been the international distribution of gains and losses from the tax. Since a move towards substantial policy measures to restrict carbon dioxide emissions is likely to require international agreement on co-ordinated emission reduction measures, knowledge of the pattern of gains and losses across countries is an important prerequisite for international negotiation. Whalley and Wigle (1991) show that the form taken by the carbon tax is critical in determining the distribution of gains and losses; a tax based on energy consumption would impose large losses on the major energy-producing countries, whilst a tax based on energy production would substantially compensate energy producers for the reduced demand for their natural resources by entitling them to a substantial share of the carbon tax revenues.

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17 See Shoven and Whalley (1984) and Borges (1986) for surveys of this approach.
6 Environmental taxes in the context of public finance

Revenues

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.

A "double dividend"?

There has been some interest in the potential of environmental taxes to reduce the overall costs involved in raising fiscal revenues. Does the revenue raised from environmental taxes constitute an additional benefit from their use, in the sense that it allows other taxes, which may have large distortionary costs, to be reduced? Some commentators (eg Pearce, 1991; Oates, 1991) have drawn attention to a potential "double dividend" from environmental taxes - the possibility that, in
addition to their environmental benefits, they have a second source of gains in the sense that the revenue raised from the environmental taxes allows other taxes, with possible distortionary effects on labour supply, investment or consumption, to be reduced.

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. The distinctive feature of environmental taxes is that they have negative deadweight burden (if the correction of the environmental externality is included in the definition of the deadweight burden) over a certain range of tax rates; rather than imposing costs by distorting the pattern of economic activity, they correct existing distortions which arise through the failure to price environmental externalities correctly. Starting from a situation where the environmental benefit of tax changes has not been taken into account, realocating the pattern of public revenues will then allow the overall deadweight burden of raising revenues to be reduced.

Empirical studies of the marginal distortionary costs (excess burden) of existing taxes show that these costs can be appreciable - for example, Ballard, Shoven and Whalley (1985) estimate the marginal excess burden of public revenues in the USA at 20-30 cents for each extra dollar of tax revenue - and if environmental tax reform permits a reduction in these costs, this may be a significant policy consideration. Terkla (1984) compares the environmental benefits from pollution abatement using emissions taxes with estimates of the deadweight loss that would be incurred in raising the same revenue through general taxation, and finds that the reduction in excess burden is of a similar order of magnitude to the net environmental benefits.

Revenue considerations will not always imply that the rate of the environmental tax should be increased, above the rate that would be appropriate if there were no need for public revenues. As Lee and Misiolek (1986) show, the optimal level of pollution abatement will depend on the elasticity of tax revenues with respect to the tax rate; if a marginal increase in the tax rate reduces tax revenues, then it will be appropriate for a lower tax rate to be set, and for the level of pollution abatement to be lower with a revenue-raising instrument than with an instrument that does not raise revenues.

A corollary of the double dividend argument is that the optimal level of pollution abatement will not be independent of the environmental policy instrument used. Where increasing the rate of the environmental tax increases tax revenue, instruments such as regulation or grandfathered tradeable permits which forego 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.
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 further 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.\(^\text{18}\)

There has recently been some discussion of the precise nature of the double dividend claim, and a spate of theoretical papers which have modelled the conditions under which a double dividend would arise (see Goulder, 1995, for a survey). Perhaps somewhat unhelpfully much of this literature defines the double dividend in somewhat ambitious terms; the second, non-environmental, dividend exists if the total deadweight costs of revenue raising (including abatement costs in the form of behavioural substitutions to higher energy prices) is negative. In other words, the double dividend argument 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.

Goulder (1995) classifies a double dividend of this form as a "strong" double dividend. He defines this as the claim that the "gross costs" of a tax switch, increasing taxes on energy and reducing existing non-environmental taxes, are negative. In gross costs he includes all the welfare costs of all behavioural changes from the tax switch, but excluding the environmental benefits. He also identifies a "weak" form of the double dividend argument, where the gross costs of the tax switch lie below the gross costs of introducing the energy tax but returning the revenues as a lump sum to taxpayers. He points out that the requirements for the weak form double dividend to hold are extremely likely to be satisfied; the strong form double dividend is a more contentious issue.

One 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 optimised 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 equalised, the aggregate deadweight costs of revenues are not minimised (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,

\[^\text{18}\] A similar point is made by Bovenberg and de Mooij (1994).
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 equalises marginal deadweight burdens across all taxes, can be satisfied only in a set of somewhat special circumstances. A series of paper by Bovenberg and co-authors has identified the limited range of possible cases where a double dividend of this form could exist (eg 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 also will 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 (ie 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 are identified in which the strong form of the double dividend argument holds. Bovenberg and de Mooij (1994a) 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.
A different approach is taken by Ulph (1992) who tries to clarify the precise meaning of the "double dividend" argument, and to separate clearly the "revenue" and "pollution" distortions involved. A key issue is the definition of the yardstick against which the distortionary cost of the tax system is to be assessed. Ulph takes as a yardstick the "first best" pattern of production and consumption, where unlimited use of lump-sum taxes is feasible and where the externality is corrected optimally, and measures both environmental and revenue distortions as deviations from this pattern.

Ulph (1992) considers whether the introduction of an environmental tax, from a starting point without any form of environmental control, would be expected to reduce the excess burden of tax revenues, whilst at the same time yielding environmental benefits. He concludes that this depends on the size of the revenues that would be raised from the environmental tax, relative to the revenue needs of the public sector. Obviously, where the public sector has no need for revenue, the revenues from an environmental tax do not substitute for other taxes; indeed, if the revenues cannot costlessly be returned to taxpayers, the revenues raised would represent a cost. Also, he argues that where the need for tax revenues is large relative to the revenues that would be obtained from correcting the externality in the first-best, there may be a tendency for revenue considerations to induce an excessive reduction in consumption of the polluting commodity - as discussed above, taking the revenue from marginal abatement into account may justify abatement beyond the first-best level.

It is possible, therefore, that there could be a greater externality distortion but a lower revenue-raising distortion with a tax system that included environmental taxes than with a tax system which did not take account of the externality. Only where the revenues from the environmental tax are broadly of a similar order to the revenue needs of the public sector is it likely that both the pollution and revenue distortions will be simultaneously improved by the use of an environmental tax.

**Distributional aspects of environmental taxes**

Distributional effects of environmental taxes are discussed in detail in Essay 6. A brief synopsis is given here for completeness.

Although both regulatory and market-based environmental policies may have distributional implications in terms of their impact (both costs and benefits) on households at different levels of incomes, the pattern of tax payments associated with the use of environmental taxes and other revenue-raising market-based instruments raises particular concerns.

The introduction of environmental taxes on energy is, in particular, likely to raise significant distributional concerns, reflecting the importance of energy expenditures in the budgets of poorer households (Dilnot and Helm, 1987; Smith, 1992). This distributional sensitivity of energy taxation is recognised in the indirect tax policies of many OECD countries, which apply lower levels of taxation to certain domestic energy products than to other goods and services.
What matters in assessing the distributional incidence of the burden of an environmental tax is the final incidence (i.e. the households which ultimately bear the burden of the tax) rather than the formal incidence (i.e. who makes the tax payments). Assessing the pattern of final incidence of a general energy tax, such as the proposed European carbon tax, will be complex. In addition to the direct distributional effects working through the prices of direct household purchases of energy, there will also be various indirect distributional effects, for example as a result of the taxes imposed on industrial purchases of energy. These indirect effects reflect the fact that the ultimate incidence of all taxes is on households - the burden of taxes on business can in principle always be traced to the households or individuals who are the shareholders or owners of each business, or to its suppliers, employees or customers. In addition to an analysis of the distributional incidence of energy taxes on consumer energy spending, a full analysis of the effects of a general tax on energy will also need to assess which of these various groups shoulders the ultimate burden of an energy tax on industrial energy use, and what place they occupy within the income distribution. Sophisticated general equilibrium modelling will thus be needed if all aspects of the distributional incidence of a general energy tax are to be quantified.

One important aspect of this, in the cases of taxes on natural resources such as energy is the extent to which the burden of the tax will be borne by the owners of the resources, rather than by resource consumers. In a freely competitive market, the balance between energy consumers and the owners of energy resources (energy producers) will be a function of the price elasticities of energy supply and demand. The more price elastic is energy supply, and the more inelastic is energy demand, the more the burden of a tax on energy will tend to be borne by energy consumers rather than the owners of energy resources. Given the likely low price elasticity of energy demand, there is good reason to believe that a large part of the burden of a carbon tax would be borne by energy consumers rather than energy resource owners. This conclusion would be even stronger in the case of an energy tax introduced by only some countries; the impact of the tax on global energy demand would be smaller, than where a world-wide energy tax was introduced.

**Taxes on consumer expenditures**

As far as the direct effects on energy products bought by private households is concerned, additional taxes on domestic energy would be likely to have a regressive distributional impact (i.e. the additional tax would constitute a larger proportion of the expenditures for poorer households). although this effect may be offset by the broadly progressive distributional impact of taxes on motor fuels. An initial indication of the magnitude of these distributional effects can be obtained from survey data on consumers' expenditure: for example, Poterba (1991) shows that a carbon tax in the USA would have a broadly regressive distributional impact, although he stresses that the regressivity appears less severe if a measure consistent with a "life-cycle" concept of distributional incidence is employed\(^\text{19}\). Pearson and Smith (1991) show that a carbon tax on consumer energy

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19 Poterba (1989) makes a similar observation regarding the distributional incidence of existing excise taxes in the US. See, however, Smith (1992), who finds less difference between distributional analyses based on current income and a life-time income proxy, expenditure.
purchases would have a broadly neutral distributional effect in many European Community countries, but the tax would have a much more regressive impact in the UK and Ireland. Scott (1991), too, finds that a carbon tax would have a regressive incidence in Ireland.

Whilst analyses based on the existing pattern of consumer spending can indicate the approximate distributional incidence of environmental taxes on particular goods or services, the approximation is poorer where households respond to the imposition of the tax by changing their pattern of spending away from the taxed items. Where behaviour changes, there are two types of distributional effect that may be of interest - changes in tax payments and welfare costs. The changes in tax payments will usually be less than the changes estimated on the basis of unchanged spending patterns, although they could be greater, if households substituted towards items that were already heavily taxed. The pattern of welfare costs may also be unevenly distributed across households, with poorer or richer households making a greater adjustment in their pattern of spending.

The conclusions of studies of the distributional effects of a carbon tax have varied, but there is a broad measure of agreement that, in some countries at least, a significantly regressive distributional impact could be expected. Pearson and Smith (1991), for example, in a study of the $10 per barrel carbon tax proposed by the EC find that for the poorest 20 per cent of the UK population, the additional payments of tax on household purchases of energy and motor fuels would be equivalent to more than 2 per cent of their total spending, compared with less than 1 per cent for the richest 20 per cent.

**Taxes on industrial inputs.**

The indirect distributional effects of fiscal changes affecting industrial inputs have been less extensively studied and measured than the direct distributional effects of taxes imposed on goods purchased directly by final consumers. One reason for this is that the data requirements are much more substantial, encompassing information on both firms and individuals. A second reason is the complexity of the effects involved, and the absence of any simple rules of thumb for assessing which are likely to be of greatest importance.

If higher prices for industrial inputs are passed on to consumers in the form of higher prices for industrial outputs, there will be distributional effects given by the pattern of consumer spending, and the price changes for different industrial outputs. However, there may be various other distributional effects. If consumer demand switches away energy intensive goods and services, this may affect the profits of firms producing energy-intensive goods, and thus the incomes of their owners, and the wages and employment prospects of their employees. Depending on the complementarity or substitutability of different factors in production, effects could be felt on the return to capital and labour even outside the sectors directly affected.

The balance of these various effects on the distributional incidence of environmental taxes on industrial inputs cannot be predicted a priori. Some important considerations affecting the strength
of different effects include the degree of monopoly in factor and product markets, whether international competitors face similar taxes, the degree of substitutability of different factors in production, and the speed of adjustment.

One simple quantification approach, however, which side steps many of the most intractable measurement issues, is to use data on the input-output structure of the economy to calculate the impact of a tax on inputs on the relative prices of different outputs, assuming the tax is fully passed on to consumers, and that no changes takes place to the pattern of inputs used in production. The change in relative prices can then be applied to data on the pattern of consumer spending to assess the distributional impact of the input tax.

These assumptions are strong, and probably only a reasonable approximation in the short-term. Over a longer time period, the assumption of no factor substitution in production is clearly restrictive. However, despite the limitations of the method, it has been used in a number of studies (Common, 1985; Symons, Proops and Gay, 1990) to provide a reasonably straightforward source of information on the first-round distributional effects of environmental taxes on industrial inputs.

**Offsetting policies**

The substantial revenues raised from a carbon tax provide scope for policy measures to offset undesired distributional effects, for example by reducing other taxes. The way in which the additional tax revenue is used will be critical in determining the overall distributional impact of a carbon tax. If the revenue is used in a way which maximises the "double dividend" efficiency gains, it will tend to be used to reduce tax rates. This will confer much greater benefits on better-off households, and the overall distributional impact of the carbon tax will remain regressive. The revenue could, however, be used in a way which returned at least as much, on average, to poorer income groups as they paid in carbon tax, by making a lump-sum return of revenues. Designing an effective lump-sum redistribution mechanism within existing tax and social security systems is complicated (Johnson, McKay and Smith, 1990), but could be approximated through a package involving increases in state pensions, social security benefits and income tax allowances. It is clear, however, that these measures are not those that would be chosen if it was intended to maximise the efficiency gains from reductions in other taxes that the carbon tax would permit. There is thus a clear trade off between efficiency and equity in the use of the revenues, and double dividend efficiency gains can only be achieved by sacrificing the distributional neutrality of the package.

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20 Clearly the assumption of fixed coefficients and no factor substitution allows the carbon tax to have little impact on carbon emissions from production - the only reduction in carbon emissions under these assumptions comes from changes in final consumption spending.

21 It will be noted that some of these measures constitute public expenditure rather than tax measures. We see no difference in principle between increasing public expenditures by increasing the level of social security benefits and increasing "tax expenditures" by raising tax allowances, and the former cannot be avoided if poorer households are to be adequately compensated.
7 Conclusions - the scope for fiscal measures in environmental policy.

Environmental taxes hold out the prospect of more cost-effective pollution control than regulatory policies which are limited by the informational capacity of regulatory authorities. Much of the academic underpinning for this claim is well-established, and the subject of a broad measure of agreement. The previous reluctance of policy makers to contemplate such measures has been the subject of considerable discussion (Hahn, 1989). Buchanan and Tullock (1975) have suggested that some of the political resistance may reflect the interests of existing firms in policy instruments such as regulation which can deter competition from new entrants. However, there are now signs that the political process may at last be starting to explore the scope for practical applications of environmental taxes.

The key issue in formulating fiscal policies towards the environment is the choice between pollution taxes based on measured emission quantities and environmental taxes with an indirect linkage between the tax base and pollution. How far can environmental policy objectives be achieved by restructuring existing taxes, such as indirect taxes on goods and services, and how far will it be necessary to institute new tax mechanisms based on explicit pollution monitoring and control? The issue has been set out in this paper as a tradeoff between the administrative costs involved in "purpose-built" taxes based on emissions, and the risks of inadequate "linkage" between tax base and pollution if "approximations" based on product taxes are employed. One half of this tradeoff has been well explored in the literature; for example, the risk that an environmental tax might make matters worse where polluting and non-polluting technologies cannot be distinguished, and the possible contribution of taxes on related goods in correcting inadequate linkage have been studied in a number of papers. The elements in the administrative cost side of the equation have been rather less well explored. Indeed, since administrative costs would seem to lie at the heart of an explanation for limiting the use to be made of externality taxes, it is surprising that the literature on this is so sparse.

On the empirical side, major strides are being made in quantification of the effects of various possible environmental market mechanisms, with a particular focus on assessing the importance of general equilibrium effects. There is a rich agenda for further work in this area. Besides quantifying the effects of environmental taxes on commodity demands, the pattern of competitiveness and production, prices and exchange rates, the income distribution, etc, empirical general equilibrium models could also be used to assess the effects of raising revenue through efficiency-enhancing taxes on the overall welfare costs of the tax system. More generally, now that policy-makers are beginning to contemplate environmental taxes like the carbon tax which could raise substantial revenues, quantification of the whole range of public finance aspects of environmental taxes will be of increasing relevance. Models which simulate the effects of environmental taxes within a general equilibrium framework, and disaggregated models able to look at the impact on different groups, will both be useful in assessing the scope that environmental taxes would provide for other taxes to be reduced, and what the overall effects would be on the efficiency and equity of the tax system.
Chapter 4

Tax Expenditures and Environmental Regulation
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Tax Expenditures and Environmental Regulation

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1 Introduction

Much of the recent interest amongst policy-makers in European Union countries in the potential for environmental tax reforms has concerned changes to the structure of indirect taxation, through, for example, the introduction of new excises on commodities linked to polluting emissions. This chapter discusses the potential contribution to environmental policy objectives that could be made by a group of tax measures which have been discussed relatively little in the recent literature and in recent policy debates, namely "tax expenditures" in the form of accelerated depreciation or other provisions within the corporate tax system.

In Germany, accelerated depreciation provisions in the income tax law had until the start of 1991 been available for investments in capital equipment with a substantial environmental purpose, including equipment for reducing air pollution, waste water discharges, noise, vibrations and waste. Investments in capital equipment qualified for the accelerated depreciation if the pollution abatement aspect of the investment counted for at least 70 per cent of the value of the investment. On these investments, accelerated depreciation of up to 60 per cent was permitted in the fiscal year when the capital equipment was purchased or constructed, followed by depreciation at the rate of 10 per cent annually thereafter until the investment was fully amortised. This compares with straight-line depreciation rates applied to fixed investments in general of some 10-12 per cent.

Similar provisions for accelerated depreciation on investments in energy efficiency have also recently been abolished in Germany. Until the end of 1991, building alterations intended to reduce energy use or to promote use of renewable energy, including thermal insulation and the installation of environmentally-favourable heating systems such as district heating, heat pumps and systems using solar and wind energy, qualified for accelerated depreciation on purchase or construction costs of up to 10 per cent in the first fiscal year, and each of the subsequent nine years.

A number of other European Union countries operate similar systems of investment incentives for categories of pollution control expenditure; a recent OECD study found that the corporate tax systems of 14 OECD countries contained some form of provision for accelerated depreciation on environmental investments or other tax expenditures on environmental or energy conservation investments (OECD, 1993). The UK, however, does not have such measures, despite its past extensive experience of using more general systems of investment incentives. More generally, such measures run counter to much of the general policy trend in corporate taxation, which is to aim for a broadly neutral tax system, without special incentives favouring particular activities or investments.

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1 In 1985 the provisions were applied to investments to a total value of some DM 3,800 million, and it was estimated that in that year the accelerated depreciation provision reduced public revenues by some 480 million (Rodi, 1993). Aggregate corporate profits tax revenues in 1985 were DM 42,500 million.

2 The provisions were estimated to involve an annual revenue loss of some DM 500 billion.
4. Tax Expenditures

This chapter considers the issues raised by environmental tax expenditures in the form of corporate
tax incentives for pollution abatement investments, such as those operated until recently by
Germany. It begins by considering the case, in principle, for the complementary use of taxes and
tax incentives to increase the responsiveness of polluters to pollution abatement incentives. It then
sets out the various forms which environmental tax expenditures could take. It then considers the
impact of investment incentives on different types of pollution control decision, and reviews the
arguments for and against the use of such measures, focussing on their potential effectiveness
as an environmental policy measure, issues of administration and enforcement, on budgetary
policy aspects, and on their compatibility with international agreements on pollution policy
-especially with the "Polluter Pays Principle". A final section draws some brief conclusions.

2 The efficiency of investment incentives in a second-best context.

A first-best environmental policy would have no role for subsidy measures. It would employ market
mechanisms in the form of taxes - specifically, in the form of emissions taxes directly related to
the pollution damage caused by marginal emissions. As discussed in Chapter 3, environmental
taxes would normally be preferable to policy measures based on subsidy, which may lead to
inefficient abatement expenditures, and inefficient entry and exit decisions: in some cases, subsidy
may increase rather than reduce aggregate pollution.

In considering how the existing fiscal system might be modified to introduce or strengthen
environmental incentives, it will generally be more efficient to focus on indirect taxes as proxies
for emissions taxes, than on direct tax adjustments - tax incentives - as proxies for abatement
subsidies.

However, this preference for environmental taxes over environmental subsidies relies strongly on
the feasibility, both from an administrative and from a political standpoint, of the first-best policy.
There are good reasons to suspect that first-best policies, relying solely on taxing polluters in
proportion to pollution damage, may not always prove feasible. In some cases, the level of taxes
required will be very high. Powerful polluter lobbies may resist being required to pay for what they
had previously regarded as an implicit property right to a given level of emissions. Governments
may be unwilling to accept the shift in international competitiveness that could arise when high
environmental taxes are levied on industrial processes. Social and distributional considerations,
too, may require moderation in the taxation of polluting necessities - such as domestic energy,

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3 It is important to define in what sense the term "first best" is being used, if the term is not to become tautological or
meaningless. In the discussion in this chapter, the "first best" policy should be understood to reflect maximisation of a
government objective function in which aggregate economic welfare (including appropriate valuation of environmental
effects) is the sole argument, and in which no account is taken of the costs of administering and enforcing taxes and
other policy instruments; in this context, distributional considerations, and considerations relating to the cost or feasibility
of administration, are seen as constraints on attainment of the "first best" policy. It would, instead, be possible to define
the initial policy problem in such a way that these constraints were reflected in the specification of the objective function.
In relation to such a modified objective function, of course, the various "second best" policy prescriptions discussed in
this chapter would emerge directly in the solution to the policy optimisation problem. Using the former terminology here
is simply intended to highlight the way in which the policy conclusions of the present chapter differ from those of
discussions in which such practical constraints on the use of environmental taxes are ignored.
perhaps. And, in some cases, the levels of taxation required may in practice be unenforceable, or may provide undesirably-high incentives for evasion. All of these arguments may suggest that it may not be possible to set pollution taxes at a level as high as the first-best policy would require.

If policy is constrained to less than the first-best level of taxes, other policy instruments, which would be unnecessary in the first best, or which would be dominated by better instruments in the first best, may become more attractive. In particular, if emissions taxes have to be set below the optimal level, policy instruments which can increase the environmental effects of a given level of emissions taxation (in other words, which can increase the elasticity of polluter responses to emissions taxes) may be an important adjunct to policy based on taxation of emissions or emissions proxies.

Subsidies for investment in pollution control equipment and facilities may have the effect of increasing elasticities in this way. As with more general investment subsidies, subsidies for pollution control investments can be paid either directly as explicit subsidies, or indirectly in the form of tax reductions to investing firms. The issues raised by such tax incentives include some common to pollution abatement subsidy more generally, and others specific to the case of pollution abatement subsidies paid through the tax system.

In the next section we begin by setting out the various possible forms that investment incentives in the direct tax system could take. Then, in subsequent sections, we assess the potential for beneficial use of such instruments under the following headings:

- potential effectiveness - for what types of environmental investments might tax incentives provide an effective stimulus to polluters to undertake greater levels of abatement investment?
- implementation - problems of identifying qualifying investments, and other practical and administrative issues.
- transparency - how far does the relatively concealed nature of subsidies paid through the tax system undermine efficiency and accountability in public decision-making?
- compatibility with the PPP - are incentives for pollution-control investments paid through the direct tax system compatible with international agreements on the form of pollution control policies, such as the "Polluter Pays Principle?"

3 Types of tax incentive

Tax incentives for investment can take a number of forms, but may be divided into two broad categories, those (such as various forms of accelerated depreciation) that operate by postponing tax payments, thus reducing the discounted net present value of tax payments, and those (such as investment tax credits) that reduce the undiscounted total of tax payments.
4. Tax Expenditures

- **Tax postponement incentives.** Most investment is in assets which decline in value over time. Both accounting and fiscal definitions of profits generally take into account this depreciation in the value of assets, and reduce reported or taxable profits by an estimate of the amount by which the value of the investment has deteriorated during the course of each year. In a system with stable prices for investment goods, the sum of these depreciation amounts over the lifetime of the project would equal the amount which is required to replace the asset. Within the context of a tax on profits, a neutral depreciation system would provide depreciation for tax purposes corresponding as closely as possible to economic depreciation. In principle, therefore, it should reflect unanticipated economic or technological obsolescence as well as the gradual process of physical deterioration of assets. However, accurate measurement of economic depreciation is technically and administratively difficult, and an attempt to use an estimate of genuine economic depreciation for tax purposes would involve the tax administration in a large amount of arbitrary judgement and negotiation, in a situation where the taxpayer has access to considerably better information than the revenue authorities. Most countries therefore utilise some form of standardised depreciation rule for tax purposes.

Accelerated depreciation allowances permit depreciation to take place at a faster rate, or over a shorter period, than would normally be permitted by the tax authorities. This increases the net present value of the depreciation provisions and should, in theory at least, encourage a greater level of investment.

The benefit conferred by accelerated depreciation arises through the change in the timing of the tax payment, rather than its undiscounted amount; its value to the firm is the value of postponement of the tax liability.

A similar tax postponement effect is achieved by incentives which take the form of partial or full expensing (partial or full cost write-off) of assets purchased for pollution control. These arrangements allow a proportion of the cost of the investment to be treated as a current business expense, and therefore deducted from profits in the year of the expenditure, rather than spread out over the full economic life of the investment, as would normally be the case with investment expenditures. The remainder of the cost of the investment is treated as an investment expenditure and may be depreciated normally. As with accelerated depreciation, the value of the incentive to the investing firm arises from the postponement of tax liability, and hence from a reduction in its discounted net present value.

It should be noted that most forms of accelerated depreciation confer greater benefits on long-lived assets than on assets with a shorter lifetime; the longer the lifetime of the asset, the longer, in general will be the period over which the tax can be deferred, and hence the greater the net present value of the tax deferral. Accelerated depreciation arrangements will thus tend to have a non-neutral impact on the choice of pollution control method, biasing investor choices in the direction of long-lived pollution control investments. Systems based on immediate expensing of the full investment value, however, have a neutral impact on the ranking of projects. A neutral impact will also be achieved if partial expensing is used, so long as the remainder of the value of the investment is depreciated in line with economic depreciation.
• **Undiscounted Tax Reduction Incentives.** In contrast to accelerated depreciation, a system of tax credits actually reduces the total undiscounted amount of tax paid by the investing firm over the lifetime of the project. Under a tax credit system of investment incentives, a proportion of the cost of the investment can be deducted from the tax liability. The asset, however, continues to be depreciated normally.

The potential distortionary impact of these types of tax reduction incentives on investment choice is in the opposite direction to that of accelerated depreciation systems, in that they tend to favour shorter-lived assets (since the incentive can be claimed more frequently).

• **Provisions for firms with excess tax preferences.** Since accelerated depreciation and tax credits will only be of use to firms if they are making profits (and hence liable to pay profits taxes), incentives in these forms will confer no benefit on firms which are not making profits. If this limitation on the scope of the incentive is undesired, it may be possible to overcome the problem by making unused tax incentives refundable, or, more commonly, by allowing unused tax incentives to be carried backwards or forwards to offset taxes payable in subsequent years. This allows new firms, and others with a low level of profits relative to their investment costs, to derive at least some benefit from the tax incentives provided through the corporate tax system, although the net present value of an allowance which is carried forward at its nominal value will generally be lower than it is to firms which are able to make immediate use of the allowance.

4 Effectiveness - the potential impact of tax incentives on pollution abatement investment decisions

The impact of investment incentives for pollution abatement measures provided in the form of accelerated depreciation or other tax expenditures will depend, firstly, on the underlying reason why inadequate investment is undertaken in the first place, and secondly on the nature of the pollution abatement technology choices which the polluter faces. In the case of environmental policies, broadly conceived, there may be two different reasons for concern about the level of investments. Investments may not be undertaken either because the returns to the Investment take the form of reductions in pollution or other social costs which are under-priced by the market, or because various forms of market failure prevent efficient, privately-profitable investments with beneficial environmental effects from being undertaken.

4.1 Under-priced returns to investment.

The first reason for under-investment in pollution control measures is simply that certain socially-desirable investments may not be undertaken because the potential returns to the investment are unpriced, or undervalued, by the market. Thus, for example, polluters may fail to invest enough in pollution-control equipment because they are not charged for the use they are making of the assimilative capacity of the environment. As discussed in Chapter 3, a first-best policy would be to levy taxes on the firm's pollution reflecting the social costs that it causes.
4. Tax Expenditures

The first-best policy, based on emissions taxation, would encourage greater investment in abatement facilities (such as chimneys, filters and effluent treatment plants) where this was the most efficient method of pollution abatement. However, the emissions tax would also ensure an efficient balance between abatement investment and other methods of abatement (such as switching to a production process less liable to generate pollution, or reducing pollution by using less-polluting inputs, or simply reducing demand for industry output through increased product prices, etc), so that these other abatement techniques would be used where they were more cost-effective than investment in abatement facilities.

In considering the range of ways in which the impact of investment incentives for pollution abatement measures provided in the form of accelerated depreciation or other tax expenditures may interact with pollution and production technologies and costs, three broad cases may be distinguished.

1. "Add-on", with no private benefit. Pollution abatement equipment which can be added on to existing production processes, to reduce the level of emissions, without otherwise affecting production outputs or costs. Examples might include emission filters, in cases where the materials recovered have no commercial value. This type of environmental investment has social value alone; it has no potential private value, whatever the cost of the investment.

It should be noted that in these cases, the failure to price the returns to pollution control investments means that subsidies provided for pollution control investments will be wholly ineffective in encouraging any more investments to take place (Kneese and Bower, 1968). Where the investment has zero private benefit, the net present value in private terms of the investment will be negative, and a profit-maximising firm would not undertake the investment. Even if the cost of the investment is reduced by some proportion through an investment incentive, the net present value will remain negative, and the project will still not be worth undertaking. In cases of this sort, where pollution abatement is wholly separable from production technology decisions, and has no impact on the commercial returns from an investment, subsidies for pollution abatement investments will be pointless. However, this is in some respects an extreme and limited example, where the technology for pollution abatement interacts with production costs and production technologies in a particular way. There are other circumstances where the stark conclusion of this argument will not apply. The argument does not apply, moreover, to cases where emissions taxes and investment incentives for pollution control are used in combination, since the emissions tax has the effect of providing the polluter with private incentives to take the social benefit of abatement into account; these cases are then similar to the next group to be considered.

2. "Add-on", with some private benefit. Pollution abatement equipment which can be added on to existing production processes, and which confers some partial private benefit in addition to the social benefit of reduced pollution. An example would be the case of an emissions filter which recovered materials with some commercial value. If the value of the recovered material is sufficiently high, the filter might be justifiable on grounds of the private benefits alone; the cases where public policy intervention would be desirable are where the private benefits are less than the cost of installation, but where the private and social benefits taken together would be sufficient to justify the cost of installation. The level of installation can be affected by changing the balance between
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the installation costs and the private benefit; the amount of installation can be increased either by reducing the installation costs, or by increasing the scale of the private benefit (for example by raising the price of recovered materials).

This category includes those cases where abatement investment subsidies are used in conjunction with an emissions tax; the emissions tax provides the potential investor in abatement facilities with some privately-appropriable benefits from the abatement investment.

3. "Integrated technology choices". Investments in which the pollution consequences cannot be separated from other elements in the technology choice. Investors face a range of possible technologies, each of which may have different private and social (environmental) costs and benefits; the combination of production and pollution characteristics involved in each technology option cannot be "unbundled" by the investor into two components, one of which comprises the production technology, and the other the pollution control component.

As in the previous case, investment subsidies, including accelerated depreciation or other tax incentives, would be liable to increase the level of investment in environmentally-beneficial technologies. However, important practical issues will arise in calculating the level of environmental investment subsidy that should be given in these cases where pollution abatement decisions are integrated with other aspects of the choice of production technology; it is not possible to identify a specifically "environmental" part of the total investment cost on which the environmental incentive can be given.

The distinction which has been drawn above between pollution abatement decisions which are separable from other decisions about pollution technology ("add-on" abatement measures), and those which are integrated with other aspects of production technology choices is closely related to a basic difference in pollution control philosophy, between approaches which are based on the neutralisation of pollution problems generated during production, and approaches based on the application of "clean technologies".

Add-on technologies are those where the production process essentially remains unchanged but the pollutants produced during the course of the production process are converted into less harmful substances by the addition of an extra piece of equipment. Environmental policy measures take the form of neutralisation of potential pollution generated during production, but do not otherwise impact on production technology decisions. For clean technologies however, the waste is transformed into a substance which can be re-used in the production process or, alternatively the waste is not produced at all.

There may in practice be a number of reasons to prefer pollution-control policies based on clean technologies to those based on add-on technologies. Clean technologies may, for example, reduce the risk of accidental pollution, and minimise the incentive for deliberate non-compliance by "rogue" operators. They may also involve energy conservation and savings in raw materials. In the long run it may be desirable for pollution control policies to encourage abatement through the choice of clean technologies, rather than through effluent treatment and other add-on abatement measures. However, in the short term, policy will also need to encourage add-on measures by
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firms which are using existing technologies where add on measures constitute the only feasible approach to pollution abatement. There may also be reasons for caution in the premature encouragement of clean technologies, since these often tend to be newer innovations and may therefore have a substantially greater degree of risk associated with them, which firms would have to bear.

The implication of the above is that it will generally be desirable for any system of investment incentives to be designed in a way which is applicable to all forms of abatement which polluters may wish to undertake. It may not always be appropriate for policy to be wholly neutral in its impact on the choice between different forms of abatement investment (over the long run, for example, policy makers may wish to encourage the use of clean technologies, and hence abatement investments of type 3, whilst over the shorter run providing some encouragement to type 2 measures). Nonetheless, to the extent that policy is not neutral between different abatement investments, this should generally be the result of conscious decision, rather than the accidental outcome of the rules by which entitlement to the incentive is operated.

4.2 Market failures.

A second possible reason for under-investment in pollution control facilities may be the existence of various forms of market failure or "barriers" to investment. These problems may exist in conjunction with problems of the first sort; alternatively, there may be some classes of environmental problem where such barriers may constitute all, or nearly all, of the reason underlying the lack of investment. In the latter cases, firms which undertake the investment may reap private benefits (in terms perhaps of savings in energy or other raw materials costs) which would be more than sufficient to warrant the investment on conventional decision-making criteria; nonetheless insufficient investment may be undertaken by these firms.

One explanation for why profit-maximizing firms may fail to undertake investments which would increase their profits may be the existence of various types of market failure, apart from externalities, such as informational failures, difficulties in appropriation, and capital market imperfections. There has been considerable research interest in the possibility that such market failures may prevent firms undertaking investments in insulation and other energy efficiency measures (Velthuijsen, 1993)⁴, but in principle such market failures could prove a barrier to efficient levels of investment of any sort. The more that the tax system is used to charge polluters for their level of emissions, the more attention may need to focus on whether polluters are responding efficiently to this incentive to reduce emissions.

• informational market failures. For relatively new technologies, it may be that firms are not fully aware that the technology exists or of the extent to which cost savings may arise were they to install it. Alternatively, new types of environmentally beneficial technology may be perceived to be more risky because there is less certainty concerning their reliability.

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⁴ Policy has also been concerned with possible market failures in domestic energy efficiency, for very similar reasons to those discussed here. See, for example, Brechling, Helm and Smith (1991) and Chapter 8.
4. Tax Expenditures

• **capital market imperfections.** If capital markets were perfect, then there should be no reason why firms should not be able to borrow from the capital markets to finance any project with a positive net present value at the market interest rate. In reality, firms may face interest rates significantly higher than the market rate, or may face other forms of capital rationing.

• **difficulties in appropriation.** Firms which undertake energy efficiency or pollution abatement investments may not be sure that they will be able to appropriate all of the gains. For example, investors may believe that not all of the value of the investment would be reflected in a higher price in a subsequent sale of the premises, equipment or facilities concerned. Similarly, in the case of firms occupying rented premises, they may be reluctant to invest because they may not be able to recover the full value of the investment if they subsequently move premises.

• **regulatory obstacles.** The structure of regulatory policies may influence the level or pattern of investment in undesirable directions. The traditional approach to environmental policy, particularly in the UK, has often emphasised using the 'best available technology not entailing excessive cost' (BATNEEC) approach to production decisions, and maximum controls on the level of effluents discharged. Implicit in the concept of BATNEEC, however, is the adoption of existing technology that has a proven track record even though this may not stimulate the adoption of new more energy-efficient or less polluting capital. Polluters may also believe that under-investment in less polluting equipment reduces the risk of regulations being tightened up, through a 'ratchet effect' on environmental standards.

• **inappropriate decision rules.** There is evidence to suggest that private sector investments may sometimes be made using inappropriate decision rules (Warren, 1987). Firms may use an excessively-high discount rate when calculating the net present value of an investment, or may base decisions on an inefficient rule such as the "payback period". They may do this for a number of reasons, including, perhaps, risk aversion on the part of managers, or "short-termism" on the part of certain categories of investors, encouraging over-emphasis on the achievement of high returns over a short period.

• **internal decision-making structure.** The internal organisation of firms needs to focus informational flows and decision-makers' efforts on those decisions which are of most significance for the firm. Many firms are currently organised in a way which separates pollution decisions from information about the taxes the firm pays, reflecting the current very limited value in integrating these aspects of business decision-making. For either pollution taxes or tax incentives to have an effect on pollution and abatement decisions, it is necessary that changes in internal information flows and in decision-making procedures are made which bring together technology decisions and tax information. These changes will not be warranted where the tax payments or incentives are small. However, even where the potential gains to the firm from integrating tax and pollution technology decisions are large, rigidity in the firm's organisational structure may mean that they continue to be overlooked.
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Where investment decisions are affected by the presence of certain market failures, the obvious policy response would be to try and correct the market failure. However, if this is not possible, there may be some justification for having tax incentives or other conditional subsidies to induce a greater level of investment as a second-best policy, or alternatively to use tax incentives as part of a package of measures to correct for some of the consequences of the specific market failures. Nevertheless, the core of the market failures argument is that firms are not responding to existing pricing signals, in the sense that they are failing to undertake apparently profitable investments. It may therefore be reasonable to suspect that increasing the strength of price incentives may only have a limited impact on investment decisions. In some cases it may be sufficient to overcome the market failure obstacles, but in other cases the market failures may continue to prevent efficient investments being undertaken.

5 Implementation issues.

A system of tax incentives for pollution abatement investments would require administrative procedures to assess entitlement to the incentive; the costs of this administrative system would constitute deadweight resource costs of the system, to be set against the potential environmental gains. Using the direct tax system to provide pollution abatement incentives is thus very different to using the indirect tax system to encourage reduced pollution; in the latter case, the modification of an existing tax allows the environmental incentive to make use of an existing administrative system at little extra administrative cost, whilst using the direct tax system to provide incentives for pollution abatement investments may involve significant additional administrative costs. Is there likely to be any administrative saving from using the tax system for administration of subsidy in the form of a tax incentive rather than using a separate administrative system established for the purpose of paying direct subsidy?

Many of the operations needed to assess eligibility for the tax incentive would be very similar to those that would be required if, alternatively, a system of direct subsidy for pollution abatement investments were used. These procedures would need to include an assessment of the investment expenditures against criteria designed to identify pollution-abatement investments from investments with no (or insufficient) pollution abatement function. They would also require procedures to ensure that the investment expenditures had indeed been incurred, and that other formal conditions for subsidy entitlement had been met.

The first group of procedures, to identify the environmental aspects of eligibility for the subsidy, may be more effectively undertaken by government environmental agencies rather than by the fiscal authorities. In the case of a subsidy paid in the form of a tax incentives, the environmental agency would then need to communicate its decision about environmental eligibility to the tax authorities; this need for inter-agency communication might be avoided by a system of direct subsidy.
The second group of procedures could probably be undertaken as efficiently by the fiscal authorities as by environmental agencies. There may, indeed be some possible scope for economies of scale in combining the verification of the formal aspects of entitlement with other fiscal administration. These verification procedures might include checking that firms possess the relevant invoices, receipts and other evidence that the investment expenditure for which the tax expenditure or subsidy is being claimed had in fact been incurred. However, even where these activities can be combined with existing fiscal procedures, there will probably be a countervailing additional cost in terms of the extra complexity of tax administration, and so the possible savings from this source may easily be overstated. There may also be some administrative savings from using the tax system as a mechanism for payment of the incentive, although again these are unlikely to be large.

One key aspect of the administration of subsidies for pollution abatement measures (whether paid through the tax system or directly) is the identification of qualifying expenditures. Where and how should the boundary between pollution-abatement investment expenditures and other expenditures not related to pollution abatement be drawn?

The issue is straightforward only in the first case of the three set out in Section 4.1 - that of "add-on" abatement measures with no private benefit. In this case, the investment in abatement facilities is clearly separable from other investment costs, and all of any expenditure clearly would qualify for the incentive. The identification of qualifying investments is less unambiguous in the second case, of "add-on" measures with some private benefit. Here, although the measure can be identified separately from other investments, it is no longer clear that its sole purpose is pollution abatement; if the private benefit were sufficient, the measure would be undertaken anyway, without subsidy. In this case, policy faces a choice between accepting that a proportion of the investments subsidised would have been undertaken anyway for commercial reasons, and introducing rules designed to identify only those pollution abatement measures which would not otherwise have been undertaken. Such rules to identify cases of "additionality" from the subsidy will be complex, and will require - in principle - substantial amounts of information of a type not readily available to public agencies, such as information on the private profitability of the investment in the absence of subsidy. The administrative problems in assessing eligibility are still greater in the third case, of investments in production technologies which have pollution and other consequences which cannot be separated. Here there may be no correct answer at all to the question of the amount of the investment which is attributable to pollution abatement; the pollution abatement is simply one consequence inseparable from the other effects of the technology which has been chosen. It may, perhaps, be possible to proceed by trying to devise some more or less rough-and-ready rules to judge how much subsidy to pay to integrated technology choices of this sort, but these are almost certain to be imprecise, given that they are attempting to separate something which cannot, in principle, be separated within the investment total.

The problem posed by the existence of abatement investments of the third type goes further than simply the costs of trying to devise a workable scheme for treating such investments. The tax treatment applied to investments of one type will affect the balance of incentives for choosing between the various possible abatement measures available to investors; an over-generous resolution of the problem of treating investments of the third type would tip the balance of incentives
in favour of investments of that type in preference to pollution-abatement investments of other forms. As discussed in Section 4.1, an efficient pattern of pollution abatement may require that different polluters choose different abatement methods, depending on their circumstances. Efficiency requires that the tax incentives should not encourage inappropriate methods to be chosen; other things (especially the environmental impact) being equal, the tax incentive should generally be neutral between different abatement methods. Where it is not possible to identify precisely the pollution abatement component of particular investments, this neutrality may be enormously difficult to achieve.

Even-handed tax treatment of a number of possible pollution abatement investments may be difficult to achieve, if in some cases they are of types 1 or 2 and in other cases they are of type 3. In the former case it may be possible to limit the size of the subsidy to the value of the add-on pollution abatement component only; however, in the latter case, the subsidy could, with almost equal justification, be paid on the whole investment, on none of it, or on some arbitrarily-chosen fraction.

How large is it likely that the response would be, in terms of additional abatement investment, to a given level of investment incentive, offered in the form of accelerated depreciation for specified categories of pollution abatement investments? Existing empirical evidence relating to the effect of general investment incentives on the level of investment provides ambiguous evidence as to whether tax incentives induce greater levels of investment. Certainly the empirical work in the late 1960s and early 1970s (Hall and Jorgensen, 1967; Feldstein and Flemming, 1971) concluded that fiscal incentives in the direct tax system could influence both the level and the location of investments. Subsequent studies have a wide dispersion in results, and provide no clear empirical consensus (Chirinko, 1989). It appears that temporary incentives may have rather larger effects on investment than permanent incentives at the same level, because they may induce changes in the timing of investments as well as in the investment level. For example, the very large, and temporary, incentive which arose during the reform of the UK corporate tax system in 1984 appears to have had an appreciable impact on investment levels during the 1980s (Bond, Denny and Devereux, 1992).

The relevance of evidence about the effectiveness of general investment incentives to the particular case of pollution-abatement incentives may be slight. The size of the response to environmental investment incentives depends on what are the obstacles impeding higher levels of such investment. Market failures may not be easily corrected by fiscal measures, since one aspect of market failure in this area may be poor responsiveness of potential investors to price signals.

6 Transparency

The various tax incentives discussed in this chapter involve a reduction in taxes that would otherwise have been paid, conditional on firms undertaking certain specified investment measures. There is a close budgetary and economic similarity between such indirect ways of making payments to the private sector, and payment of a direct cash subsidy. This similarity is frequently emphasised by
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referring to the use of the tax system to deliver indirect subsidies as involving "tax expenditures" - reductions in taxes that would otherwise be paid. Tax expenditures may, however, have certain significant differences when compared to direct subsidy, especially concerning the quantification of the size of the incentives provided, and the "transparency" of the public decision-making process.

Precise definition of what constitutes a tax expenditure, and hence measurement of the scale of the incentive and implicit expenditure, is rather less straightforward than the intuition behind the general concept (OECD, 1984). Tax expenditures have to be defined in terms of a reduction in taxes that would otherwise have been paid. The concept thus requires some notion of a baseline tax system, without tax expenditures, against which yardstick the scale of tax expenditures can be measured. Unfortunately, it is difficult to reach a widely-agreed definition of what constitutes the baseline system. Within the corporate tax system, for example, should the baseline be assumed to be a classical system, an imputation system, or some other? Depending on what answers are given to this question, very different estimates may result for the level of tax expenditures, calculated as departures from the chosen baseline.

In comparison with direct subsidy, tax expenditures are considerably less transparent within the public budgetary system. This may have a number of implications. First, the scale and extent of tax expenditures is often unknown. Although some countries publish estimates of the scale of tax expenditures alongside their public budgetary estimates, these are subject to all of the above methodological and conceptual difficulties. Whilst use of the "tax expenditure" terminology may help to emphasise the nature of these provisions, the concept is nonetheless less clear and likely to be less well understood by decision-makers and the general public. Public decisions to make expenditures in the form of tax expenditures may be easier to make, given that the expenditure may be poorly-documented, or to some extent concealed. Generally, good practice with respect to public decision-making would frown on the deliberate choice of untransparent instruments to ease legislators' acceptance of a particular measure.

Secondly, decision-making processes with regard to decisions about tax expenditures may differ from those which have to be followed for direct subsidies; they may be more rigorous, or less, depending on the precise institutional arrangements. One aspect which will frequently be relevant is that total outlays in the form of tax expenditures will generally be less effectively controlled than expenditures on direct subsidy. Expenditures taking the form of direct subsidy can be cash-limited, or restricted in other ways to the total amounts specified in budgetary decisions. Outlays on tax expenditures will normally be the endogenous outcome of the rates and provisions of the tax system, and of the decisions by private sector agents to behave in ways which make them entitled to benefit from the tax expenditure. Depending on decisions taken elsewhere in the tax system, it may be possible that the value of subsidy paid in the form of tax expenditures could escalate rapidly, without any explicit budgetary decision being taken.

Third, tax expenditures may have different implications for the level and targeting of financial support or financial incentives compared to direct subsidy. The level of subsidy provided through a tax expenditure system will often depend on the tax position of the recipient; different taxpayers, for example, could receive different benefits if they would otherwise be liable to pay tax at different
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rates. Non-taxpayers will generally receive no benefit from tax expenditures. A particular category of non-taxpayers which is important in the present context are companies paying no tax, either because they are making losses, or because they are entitled to receive tax expenditures which in total exceed the tax they would have paid in the baseline system.

7 Compatibility with the Polluter Pays Principle.

It has long been recognised that environmental policies in individual countries may raise issues of wider, international, concern. The existence of cross-country environmental spillovers, for example through flows of atmospheric pollution across national frontiers, means that environmental policy measures adopted in one country have significant external environmental effects in other countries, which may not be adequately reflected in national policy decisions. International discussion and coordination has become an important dimension of the formulation of environmental policy in a number of areas where environmental spillovers are significant, especially policies relating to the global atmosphere, to acid rain, to pollution of certain rivers and seas, transport of dangerous materials, and regulation of economic pressures on endangered species.

In addition to these environmental spillovers, international policy discussions have also been concerned about possible international economic consequences of environmental policies adopted in individual countries. The extent to which the cross-country economic consequences of national environmental policies should be regulated through international agreements is much more contentious than the case for coordination based on environmental spillovers. It has been observed that the economic consequences of environmental policies constitute a "price" that individual countries bear for environmental policy measures, and that willingness to bear that price will vary between countries. Some of the economic effects of environmental policy, especially those relating to the displacement of productive activities from countries implementing stringent environmental regulation to countries with less restrictive policies, simply reflect a mutually-beneficial trade between countries with different relative preferences for environmental quality and higher income. Requiring countries with low environmental standards to increase their standards of environmental protection to prevent this displacement will require these countries to bear the costs of a level of environmental protection higher than they would wish, and may also increase the cost of achieving a given level of environmental quality in the country with high standards of protection, by preventing it making use of international displacement of polluting activities, where this is the least-cost way of reducing its pollution.

Whilst this argument may suggest that there is little need for regulating the international economic effects of national environmental policies, there are in fact a number of other aspects of the economic effects of environmental policies which may be important, and which have been the subject of international coordination and regulation. There are, in particular, a number of ways in which national environmental policies may be seen as giving scope for protectionist policies to be adopted by individual countries in the guise of environmental measures.
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One, which has been important in the EC context, is the possible use of national standards, regulations and tax provisions to discriminate, indirectly, between national producers and their foreign competitors. In the field of environmental taxation, the European Commission has been concerned that national tax provisions in individual member states to encourage use of returnable bottles, or to encourage the sale of motor vehicles fitted with catalytic converters, could be designed to give domestic producers a competitive advantage over producers from other member states. Similar problems could be envisaged with direct tax incentives for pollution abatement investments. There is a risk that individual countries could draw up the list of qualifying investments so as to include the products of national suppliers of abatement technologies, and to exclude the abatement technologies sold by their foreign competitors.

A second possible use of national environmental policies as disguised trade protection is the possibility that subsidies for environmental protection could be provided at higher levels than warranted by environmental considerations, thus providing a subsidy to domestic production more generally. International agreements on trade policy largely prohibit the use of government subsidies in trade policy. However, one problem in implementing these agreements is in distinguishing subsidies provided for reasons of trade protection from subsidies paid for other, more legitimate, purposes. Given the asymmetry of information (especially regarding the administrative application of national policies) between the country concerned and its competitors or international monitoring agencies, distinguishing legitimate from illegitimate subsidy will always be difficult.

For this reason, the countries of the OECD agreed in 1974 to implement the Polluter Pays Principle (PPP) in environmental policy. This rule requires that polluters should "bear the costs of carrying out pollution prevention and control measures mandated by government" (OECD, 1974). The precise interpretation of this rule has been extensively debated, and in recent years the interpretation of the PPP has increasingly been seen to provide positive support for the implementation of environmental taxes and other market mechanisms. Nevertheless, its primary purpose remains in regulating the possible economic conflicts that may arise as a result of the environmental policy measures implemented by OECD members, by placing severe limitations on the use of subsidy measures in environmental policy. A rule of this form - outright prohibition - has the attraction that it is more likely to be verifiable (and, hence, credible) than a rule which draws a distinction between legitimate and illegitimate grounds for subsidy.

The argument in this chapter has suggested that there may, in principle, be a legitimate role for subsidy measures of certain types in environmental policy, where, for a range of possible reasons, "first best" policies based on emissions taxes at the optimal level prove infeasible. Policy packages of the sort advocated in this chapter, in which taxes and tax expenditures are combined to enhance the incentive effects achievable through (constrained) taxes alone, are to some extent a departure from the spirit of the PPP. The significance of this conflict with the PPP should not be downplayed, and may be an important reason for cautious implementation of measures of the sort advocated here, and adequate international monitoring and control of their operation. The PPP plays an

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5 To date, tax incentives for abatement measures have generally been on a modest scale, and have been seen as little threat to the no-subsidy principle which the PPP seeks to maintain.
important role in preserving the credibility of trade policy institutions, and policy changes which might undermine the clarity of the PPP may have wider economic costs which should be taken into account.

8 Conclusions.

A “first best” environmental policy, able to set pollution taxes at a level equal to the marginal social damage of pollution, would have no role for environmental tax expenditures, such as accelerated depreciation on environmentally-beneficial investments. Such measures would suffer from the general deficiency of subsidy in pollution control, which is that they may fail to lead to the optimal level of rationalisation in polluting industries; pollution-abatement subsidies maintain the profits of polluting firms at a higher level than pollution taxes, and thus tend to encourage an excessive number of firms to remain in the industry. The first-best policy may, on the other hand, be one in which the number of firms in polluting industries is reduced; exit, or bankruptcy, may be one of the processes through which the first-best policy has its desired effect.

There may, however, be difficulties with pursuing a first-best environmental policy of this form. One, of course, is that political constraints (arising, perhaps, from the lobbying power of polluting firms) may prevent governments using policy instruments which lead to significant exit. Another may be a constraint on the level of environmental taxes which may be set. For a variety of reasons, governments may be constrained to set pollution taxes at less than the first-best level. In this context, it is possible to develop a theoretical rationale for the use of pollution abatement investment subsidies, as a possible complement to pollution abatement incentives based on modest, constrained, environmental taxes.

The point of such a combined use of instruments is that the investment subsidies may play a role in increasing the elasticity of response to the limited environmental tax. Since the tax cannot be set at the first-best level, the combination of investment subsidy plus tax may induce greater change in polluting behaviour than could be achieved through the use of the tax alone. (Also, of course, it is possible that the payment of the subsidy could relax the constraint on the level of the tax, although this is not necessary for the argument).

A theoretical case for the use of environmental tax expenditures, in the form of investment incentives for pollution-reducing investments, can thus be made. How cost-effective, in practice, would such a policy be likely to be?

The environmental impact will partly depend on the nature of the pollution control technologies which are available. Where these take the form of "pure" technologies, in which the investment is added to existing production processes, and confers no benefit other than the social benefit of pollution reduction, subsidising part of the cost would not be likely to have any impact on firms' decisions. There are, however, a further group of pollution control investments which reduce private costs or confer private gains, perhaps in the form of materials recovery. Subsidy might, in principle, be effective in increasing the level of such investments; it could be paid either directly, or indirectly in the form of tax incentives for pollution abatement investments. In addition, a combined package,
involving both subsidy and emissions taxation, could be effective, even where subsidy alone would fail, since the emissions taxation would provide the firm with a private benefit from reduced emissions.

Evidence from experience with more general investment incentives suggests that the effects might be quite modest. There are major difficulties in the way of empirical investigation of the impact of investment incentives; however, studies of incentives paid through the tax system in the US and the UK during the 1970s and 1980s do not suggest that the effects have been large. Some effect, however, has clearly been found of the very large, and temporary, incentive which arose during the reform of the UK corporate tax system in 1984. Not all of this experience may be relevant to the case of tax incentives for pollution abatement investments: these require closer integration of tax and technology decisions than is usual in existing business practice.

The aspect of experience which gives most reason for caution in the widespread application of environmental investment incentives is the practical difficulty of assessing eligibility for the incentive. The problem is one of policing the boundary between qualifying and ineligible categories of investment. Even with incentives requiring apparently quite simple eligibility criteria to be applied (such as those limited to manufacturing industry, for example), borderline cases have often proved difficult to handle. In the case of environmental incentives, the difficulties of defining what forms of investment should qualify, and of distinguishing between the qualifying and ineligible components of major investment projects would be formidable, and potentially a source of distortion and inefficiency in firms’ pollution abatement technology choices.

Similarly, careful consideration needs to be given before measures which undermine the role of the Polluter Pays principle are adopted. The PPP plays a valuable role in preventing environmental policy measures being subverted into a process of trade-distorting competitive subsidy. On the other hand, we have argued that there may also be strong arguments for greater use of investment subsidies in environmental protection, and that politically-feasible policies which rely on environmental taxes alone are unlikely to maximise the incentive for environmental protection.
Chapter 5

The European Community Carbon Tax Proposal: Some Practical Aspects
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Introduction

In September 1991 the European Commission announced proposals for a Community carbon tax. A written Communication to the Council (Commission, 1991) set out the Commission’s reasons for the proposal, and, in particular, the role which the tax and other, non-fiscal, measures were to play as part of the Community’s contribution to international action to reduce the risks of global warming. The Communication also gave broad details of the tax, although a number of key issues concerning its structure and operation were left unresolved. More detail of the Commission proposal was then provided in the form of a draft Directive, issued in June the following year (Commission, 1992). This draft also made a number of changes of emphasis and detail from the scheme suggested in the earlier Communication, especially concerning the preconditions for its introduction, in terms of international agreement and coordination, and concerning the treatment of energy-intensive sectors of industry.

As noted in Chapter 2, the proposal met with opposition from some member states, and was not implemented. The current focus for discussion concerns a less-ambitious proposal for a Community framework to regulate the forms of carbon tax which might be introduced, as a matter of national policy, in some member states. The issue of coordinated Community-wide introduction at a harmonised rate, which proved a particularly controversial aspect of the initial proposals, is not currently under consideration.

This chapter considers a number of issues prompted by the Commission’s initial proposals, concerning the efficient specification of the carbon tax base. How should the tax be structured, in order to achieve both efficient administration, and efficient environmental responses? It is observed that there are interactions between considerations of environmental efficiency, administrative efficiency, and revenue allocation. These are complicated by the need to accommodate various features of the Commission’s proposals, especially those concerning the treatment of external trade and exempt sectors.

Following this introduction, the paper is in five main sections. The first gives a brief description of relevant details of the Commission’s proposals. The second section introduces two basic options for the specification of the carbon tax base, described as “primary” and “final” carbon tax respectively, and discusses the implications of this choice for the environmental efficiency of the tax. The third section sets out the revenue allocation issues which arise in the choice between primary and final forms for the carbon tax, whilst Section 4 reviews briefly a number of further issues. A final section draws some conclusions about the relative merits of the two approaches.

1. The Commission’s Proposals

The tax proposed by the Commission was to be a combined carbon / energy tax; in other words, a tax levied partly on the carbon content of fossil fuels, and partly on the energy content of all non-renewable forms of energy. Thus, fossil fuels such as gas, coal and oil would bear 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 be subject to the energy-related part of the tax, but would not bear the carbon component. Overall, the two components were to be combined in equal proportions, in the sense that half of the tax on a typical barrel of oil would be related to the carbon component and half to the energy component.

The introduction of the tax was to be phased over a period of seven years, starting in 1993 at an initial level equivalent to $3.00 per barrel of oil, rising in stages to an eventual level of $10.00.

The Commission proposed that the tax should be introduced on a coordinated basis throughout the member states of the Community, but that the revenues from the tax should accrue to the exchequers of member states. It would be for member states to decide what would be done with the revenue - for example, to choose which other taxes might be reduced. However, partly in order to avoid the charge that it was advocating an increase in the overall burden of taxation, the Commission stressed that the tax should be introduced on a revenue-neutral basis - in other words, the revenue should be used to reduce other taxes rather than to increase public spending.

The initial Communication included provision for a number of sectoral exemptions from the carbon tax, which would have exempted from the tax a number of highly energy-intensive sectors, such as the steel and cement industries. The rationale for these exemptions was set out in terms of the effects that a carbon tax could have on the international competitiveness of energy-intensive sectors, and it has been suggested that the subsequent removal of the sectoral exemptions might have been made conditional on the adoption of similar legislation in competitor countries, especially in the United States and Japan.

This part of the proposal was substantially modified by the time the draft Directive was issued in June 1992. In part this reflected a strengthening of the "conditionality" requirement that other OECD countries should introduce similar measures; the draft Directive explicitly required that the EC tax should not be introduced until other OECD countries had brought in a similar tax "or measures having an equivalent financial impact" (Art 1.2). Instead of a general exemption of energy-intensive sectors, it was proposed that special provisions granting temporary tax exemptions and tax reductions and refunds should apply to "firms with a high energy consumption that are seriously disadvantaged on account of an increase in imports from third countries" which had not taken similar measures. In these cases, member states could apply to the Commission for authorisation to grant one of two forms of relief from the tax. Where the firms concerned had total energy costs above 8 per cent of value added, member states could grant a graduated reduction in the carbon tax payable, or an equivalent refund; in other cases a full, but temporary, exemption (or, again, an equivalent refund) could be made, so long as the firms had made "substantial efforts to save energy or to reduce carbon dioxide emissions" (Art. 10).

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1 The requirement that measures should have an equivalent financial impact would presumably be met by a scheme of auctioned tradeable permits; it is not clear that it would be satisfied if other countries achieved similar levels of abatement through regulatory policies, moral suasion, pollution-abatement subsidies, or even "grandfathered" tradeable permits.
5. Carbon Tax: Practical aspects

In addition, the 1992 Directive also provided for the carbon/energy tax to be reduced or refunded, to provide a system of investment incentives for investments which improve the efficient use of energy or which limit carbon dioxide emissions. The refund would be equivalent to the full value of the investments made, and these incentives would not be limited by the amount of carbon tax paid in any period, but could be carried forward, to be offset against future tax. The terms on which the investment incentives would be available (for example, the reference period over which the investments would qualify) would have been determined by the Commission, which would then have provided instructions to member states for their implementation.

2. A "Primary" or "Final" Carbon Tax?

Chapter 3 has discussed the general issues involved in the choice between environmental tax instruments directly related to polluting emissions and those which, instead, are based on an indirect relationship between polluting emissions and some other tax base which is assumed to be linked to the amount of pollution caused. The carbon tax occupies an intermediate position between the two extremes of a tax levied on measured polluting emissions, and the use of existing taxes to provide environmental incentives. On the one hand, the carbon tax is not a tax based on measured emissions, but on a presumed (albeit very close) linkage between carbon content and carbon emissions. On the other hand, however, the proposed carbon tax does not simply reflect a restructuring of the existing tax system. The tax would have similarities with some of the excise duties operated by European Community countries, such as those on mineral oils, and some aspects of the administration of excise duties could be used as a model for the design of an administrative system for carbon taxes. Indeed, it could be appropriate to seek to incorporate the existing excise duty mechanisms for mineral oils into the carbon tax system, although, as described below, this may not always be straightforward. However, certain energy sources such as coal which are currently wholly untaxed would be taxed under the carbon tax proposal, and, at the very least, new administrative apparatus would be required in order to tax these fuels.

The practical details of how the proposed EC carbon/energy tax would be administered are not discussed in detail in Commission (1991), and appear, indeed, to have been the subject of less consideration than other aspects of a carbon tax by academic and other commentators. One exception is the discussion in Cnossen and Vollebergh (1991), who consider the administration of a carbon tax as an extension of the approach adopted for other fuel excises, and who discuss a number of administrative issues, including questions of duty suspension and enforcement, which arise in the case of existing excises. In the European countries (Sweden, Norway, Finland, the Netherlands and Denmark) which have actually introduced carbon taxes these, too, have taken the form of extended systems of fuel excises, levied using the existing administrative mechanisms for excise taxation. Indeed, in some cases the taxes amount to little more than a re-naming of some part of existing fuel excises, coupled with some restructuring of rates. The rates of tax are defined separately for each fuel, in terms of fuel quantities, and the sense in which the taxes constitute carbon taxes is simply that relative tax levels on different fuels are set at a level which equates the implicit rate of tax per unit of carbon across fuels. Even 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, in particular, the extensive provisions for refunding the tax to industrial energy users mean that the full tax rate is effectively levied only on energy use by private households.

The presumption that a carbon tax should naturally be implemented using an extension of the approach employed for existing excise duties on fuels may, however, be questioned. Although this is the approach which has been adopted in the existing carbon tax applications, this chapter will show that at least one other scheme for administration could be contemplated, with significant advantages, in at least some respects, compared to the excise duty route. In particular a contrast is drawn between two possible schemes for implementing a carbon/energy tax of the form advocated by the Commission, one which would follow closely the route adopted in the existing applications, and the other taking a different approach.

To simplify the discussion, the argument is conducted simply in terms of a tax on carbon content alone, in which the amount of tax is related to the carbon content (and, hence, the potential to give rise to carbon dioxide emissions) of each different fuel. Although the Commission was in practice proposing a hybrid carbon-and-energy tax, in which the tax base would be related both to the carbon content and the energy content of fuels, the administrative issues are much the same as those for a pure carbon tax; the description of the tax base is merely a little more cumbersome.

The most difficult decision about the administration of a carbon tax concerns the stage in the production chain at which the tax should be levied. Most fuel products go through a series of stages of production, refining the raw, or “primary”, fuel to produce the fuels which are actually used by industries and households - “final fuel products”. It should be possible to conceive of a carbon tax imposed at various points during this successive process of refinement; the two forms of carbon tax described in this chapter are levied at the beginning and at the end of the process respectively (Figure 1). Thus the two basic types of carbon tax considered are:

(i) a “primary” carbon tax, levied on primary fuel products where they are mined, extracted or imported;

(ii) a “final” carbon tax, levied on final fuel products - in other words, on the fuels sold to industrial users or households.

A primary carbon tax would thus apply to products such as crude oil, coal, and gas. A final carbon tax would apply to the fuel products produced from these primary fuels, such as coke, anthracite, four star petrol, and so on. For the purposes of operating a final carbon tax, it would be possible to consider the electricity industry as either a producer of a final fuel product, electricity, or as a user of final fuel products in an industrial process. The issues involved in levying the carbon tax on the electricity industry are discussed later in this chapter, and are for the moment left on one side.
In both cases, the tax would need to take the form of a specific tax, in other words, a tax related to the quantity of some physical attribute of the taxed product - tonnes of carbon, or joules of energy. An ad valorem structure for the carbon tax would clearly be inappropriate, since some of the cheaper fuels, such as coal, are associated with particularly high carbon emissions.

Figure 1.

"Primary" and "Final" carbon taxes.

At first sight, a carbon tax of the "primary" type would appear to be more straightforward to administer. The range of fuels involved is less, and the number of taxable individuals is much smaller. Generally, the plants involved in mining or extracting primary fuels operate on a very large scale, and the number of producers which need to be controlled and taxed is therefore small. With fewer taxable individuals, administrative costs would be expected to be low, and there would be scope for tight supervision to prevent evasion.
The fact that the tax would be applied at an earlier stage in the production chain would not necessarily imply that it would have different economic effects from an equivalent tax levied on final fuel products. Whilst there is an important economic issue about whether the ultimate burden of the carbon tax would be borne by fuel consumers and the consumers of goods produced using fuels in the course of manufacture, rather than being passed back to the owners of fuel resources, no great difference would be expected in the effects on fuel prices of a primary carbon tax compared with a final carbon tax. To the extent that a carbon tax would be borne by fuel consumers rather than the owners of fuel resources, the burden of a primary carbon tax would generally be passed on in the prices of fuel products according to their carbon content, and the prices of fuels purchased by industry and consumers would be likely to be much the same as if an equivalent final carbon tax had been levied.

The issues under discussion here are thus different from those involved in the literature on the relative merits of energy taxes levied on energy production and levied on energy consumption. In this literature, the choice of tax basis clearly affects the cross-country incidence of the energy tax burden (a production-based tax benefits energy-producing countries at the expense of energy-consuming countries). A further dimension, discussed by Hoel (1994c), is that the choice between the two bases may affect the incentive for countries to free-ride in an international agreement on carbon abatement, and may influence the trade consequences for countries imposing a carbon tax when others do not. In the discussion in this chapter, however, it is assumed throughout that the carbon tax being implemented would be of the consumption type; the primary and final carbon taxes simply reflect two alternative ways of achieving this. A carbon tax of the production type could also be implemented through either route; the main difference would be whether and how the carbon tax would be adjusted on traded energy.

A final carbon tax would be levied on the fuel products sold to final consumers. It would not actually be necessary to levy the tax at the retail level, but merely to identify those wholesale deliveries that were being made to distributors and retailers, rather than for further processing. Broadly, therefore, it would operate at a similar point in the production and distribution chain to the existing excises on mineral oils, and would require similar administrative and enforcement procedures, including close supervision of all fuel extraction, distribution and processing activities up until the point when the tax is levied (see Cnossen and Vollebergh, 1991).

A final carbon tax would require the system to cope with a greater number of fuels and producers than a primary carbon tax, although it would have the offsetting advantage that the existing mineral oil excise system could be used to administer part of the carbon tax. Its principal drawback, however, is that unlike a primary carbon tax, the level of tax that should be applied to a particular fuel cannot be determined simply on the basis of the characteristics of the fuel. During the various stages by which primary fuels are transformed into final fuel products, considerable amounts of energy may be used, with associated emissions of carbon dioxide. Thus, for example, in transforming coal into coke, a process of combustion takes place, resulting in a refined fuel product, containing less carbon and less energy than the original coal, but in a form which can be burned more efficiently in certain industrial and domestic applications. Unless the use of coke is not to be fiscally advantaged, the emissions of carbon dioxide during the process of coke production cannot be
disregarded in calculating the amount of carbon tax that should apply to coke. To do so would encourage the inefficient use of coke over coal in applications where the overall emissions of carbon dioxide, taking into account both the emissions in coke production and from the subsequent burning of coke by final users, actually exceeded the carbon dioxide emissions from the direct use of coal. In effect, unless the carbon emissions during fuel refining were reflected in the taxes applied to final fuel products, there would be an undesirable incentive towards the use of highly-refined fuel products, in which as much as possible of the carbon dioxide emissions have taken place before the tax is applied.

The implication of this, however, is that to calculate the carbon tax to be applied to a final fuel product requires information not only about the actual carbon content of the fuel, but also about the carbon emissions associated with its production. This means that the amount of tax to be applied to a particular final fuel product can no longer be determined simply by reference to its physical characteristics (which would provide a straightforward and uncontroversial basis for administration of the tax) but requires in addition that these measurements be supplemented by assumptions about the carbon emissions associated with its past history.

Unless a final carbon tax is to be applied in a wholly-discretionary manner, based on judgements about each individual case, it will be necessary for the amounts of tax relating to carbon emissions during processing to be based on specified standard amounts, based for example on average emissions (carbon "losses") during processing. Unfortunately, to do this weakens the incentives for economy in carbon emissions during processing, since producers that have emissions during processing which exceed the average are taxed on the basis only of the standard amount.

It also does not deal adequately with the situation where a particular final fuel product can be produced from primary fuels which differ in the amount of processing needed to get to the final fuel product. A given final fuel product would be taxed at the same average rate, regardless of whether it was produced from "near" or "distant" primary fuels. Moreover, it is clear that in such cases the possibility of establishing actual emissions during processing may not even exist; the fuel may have passed through various stages, and the firm producing the final fuel product may not even know the full details of its past history.

The difficulty of defining appropriate rates of tax for final fuel products is enhanced where a process of refining leads to more than one final fuel product. In the case of oil refining, for example, a single input (crude oil) is transformed into a large number of different fuel products (heating oils, petrol, kerosene, etc.), and the process of transformation involves the use of energy, with associated carbon dioxide emissions. How should these emissions be allocated between the various final fuel products, so as to calculate the rate of carbon tax that should apply to each?

All of these arguments amount to a strong case for considering a carbon tax on primary fuels to be much more practicable from the point of view of administration than a carbon tax on final fuel products. Unfortunately, however, the difficulties of defining appropriate carbon tax rates for final fuel products cannot be avoided, even if a carbon tax that is basically of the primary type is adopted. There are two reasons.
First, if (as is assumed throughout this paper) the carbon tax is intended to be levied on European countries’ consumption of energy (rather than European countries’ energy production), it is necessary to arrange for the carbon tax to be levied on imported energy, and to be rebated on energy exports. Because fuels are traded internationally both in the form of final fuel products and in the form of primary fuels, it is necessary to define a set of tax rates for intermediate and final fuel products to be applied when fuels are imported. These tax rates need to reflect both the carbon content of the fuel product, and the carbon emissions involved in its processing, so that the burden of tax on the imported fuel matches the burden of the primary carbon tax passed on to final fuel products.

Second, if a carbon tax is imposed on fuels at the primary stage, the initial allocation of carbon tax revenues between Community member states will not match the pattern of carbon dioxide emissions. If it is intended that the allocation of revenues should match the pattern of emissions, it will be necessary to devise a mechanism to channel revenues to the country of consumption, and this will generally require information on the carbon content of all fuels traded within the Community. The specific issues that this raises are discussed in the next section.

3. Revenue Allocation between Member States

The European Commission’s carbon tax proposals make clear that the revenues from the carbon tax should accrue to member states, rather than to the Community as a whole. The issue thus arises as to how the revenues should be divided up between member states. Although the administration of a carbon tax may be undertaken by the revenue authorities of member states, different types of carbon tax will allocate the revenue between member states in different ways. The allocation of revenues by different types of carbon tax may be a consideration in choosing the type of carbon tax to be operated. Alternatively, it may be worth considering whether it is possible to adjust the pattern of revenues, so that objectives regarding the allocation of revenues can be separated from the choice of taxation system.

Where a carbon tax is levied on primary fuels, the pattern of revenues accruing to member states will reflect the pattern of primary fuel production. If the carbon tax is also applied to fuel imports, the initial allocation of revenues from fuel imports will accrue to the country in the Community where the fuel import takes place. A primary carbon tax would thus tend to make a larger revenue contribution to those member states where coal, oil and gas are mined or extracted, and to member states with ports through which fuels from outside the Community are imported.

On the other hand, a carbon tax imposed on final fuel products would tend to allocate revenues to member states according to the pattern of deliveries of final fuel products to industrial and domestic purchasers. In general, the allocation of revenues between member states will be much closer to the pattern of consumption of carbon-based fuels.
5. Carbon Tax: Practical aspects

A rough estimate of the difference in the pattern of revenues for the proposed European carbon tax at its full $10 per barrel level is given in Table 1, assuming 1990 levels of production and consumption. The first panel of the table allocates revenues between member states according to the country pattern of energy consumption; the second allocates what in principle should be the same revenue total according to the pattern of production and (net) imports of energy.

Overall, the revenues from a $10 per barrel carbon tax levied on 1990 energy consumption would be some 1.2 per cent of EC GDP. With the "final" carbon tax country revenues would range from 0.9 per cent of GDP in Italy and Denmark to 2.8 per cent of GDP in Luxemburg (which has a highly energy-intensive industrial sector). With a "primary" carbon tax, revenues would range from 0.8 per cent in Ireland and Denmark to 3.2 per cent in the Netherlands. The most significant reductions in revenues, compared with the "final" tax, would be in Luxemburg and Belgium where revenues would be roughly halved; in Germany revenues would be lower by about a quarter, equal to nearly ECU 4 billion.

Clearly member states may differ in their interests as regards the choice of one or other revenue allocation. But are there any general considerations which might suggest a revenue allocation based on production or on consumption should be preferred?

One consideration is that the allocation of revenues between member states is likely to be more uneven if based on the pattern of production. Production of primary fuels is concentrated in few member states (UK oil and gas production, Dutch gas production), and a large proportion of the Community's imports of fuel from outside the Community arrive in a few large ports.

A second consideration reflects the incidence of the ultimate burden of the carbon tax. If the effective incidence (the final "destination" of the tax burden) is on the consumers of carbon-based fuels, then a pattern of tax revenues which corresponds to the pattern of consumption will minimise the redistributive impact of the tax between member states; broadly speaking, national governments will receive revenues which will correspond to the additional costs of fuel to their residents. On the other hand, if the carbon tax is incident on fuel producers (or on the owners of carbon-based fuel resources), then an allocation of carbon tax revenues which leads to little redistributive impact between member states may be harder to achieve. It is unlikely that the allocation of revenues resulting from a "primary" carbon tax would have this effect, for two reasons. First, the owners of oil and gas resources will not necessarily be residents of the country where the resources are located. In addition, if the burden of the carbon tax falls on resource owners, the revenues from the carbon tax on imports would accrue to the importing member state without any corresponding burden of final incidence on any Community resident.

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2 The figures also assume that arrangements for duty suspension would apply for imported energy until it reaches its initial EU customer. For example, oil imported through Rotterdam for a German customer counts as a German import only if the oil is traded in the Netherlands would it count as a Dutch import. This assumption is broadly consistent with the basis on which the trade statistics used in calculating Table 1 have been compiled. Without this assumption the divergence between primary and final carbon tax revenues would be much greater.

3 In practice, of course, since the estimates are based on applying the appropriate carbon/energy tax rates to production, consumption and trade data which have not been reconciled to satisfy the identity between production-plus-net-imports and consumption, it is not to be expected that the estimated revenue totals for the EC as a whole would be identical in the two cases. In practice, in the table they are remarkably close, which is largely coincidental.
Table 1
Estimated carbon tax revenues in EC member states, on the basis of 1990 patterns of energy production, consumption and trade.

(a) "Final" carbon tax (revenues allocated according to consumption)

<table>
<thead>
<tr>
<th>Country</th>
<th>Revenues (ECU bn)</th>
<th>as percentage of GDP</th>
<th>as percentage of total tax receipts</th>
<th>as percentage of indirect tax receipts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>14.2</td>
<td>1.2</td>
<td>3.2</td>
<td>11.8</td>
</tr>
<tr>
<td>Spain</td>
<td>4.4</td>
<td>1.1</td>
<td>3.3</td>
<td>11.7</td>
</tr>
<tr>
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<td>1.0</td>
<td>2.3</td>
<td>8.2</td>
</tr>
<tr>
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<td>0.6</td>
<td>1.7</td>
<td>4.5</td>
<td>10.7</td>
</tr>
<tr>
<td>Italy</td>
<td>8.0</td>
<td>0.9</td>
<td>2.4</td>
<td>8.5</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3.5</td>
<td>1.6</td>
<td>3.5</td>
<td>13.2</td>
</tr>
<tr>
<td>UK</td>
<td>11.4</td>
<td>1.5</td>
<td>4.0</td>
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</tr>
<tr>
<td>Belgium</td>
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<td>1.6</td>
<td>3.5</td>
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</tr>
<tr>
<td>Denmark</td>
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<td>0.9</td>
<td>2.0</td>
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</tr>
<tr>
<td>Greece</td>
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<td>2.4</td>
<td>6.6</td>
<td>14.3</td>
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<tr>
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<td>1.8</td>
<td>5.1</td>
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</tr>
<tr>
<td>EC 12</td>
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<td>1.2</td>
<td>3.1</td>
<td>10.7</td>
</tr>
</tbody>
</table>

(b) "Primary" carbon tax (revenues allocated according to production and net extra-EC imports)

<table>
<thead>
<tr>
<th>Country</th>
<th>Revenues (ECU bn)</th>
<th>as percentage of GDP</th>
<th>as percentage of total tax receipts</th>
<th>as percentage of indirect tax receipts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>10.5</td>
<td>0.9</td>
<td>2.4</td>
<td>8.7</td>
</tr>
<tr>
<td>Spain</td>
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<td>1.2</td>
<td>3.5</td>
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<tr>
<td>France</td>
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<td>0.9</td>
<td>2.0</td>
<td>7.3</td>
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<tr>
<td>Ireland</td>
<td>0.3</td>
<td>0.8</td>
<td>2.1</td>
<td>4.9</td>
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<tr>
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The arguments would tend to favour a consumption-based allocation of revenues in circumstances where the carbon tax burden was borne by final consumers. At least partial incidence on consumers is to be expected, and the incidence on consumers will be stronger where the Community introduces a carbon tax without corresponding measures being taken by other major countries. A consumption-based allocation of revenues is also the basis on which existing indirect taxes (VAT and excise duties) in Community countries operate.
Taking a consumption-based revenue allocation as an objective for a Community carbon tax does not necessarily require that the carbon tax should be levied on final fuel products, although a carbon tax of this form would certainly achieve this pattern of revenues. It may instead be possible to separate the form of carbon tax chosen from the pattern of revenue allocation between member states, although the mechanisms by which this separation can be achieved can be a source of administrative complexity, and can give rise to problems of co-ordination and incentives. Similar issues arose during the debate over indirect tax harmonisation in the Community, and are discussed in Chapter 1.

How might a revenue allocation according to the pattern of consumption be reconciled with a carbon tax levied on primary fuels rather than final fuel products? Broadly speaking, two possible approaches to the problem would appear to be available, based on statistical reconciliation and administrative "chaining" respectively.

Statistical reconciliation would appear to offer a relatively cheap solution to the reallocation of carbon tax revenues between member states. What would be required are statistics on the aggregate consumption by domestic consumers and industry of each of the range of final energy products, together with an agreed set of factors by which the actual carbon content of each final energy product can be translated into the total carbon emissions to be associated with the fuel product (including emissions during fuel refining and processing). Aggregate carbon emissions associated with the pattern of energy consumption can then be compared with the pattern of carbon tax revenues from taxes imposed at the point of resource extraction or import, and the appropriate set of revenue transfers between member states calculated, so as to leave member states with the revenues that they would have had, if a "final" carbon tax had been imposed.

Given the required data for the statistical reconciliation, the calculation of the revenue transfers would be straightforward, inexpensive and uncontroversial. The main difficulties of this approach have to do with obtaining data of the sort required. Aggregate fuel consumption could be calculated either by subtracting net exports from production, or from a direct survey of consumption. The abolition of internal frontiers within the Community has reduced the ease with which statistics on trade flows of particular commodities can be obtained, and it is necessary instead to rely on sample surveys and other statistical inquiries about trade flows conducted away from the actual frontier. Inevitably, this makes it more difficult to corroborate the information provided in such inquiries, since it will not be possible to observe the actual goods in transit, and the greater the reliance placed on sampling rather than comprehensive returns by all traders, the more room for argument will be opened up about the accuracy of the data. Where large revenue transfers between member states are at stake, the accuracy of statistical inquiries will come under an unusual degree of scrutiny. Similar problems would arise if the alternative was pursued of instituting a direct survey of fuel consumption by industrial and domestic users. Indeed, the controversy over a consumption survey could be exacerbated by the lack of scope for verifying the answers obtained; with trade data, it is possible to use import statistics to corroborate estimates of trade flows based on export statistics, and this can help to identify errors (or deliberate misreporting).4

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4 See Cornilleau, Pearson and Smith (1989) for a discussion of the scope for statistical approaches to VAT "clearing".
Administrative "chaining" provides a basis for revenue adjustments between member states based on data obtained from individual transactions, rather than aggregate estimates of the overall revenue transfers required. The basic idea would be that the carbon tax would be imposed on primary fuels, but the fuels would then be tracked by some administrative mechanism up until the point at which they were sold to industrial or domestic consumers. Unlike VAT the purpose of this mechanism would be to track trade flows, rather than to adjust tax levels. Where fuels moved between member states, appropriate revenue adjustments would be made, which would have the effect of transferring the carbon tax revenue paid in the exporting country to the revenue authorities in the importing country. The precise mechanism by which this transfer takes place is unimportant; what is crucial is the "chaining" of the two parties in the transaction, so that the revenue authorities in both countries are notified and can verify the transaction.

The procedure has some similarities both with the system of linked bonded warehouses envisaged for the control of the movement of dutiable goods (alcohol, tobacco and mineral oils) between member states, and with the administrative mechanisms by which VAT has been operated on transactions between Community countries after the abolition of VAT frontier formalities. However, it has the crucial difference that the chaining for carbon tax would merely serve to reallocate between member states a given total of carbon tax revenues which have been collected at an earlier stage, rather than (as in the case of bonded warehouses) to maintain the integrity of the revenue system, to ensure the collection of tax due at a later stage.

This difference between the chaining mechanism for a carbon tax and bonded warehousing for consumer excises is important because it highlights the role of the tax rates to be applied to each transaction in fuels between chained parties. This tax rate does not have any role to play in determining the amount of tax on the fuels in question; this is determined by how the carbon tax levied on the primary fuel stage has been passed on and divided up in later stages of fuel processing. Instead, the tax rate applied to the chained transaction is simply used to determine how much revenue should be transferred between member states' revenue authorities. Thus, although the carbon tax rates appropriate to various intermediate and final fuels are like the final fuel product carbon tax rates discussed earlier in the sense that they require assumptions to be made about carbon emissions during processing, unlike a final carbon tax, the tax rates are not liable to give rise to perverse incentives for fuel processors or users, even if they are set at the wrong level. All that will be affected is the allocation of tax revenues between member states, not the decisions of producers and consumers.

Separating revenue allocation in this way from the procedures for levying the carbon tax has the attraction that the difficulties that would be encountered in operating an accurate carbon tax on final fuel products and in levying appropriate carbon taxes on imported fuels, do not cause problems of the same magnitude in intra-Community trade, even though this trade is in intermediate and final fuel products as well as in primary fuels. Nevertheless, the mechanism is not without its problems. In particular, although the process of chaining depends on a link being drawn between fuel exporters and fuel importers, and the corresponding revenue authorities, it is clear that only

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one of the parties involved has any interest in ensuring that transactions are recorded fully - namely
the importing member state. Since the tax has already been levied, and the process of chaining
does not affect the tax liability of either the exporting firm or the importing firm, neither the exporter
nor the importer has any interest in the process. Moreover, it is clearly in the interests of the
exporting member state to ignore as many transactions as possible, since each export transaction
that is recorded reduces the exporting state’s tax revenues. How comprehensive the chaining
process can be expected to be in these circumstances is unclear.

4. Some Further Issues

The discussion above has suggested reasons to prefer a carbon tax levied on primary fuels rather
than one levied on final fuel products - especially the difficulty of defining tax rates for final fuel
products that take appropriate account of the carbon emissions during processing. This section
treats briefly some further administrative issues.

Exempt Users

The Commission’s proposals envisaged that certain major energy-using sectors should be exempt
from the carbon tax. This gives rise to a need for the administrative arrangements to take a form
which would be compatible with industry-specific exemptions.6

It is clear that administration of exemptions would be easier with a carbon tax on final fuel products
than with a carbon tax on primary fuels. From information about the quantities and types of fuels
purchased by an exempt user, it would be possible to determine the amount of carbon tax that
had been paid on fuel purchases, and fairly straightforward procedures could thus be set up whereby
exempt users were refunded the carbon tax they had paid, after providing suitable documentary
evidence about fuel purchases. Clearly, a number of supplementary rules would be required,
governing matters such as the resale of fuels by exempt users, the proportion of tax to be refunded
where enterprises produce a mix of products only some of which count for exemption, and so on.
Given the level of the carbon tax and the consequent substantial gains from evasion, the exemption
of energy-intensive industries would require considerable supervision and enforcement, and would
have a far from trivial administrative cost.

Administration of sectoral exemptions would be less practical where a carbon tax was levied on
primary fuels, since some of the fuel purchased by exempt sectors would be processed or refined
fuels, with an unknown carbon tax element in their price. It would be possible to refund the tax on
fuel purchases on the basis of the carbon tax rates applied to similar intermediate or final fuel
products imported from outside the Community, but there are obvious dangers that the refunded

6 Whether the tax should include such exemptions is a different, and controversial, issue. Pearson and Smith (1991)
identify a number of costs and risks which might arise when energy-intensive sectors are exempted from the tax. Hoel
(1995), on the other hand, as discussed in Chapter 3, identifies circumstances under which sectoral differentiation of a
carbon tax would be efficient; sectoral exemption may be an administratively-attractive approximation to the optimal
sectoral differentiation of carbon tax rates.
tax would be arbitrary, and could provide considerable scope for concealed production subsidies. Also, unless the administrative chaining procedure described above were in operation, the fuel purchases made by exempt industries may be from fuel suppliers not otherwise involved in the carbon tax process; supervision of both buyer and seller by the carbon tax revenue authorities may be required, solely for the purposes of administering the exemption.

Electricty Generation

With a carbon tax on primary fuels, there would be no reason to involve the electricity industry in the administrative system for the carbon tax; its carbon-based inputs would be taxed, and the impact of the carbon tax on electricity prices would arise from the effect of the higher prices for inputs on the industry's output pricing decisions. With a mixed carbon / energy tax such as that envisaged by the Commission levied at the primary fuel stage, it would be necessary in addition to levy a tax on the nuclear generation of electricity, but otherwise there would be no need to tax electricity producers.

Where the carbon tax is imposed on final fuel products, two possibilities exist - either to treat electricity as a final fuel product, or to treat electricity generation as an industrial user of final fuel products. The latter will generally be more convenient, since it will minimise the number of taxable individuals, but it may not be practicable, if it is intended to allow certain industries to be exempt from the carbon tax.

Exempting industrial users of electricity from the carbon tax on the electricity they purchase illustrates in a particularly acute form the difficulties of administering a carbon tax at the level of final fuel products. Where an electricity supplier uses various fuels for generation, what is the carbon content of the electricity purchased by one customer?

It is at least possible to argue that the straightforward answer, that the carbon content of a supply to one customer is the average carbon content of all the electricity supplied by the generator, is actually inappropriate. Many large users have a steady demand for electricity, without the time-of-day peaks that domestic usage shows. A case can obviously be made for saying that the carbon tax refunded should then reflect the fuels used in generating base-load electricity, rather than peak-load electricity, although identifying the appropriate amount of carbon tax to be refunded in such cases will clearly be far from straightforward.

Non-Fuel Uses

A number of fuels have significant non-fuel applications. Thus, for example, oil is used to make plastics and various other products, and natural gas is used in the manufacture of some fertilisers. Where these non-fuel uses do not result in carbon dioxide emissions, it will not be necessary for the carbon tax to be applied, and in general it will be desirable for non-fuel uses to be exempted from the tax.
Non-fuel uses create a requirement for an administrative mechanism to monitor and enforce the exemption arrangements, to ensure that fuels destined for non-fuel applications are not diverted instead for use as fuels. It is also necessary to determine the appropriate rates of tax at which exempt users should be credited. As with sectoral exemptions, this is straightforward with a carbon tax levied on final fuel products, but considerably more complicated where the carbon tax has been levied earlier on primary fuels.

5. Conclusions

The issues addressed in this chapter concern the administrative choices available for a carbon tax. How should the tax be structured, in order to achieve both efficient administration and efficient environmental responses? The chapter has identified a basic choice between a "primary" carbon tax, levied at an early stage in the chain of fuel processing, and a "final" carbon tax, levied at a later stage, on processed final fuel products, at the point at which they are about to be delivered to final fuel users. Each has advantages and disadvantages, which need to be weighed carefully.

The primary carbon tax would be likely to have lower costs of direct administration, since it would need to deal with fewer taxpayers than a final fuels tax, and would have no need to monitor the chain of fuel processing beyond the initial stage. It also has the great merit that it would ensure the efficient relative taxation of different fuels, to reflect not only their current carbon content but also the carbon dioxide emitted in the course of refining, processing or generation activities. By contrast, a final carbon tax can only tax processing emissions on the basis of assumed coefficients, which provides no incentive for emission reduction in individual cases, and which, over time, may easily become out-of-line with actual processing emissions. A primary carbon tax would therefore be liable to provide more efficient environmental incentives, and in the case of electricity generation, at the very least, would appear to be very desirable.

On the other hand, the primary tax has two disadvantages. One is that it cannot, in fact, completely avoid the specification of carbon tax rates to apply to final fuel products, where these may be imported, or where it is intended that the tax on particular energy uses (by exempt sectors, or in non-fuel applications) should be refunded. The former is relatively unimportant for the Community as a whole. The latter, however, is a major drawback, given the intention to deal with problems of international product market competition by exempting certain firms or sectors from the carbon tax. The second disadvantage of the primary carbon tax is that the pattern of revenues across member states would be more uneven than with a final carbon tax, in that it would be liable to reflect the pattern of fuel production and import rather than fuel consumption. To the extent that the main incidence of the tax might be borne by fuel consumers, it may be felt that the allocation of revenues between member states should be based on consumption. In this case, whilst mechanisms for revenue reallocation could be devised, there may be a preference for a tax of the final type, which automatically achieves a consumption-based revenue allocation.
Chapter 6

The distributional consequences of carbon/energy taxes
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Introduction

Both regulatory and market-based environmental policies may have distributional effects, in the sense that the costs and benefits of environmental policy measures may bear unevenly on households at different levels of income. The range of relevant costs and benefits will vary, depending on the instruments used. With all environmental policy measures, the list of relevant costs and benefits will include abatement costs (in terms of the costs of adjustments in production and consumption, and costs of emissions control devices), and, to be balanced against these, the value of the environmental benefits. All may be unevenly distributed across income groups.

Distributional issues of a distinctive sort are, however, raised by environmental taxes and other revenue-raising market-based instruments. With these instruments, the pattern of tax payments is an additional source of potential distributional effects, over and above the costs and benefits directly involved in reducing emissions. It is possible that the distributional incidence of the tax payments could be more uneven, and of greater quantitative significance, than the distributional incidence of the costs and benefits associated with non-revenue-raising instruments.

The introduction of environmental taxes on energy is, in particular, likely to raise significant distributional concerns, reflecting the importance of energy expenditures in the budgets of poorer households (Dilnot and Helm, 1987; Smith, 1992). This distributional sensitivity of energy taxation is recognised in the indirect tax policies of many OECD countries, which apply lower levels of taxation to certain domestic energy products than to other goods and services.

This chapter assesses the likely distributional effects in EC member states of the imposition of the proposed EC carbon/energy tax at a level equivalent to US $ 10 per barrel of oil, focussing in particular on the impact on the household distribution of income of the higher taxation of households' direct energy expenditures.

The analysis begins in Section 1 by considering the pattern of household expenditures on domestic energy and motor fuel, which may provide an initial indication of the possible distributional incidence of a tax on these commodities, in the absence of significant change in household consumption patterns. The initial focus of this section is Eurostat data on household budgets analysed by income groups, available for seven EU member states. This is used to make some straightforward initial estimates of the distributional incidence of a carbon tax in each of these countries (which include all the major EU states), and to identify the extent to which common distributional issues arise throughout the EU.

The data available has, however, certain limitations, and these are then explored in detail. One issue is that, since the underlying micro-data are not available, the analysis is constrained to use the distributional classifications selected by Eurostat in the presentation of its data, where households are classified into groups on the basis of household income. This is potentially problematic: Poterba (1991), analysing data for the United States, has argued strongly in favour of using household spending rather than current income in distributional analysis. He has argued that this is more consistent with a life-cycle concept of tax incidence, and that it shows taxes on
spending in the US to be less regressive than they appear if current income is used. Using micro-data for the UK, this issue is explored further, and an assessment is made of the sensitivity of distributional analyses with UK data to the choice between current incomes and total spending as the measure of household living standards. The section then considers whether the results are significantly affected by taking into account the likely behavioural responses of consumers; again, quantitative estimates are provided for the UK. The section concludes with an informal discussion of the indirect effects on the household income distribution of carbon and energy taxes on industrial inputs - effects through the prices of goods and services which use energy in their production, and other indirect effects.

Section 2 of the paper discusses a number of ways in which carbon/energy tax revenues might be used to offset undesired distributional or other effects. This starts by considering the scope for distributional problems to be addressed by a simple lump-sum, per-household, return of the carbon tax revenues, and identifies a number of practical difficulties with such an approach. It then considers arguments which would suggest that a simple lump-sum revenue return would be an inadequate response to the identified distributional effects. Conclusions are drawn in Section 3.

1. Distributional effects of a carbon/energy tax

1.1 The pattern of direct consumer purchases of energy.

Although the purpose of introducing a carbon tax is to change the level and pattern of energy use, by encouraging greater energy efficiency and a substitution away from high-carbon fuels, the natural starting point for assessing the direct distributional impact of taxes on energy and the carbon content of fuels is data on the existing pattern of consumers’ expenditure. Given that, in the main, price elasticities of energy demand would appear to be low, the current pattern of energy spending will provide a reasonable initial approximation to the distributional effects of higher energy taxes.

Figures 1 and 2 show the pattern of household expenditures on domestic energy and motor fuels in seven EC member states. Specifically, the Figures show the average household spending on domestic energy and motor fuels by households in each quartile group of the income distribution, expressed as a share of the average total spending of the quartile. The figures for Germany, Spain, France, Ireland, Italy and the Netherlands are drawn from the results of an exercise by Eurostat to produce comparable international figures for the pattern of household spending in 1985 or the

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1 The Community Statistical Office has published the results of two exercises to construct comparative tables of household spending analysed by income groups based on data derived from existing national surveys. The first covered in total ten Community countries, with data for 1980 or the nearest available year. The second covers six countries, Germany, Spain, France, Ireland, Italy and the Netherlands, and contains data for 1985. This second survey, augmented by data from the UK Family Expenditure Survey, has formed the principal source of data used here. For the Community countries not included in the 1985 survey, estimates have been made using the earlier 1980 survey, though these should be regarded as having a rather wider margin of error.
The nearest available year. This source does not, however, include figures for the UK. In this chapter, therefore, the Eurostat data has been supplemented by the author's estimates of corresponding figures for the UK, based on appropriate variables from the 1988 UK Family Expenditure Survey².

The average income levels of quartile groups vary widely across the Community; poorer households in the richer member states of the Community may have a similar standard of living to households with an above-average income in poorer member states. If the quartile data is to provide information on anything other than the relative position of different groups within each country, it is necessary to find some appropriate measure of the relative standard of living of income groups, compared across countries.

Making such a comparison with the Eurostat data involves an unavoidable element of imperfection and approximation, for three principal reasons.

First, what would in principle be desirable is a comparison based on purchasing power parities rather than on market exchange rates. These would in principle need to vary across income groups, reflecting differences in the proportions of tradeable and non-tradeable goods consumed at different income levels. The available purchasing power parity data is not disaggregated in this way.

Second, the proportion of the population covered by the Eurostat data in different countries will tend to vary, due to differences in survey methodology (e.g., the German survey excludes households with incomes above a certain level), and differences in response rates. Thus, even applying purchasing power parity data to the Eurostat figures for all households involves an unknown, but possibly appreciable, bias, since the "all households" Eurostat data may not be representative of the population as a whole.

Third, there are difficulties in making an appropriate adjustment for differences in average household size. Such an adjustment is needed in order to interpret the average income figures for each quartile. Average household size varies widely between different income quartiles within the same country, and also between countries. Thus, for example, the bottom quartile of households in Germany contains on average 1.3 members (about 0.1 of them children), whilst the second, third and fourth quartiles contain on average 2.0, 2.8, and 3.4 members respectively (0.3, 0.7 and 0.9 children). Across countries, average household sizes range from 2.4 in Germany to 3.5 in Ireland and 3.7 in Spain; the number of children within these averages is 0.5, 1.3 and 1.1 respectively. Some form of equivalent income concept would be appropriate to adjust for these differences in size. However, since the Eurostat comparisons programme provides only group averages (the underlying micro-data are retained by the member states and are not available on the harmonised basis), households cannot be re-ranked into quartiles of equivalent income. Any equivilisation adjustment can be applied only to the averages for the existing groups. The classification of households to the groups will remain, and groups may be partly overlapping (and may be quite heterogeneous) in terms of the equivalent incomes of their members.

² 1985 data would have been available for the UK, but 1988 was chosen so that the figures shown here for the UK are comparable with more detailed results for the UK presented later in this chapter.
6. Distributional aspects of carbon/energy taxes

Nevertheless, in spite of these qualifications, an attempt has been made to assess the relative living standards of households in each group on a basis which provides scope for some cross-country comparison. Estimates of average equivalent income, based on purchasing power parities, have been used to locate the quartile observations on the horizontal axis of Figures 1 and 2.

The precise procedure adopted has been complex, since there are reasons to doubt the comparability of the income data provided in the Eurostat survey. Equivalent total expenditures have been calculated for each group, based on the following equivalisation formula:

\[
\text{Equivalisation factor} = \frac{(0.5 \times \text{Adults} + (0.5 \times \text{Children}))}{2.5}
\]

These have then been used to determine the position, relative to each other, of the quartile groups from each country. The positioning of the countries relative to each other has been based on an estimate of relative equivalent household income for all households, based on OECD data using 1985 purchasing power parities.

Figure 1

Budget shares for household spending on fuel and power in seven European Community countries, by quartile groups of gross household income.
In all the Community countries shown, spending on domestic fuel constitutes a higher proportion of the total expenditures of the poorest quartile than of the other three quartiles, and in all member states except Italy the budget share of domestic fuels declines steadily through the income distribution. There is also a discernible tendency for domestic fuel budget shares, especially of poorer quartiles, to be lower in the southern part of the Community, which may reflect the reduced need for heating fuels in warmer countries\(^3\).

In contrast, the budget shares for motor fuels in all six countries rise steadily from the bottom to the third quartiles, although the budget share levels out between the third and fourth quartiles. The motor fuel budget shares are in general highest in Italy, where petrol is heavily taxed, and lowest in the Netherlands, Germany and the UK.

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\(^3\) The rise in the budget share in Italy for the top quartile may reflect the effect of climate; richer households in Italy are predominantly in the (colder) northern half of the country.
6. Distributional aspects of carbon/energy taxes

1.2 Estimates of the distributional incidence of a carbon tax, assuming no behavioural response

In this section estimates are made of the distributional incidence of a carbon/energy tax along the lines proposed by the European Commission, based on the assumption that the quantity of energy purchased by households would be unaffected by the imposition of the new tax. The estimates, which relate to a tax imposed at the full level of $10 per barrel of oil, are based on the consumer spending data for seven EC member states described in the previous section, and the ad valorem equivalent carbon/energy tax rates calculated on the basis of energy prices and carbon/energy content for each fuel, as set out in the Annex to this chapter.

The estimates reflect two strong assumptions:

First, the estimates of the amount of tax that would be paid by individual households are based on the existing pattern of household energy consumption in volume terms. This assumption is unlikely to be strictly accurate; amongst other things it violates the "adding up" requirement for household budget balance. It is also, of course, inconsistent with the aim of introducing a carbon tax which is to reduce the use of carbon-based energy. However, price elasticities of energy demand may be quite low and, in assessing the distributional effects of energy taxation, the assumption of no behavioural response may give a reasonable indication of the distributional of tax payments across income groups. Later in this section the sensitivity of distributional incidence estimates to the inclusion or omission of behavioural responses is evaluated, using data for the UK and a behavioural model of household spending; it is found that, in the case of the carbon tax, making an allowance for behavioural responses does not make a substantial difference to the overall distributional impact of the tax, in terms of additional tax payments, despite the fact that price elasticities differ considerably between income groups.

Secondly, the estimates assume that the taxes would be fully passed on to consumers in the prices of energy products. This is, of course, a strong assumption. Although introduction of carbon tax in the Community alone might have only a small impact on global energy demand, co-ordinated introduction of a carbon tax in all major countries could have a significant impact on the demand for energy, and hence on the price of energy. In these circumstances, part of the burden of a carbon tax would be borne by the owners of energy resources, and an analysis which assumes that all of the tax is passed on to consumers would then tend to overstate the impact on household incomes in consuming countries.

Non-behavioural estimates made on the above basis are summarised in Tables 1 and 2 and Figure 3 for the seven EC member states. These show the distributional incidence of household payments of the EC carbon/energy tax on household direct energy purchases, based on 1985 patterns of income and expenditure. Tables 3 and 4 show separately the carbon tax burden on purchases of domestic energy and motor fuel respectively. A number of results may be highlighted:

- On average across the seven member states, carbon/energy tax payments by the average household would amount to some ECU 120 per annum in 1985 prices, equivalent to about 0.85 per cent of average household expenditures.
• There would be a considerable range in average tax burdens, reflecting differences in the level of energy consumption at different income levels, and in the carbon/energy content of that consumption. The former explanation mainly accounts for the contrast between the UK and Ireland on one hand, where the carbon tax burden per household would exceed ECU 160 annually (some 1.2 per cent of household total expenditure), and Spain on the other, where the annual carbon tax burden would be little more than ECU 50 (some 0.5 per cent of spending). The latter explanation accounts for the low tax burden in France, of ECU 106 per household per annum, equivalent to about 0.7 per cent of total spending.

• The variation in the overall tax burden arises principally because of variation in the carbon tax burden on domestic energy, where the amounts of tax are both larger and more variable across countries than the carbon tax burden on motor fuels. Except in the case of the Netherlands and Germany, the percentage burden of carbon tax payments on motor fuels lies in a very narrow band of 0.21 - 0.25 per cent of spending.

• In all countries, the carbon tax burden on domestic energy for the bottom quartile group is higher than the average for all households, and also higher than the figure for the top quartile. Carbon tax payments on domestic energy would thus be regressive in all seven member states.

• In all the member states the carbon tax burden on motor fuel of the bottom quartile group lies below the average for all households, reflecting below-average fuel spending (and presumably also lower-than-average rates of vehicle ownership). Across the remainder of the income distribution the carbon tax burden on motor fuels is broadly a constant proportion of total household spending.

• The overall distributional incidence of the carbon tax, shown in Figure 3, reflects the combined distributional effects of the tax on domestic energy and motor fuels. Where domestic energy use is relatively low, and motor fuel consumption relatively high, the regressivity arising from the taxation of domestic energy is counteracted by progressivity from the taxation of motor fuels (at least, as far as the relative position of the bottom quartile is concerned). In Spain and Italy the overall effect is broadly distributionally neutral, and in Germany, France and the Netherlands only mildly regressive. Only in the UK and Ireland of the countries shown does the overall effect of the carbon tax on direct household purchases of energy seem likely to be significantly regressive. In the UK the ratio of the percentage burden of the carbon tax on the bottom quartile to the burden on the average household would be 1.8 and in Ireland the same ratio would be 1.6.
6. Distributional aspects of carbon/energy taxes

**Table 1**

Carbon tax payments per household, by decile and quartile groups of gross household income.

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<tr>
<td>UK</td>
<td>160.96</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quartile groups</th>
<th>1985, ECU per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poorest 25%</td>
</tr>
<tr>
<td>Germany</td>
<td>77.42</td>
</tr>
<tr>
<td>Spain</td>
<td>25.88</td>
</tr>
<tr>
<td>France</td>
<td>64.26</td>
</tr>
<tr>
<td>Ireland</td>
<td>112.69</td>
</tr>
<tr>
<td>Italy</td>
<td>39.87</td>
</tr>
<tr>
<td>NL</td>
<td>85.96</td>
</tr>
<tr>
<td>UK</td>
<td>107.80</td>
</tr>
</tbody>
</table>

**Table 2**

Carbon tax payments as a percentage of household total expenditures, by decile and quartile groups of gross household income.

<table>
<thead>
<tr>
<th>Decile groups</th>
<th>Percentages of total household spending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All households</td>
</tr>
<tr>
<td>Germany</td>
<td>0.86</td>
</tr>
<tr>
<td>Spain</td>
<td>0.46</td>
</tr>
<tr>
<td>France</td>
<td>0.66</td>
</tr>
<tr>
<td>Ireland</td>
<td>1.17</td>
</tr>
<tr>
<td>Italy</td>
<td>0.78</td>
</tr>
<tr>
<td>NL</td>
<td>0.83</td>
</tr>
<tr>
<td>UK</td>
<td>1.19</td>
</tr>
</tbody>
</table>
6. Distributional aspects of carbon/energy taxes

Figure 3
Carbon tax payments as a percentage of household total expenditures, by quartile groups of gross household income.

These estimates of the distributional incidence of the EC carbon/energy tax may be compared with estimates of the distributional incidence of a carbon tax in the United States, made by Poterba (1991) using a similar methodology. Poterba’s estimates (reproduced in Table 5), show the distributional effects of a carbon tax of $100 per ton of carbon in 1990 price terms, using data from the 1985-6 Consumer Expenditure Survey. The equivalent carbon tax in the US in 1991 price terms (ie inflated by the US consumer price index) would be some 4 per cent higher (ie some $104 per tonne of carbon), some 18 per cent higher than the EC proposal\(^4\) of $10 per barrel, equivalent to some $88 per tonne.

---

\(^4\) Made in 1991 and assumed throughout this chapter to be understood in 1991 price terms.
6. Distributional aspects of carbon/energy taxes

**Table 3**

Carbon tax payments on domestic energy as a percentage of household total expenditures, by decile and quartile groups of gross household income.

<table>
<thead>
<tr>
<th></th>
<th>Percentages of total household spending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decile groups</td>
</tr>
<tr>
<td></td>
<td>All households</td>
</tr>
<tr>
<td>Germany</td>
<td>0.67</td>
</tr>
<tr>
<td>Spain</td>
<td>0.24</td>
</tr>
<tr>
<td>France</td>
<td>0.45</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.95</td>
</tr>
<tr>
<td>Italy</td>
<td>0.53</td>
</tr>
<tr>
<td>NL</td>
<td>0.68</td>
</tr>
<tr>
<td>UK</td>
<td>0.95</td>
</tr>
</tbody>
</table>

**Table 4**

Carbon tax payments on motor fuel as a percentage of household total expenditures, by decile and quartile groups of gross household income.

<table>
<thead>
<tr>
<th></th>
<th>Percentages of total household spending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decile groups</td>
</tr>
<tr>
<td></td>
<td>All households</td>
</tr>
<tr>
<td>Germany</td>
<td>0.18</td>
</tr>
<tr>
<td>Spain</td>
<td>0.22</td>
</tr>
<tr>
<td>France</td>
<td>0.22</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.21</td>
</tr>
<tr>
<td>Italy</td>
<td>0.25</td>
</tr>
<tr>
<td>NL</td>
<td>0.14</td>
</tr>
<tr>
<td>UK</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Poterba finds that the carbon tax of $100 per ton of carbon would impose an additional tax burden of, on average, about 3.3 per cent of total household spending, a higher percentage burden than for the EC member states included here, even allowing for the slightly higher tax rate in the Poterba study. This probably reflects the substantially greater levels of per capita energy consumption in the US, especially of motor fuels, than in other developed countries.

In the columns marked (a) in Table 5, where current income is used as the measure of household living standards, the carbon tax appears sharply regressive. The percentage burden of the additional tax falls sharply with increasing income; for the poorest decile the additional tax burden would be equivalent to 10.1 per cent of income, whilst for the second 5 per cent, and for the top decile, 1.5 per cent.
6. Distributional aspects of carbon/energy taxes

Table 5
Poterba’s estimates of the distributional incidence of a carbon tax of $100 per ton in the United States, 1986, using income and expenditure to measure household living standards.

<table>
<thead>
<tr>
<th>Decile</th>
<th>Annual additional tax burden ($)</th>
<th>Annual additional tax burden (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>1</td>
<td>$452</td>
<td>$253</td>
</tr>
<tr>
<td>2</td>
<td>$375</td>
<td>$350</td>
</tr>
<tr>
<td>3</td>
<td>$485</td>
<td>$466</td>
</tr>
<tr>
<td>4</td>
<td>$521</td>
<td>$528</td>
</tr>
<tr>
<td>5</td>
<td>$564</td>
<td>$589</td>
</tr>
<tr>
<td>6</td>
<td>$609</td>
<td>$681</td>
</tr>
<tr>
<td>7</td>
<td>$690</td>
<td>$772</td>
</tr>
<tr>
<td>8</td>
<td>$763</td>
<td>$804</td>
</tr>
<tr>
<td>9</td>
<td>$875</td>
<td>$944</td>
</tr>
<tr>
<td>10</td>
<td>$900</td>
<td>$871</td>
</tr>
</tbody>
</table>

(a) Households classified in income deciles, and % tax burden calculated as % of total household incomes.

(b) Households classified in expenditure deciles, and % tax burden calculated as % of total household expenditures.


The key finding of the Poterba study, however, is that the carbon tax appears substantially less regressive on the basis of an analysis in which household total spending is taken as the yardstick of living standards. Using expenditure deciles and using spending as the denominator in calculating the percentage burden, the pattern of carbon tax payments shows a much less regressive profile. The bottom decile would pay additional tax equivalent to 3.7 per cent of spending whilst the top decile would pay an additional 2.3 per cent of spending. Poterba expresses a clear preference for the latter basis of calculation, which he argues is more consistent with a life-cycle concept of income than the use of current income; on this basis he concludes that a carbon tax in the US would be only mildly regressive.

1.3 "Annual" and "lifetime" incidence

This section considers further the theoretical distinction drawn by Poterba (1989) between annual and lifetime tax burdens, and its implications for the analysis of the distributional effects of carbon/energy taxes. Although it is not possible to examine this distinction using the Eurostat data (since the underlying micro-data are not available), it is possible to examine the implications of the choice of methodology in the UK case, and to explore a number of sensitivity calculations and a decomposition of the effects. It is shown that the sharp difference between the two measures found by Poterba for the US is not found using data for the UK, where the difference is much smaller.
Further, although there are differences between estimates using different methodologies, these can be attributed to a considerable extent in the UK case to the influence of a very small number of households (five out of a total sample of some 7000) with close-to-zero incomes.

\(\text{(i) Theoretical issues}\)

The main elements of Poterba’s argument are set out in Poterba (1989). Household incomes are observed to fluctuate over time for reasons that may include both random variations (unexpected income windfalls, temporary unemployment or sickness, etc), and predictable life-cycle variations in wage rates and labour force participation. Poterba presents data from the US Panel Study of Income Dynamics which shows that a randomly-chosen individual had only a 41 per cent chance of being in the same quintile of the income distribution in 1971 and 1978. Amongst those in the bottom quintile in 1971, the probability of remaining in the same quintile in 1978 was somewhat higher at 54 per cent, and mobility between quintiles was greater amongst those towards the middle of the income distribution.

To the extent that public policy is concerned with issues of poverty and distribution, the underlying objectives of policy would presumably be expressed in terms of the standard of living that particular households or individuals could sustain, rather than in terms of household or individual incomes, per se. Where individuals are freely able to save and borrow, they may be able to maintain a smooth pattern of consumption over time, despite temporary fluctuations in income. Where consumption smoothing of this form can be undertaken without any limitation on the amounts saved or borrowed, the relevant variable for assessing the household’s standard of living will then be its expected lifetime income, rather than its current income.

In assessing policy changes, however, both current and lifetime incomes may be relevant, especially in assessing the impact of a policy change on current generations, rather than in a long-term steady state. Thus, for example, the present generation of old age pensioners would be more adversely affected by new taxes on expenditures than on incomes, even if subsequent generations would pay the same lifetime tax bill under each.

In practice, expected lifetime incomes are difficult to measure. One alternative is to use current household expenditure as a proxy for expected lifetime incomes to rank the living standards of different households, and as the denominator in calculating the percentage tax burden. The implicit assumptions being made are that desired expenditures reflect lifetime rather than current incomes, and that they are more stable over time than incomes. Expenditure will then be a better proxy for lifetime income than is current income\(^5\).

\(^5\) The principal difference between current income and current expenditure is, of course, current savings (or dissaving, where spending exceeds income). Savings are not however omitted entirely if expenditure is used to assess living standards. Where income is saved to permit future spending, savings in one period will be followed by dissaving at a later date, and the expenditure measure of living standards will take account of any income that has been saved at this later date.
Using current expenditure in place of a direct estimate of lifetime incomes has a further advantage. The relevance of lifetime income to the identification of poverty and of relative living standards depends on the assumption that households can, if they wish, smooth consumption patterns through unrestricted lending and borrowing. There are good reasons to believe that unlimited borrowing in particular will not always be practicable, and that the expenditures of some households may be constrained by current incomes. Where this is so, ranking households by current expenditures may give a better indication of current living standards than a ranking by lifetime incomes, since current expenditures can exceed current incomes only when inter-temporal expenditure smoothing is possible.

If current expenditure rather than current income is used as the basis for classifying households according to their standard of living, what implications would this be likely to have for estimates of the distributional incidence of indirect taxes, such as excise duties or a carbon tax? Poterba (1989) highlights the case where households try to smooth consumption patterns in the face of fluctuating incomes. In these circumstances, inclusion of households with temporarily-low incomes in the lowest income groups will tend to overstate the regressivity of taxes on spending on goods with a positive income elasticity. However, there may be other effects too. Where incomes are smooth over time, but desired consumption is not, neither current income nor current expenditure will be a good indicator of lifetime tax burdens.

(ii) Data issues

In addition to the theoretical arguments for and against the use of expenditure rather than income as the basis for distributional comparisons, arguments about the accuracy of the two variables are also relevant. Both incomes and expenditures may be misreported by survey respondents. For example, individuals who are trying to evade tax may be reluctant to report their incomes to an official budget survey. Spending on certain goods, especially alcoholic drinks, is also widely under-reported in certain countries. In general, it is likely that systematic under-reporting is greater for incomes than for expenditures. On the other hand, the use of a relatively short reporting period for expenditures in most budget surveys may mean that reported expenditures for the survey period are an inaccurate guide to annual spending levels for particular households. Where a household's expenditures are affected by transitory factors (e.g. the purchase of durables, payment for an annual delivery of coal or fuel oil, etc), it may be classified to a higher expenditure decile than it would have been if its expenditure had been measured over a longer period.

Also, where survey data on household expenditures covering a short period is used as the basis for assessing household living standards, households with large durables purchases in the survey period will tend to be allocated to higher expenditure groups than they would have been if their expenditure over a longer period had been known, and this would generally tend to overstate the regressivity of taxes on expenditure items with a positive income elasticity.
A different possible bias arises where the "lumpy" expenditure is expenditure on fuels. For most fuels, payments tend to be made infrequently, although the general practice appears to be that for fuels billed on a regular basis (e.g., electricity), the most recent bill is used to estimate expenditure, even if it was received or paid outside the survey period. In the UK, household spending on coal and other solid fuels is not smoothed in this way, and most households recorded as spending anything on coal during the survey period will thus tend to have total spending above its average level. This source of error would tend to understate the regressivity of taxes on coal; households purchasing coal would have much higher tax payments than other households, and would also tend to be classified, incorrectly, to higher expenditure groups than their true level.

(c) Empirical significance

In practice, what are the implications of using a household expenditure basis rather than a household income basis to assess the distributional incidence of a carbon tax? Poterba's results (Poterba, 1991) show that the choice may make a considerable difference to the estimated distributional incidence of a carbon tax. From the discussion of the theoretical issues above it is not wholly clear that an expenditure basis should always be preferred, and it may be desirable to look at both bases.

With access to individual micro-data it is possible to make a free choice of how the results are to be analysed and presented, and thus to choose between income-based and expenditure-based analyses on the basis of an assessment of their relative merits. However, published data on household spending patterns are rarely presented on more than one basis. The Eurostat data for EC member states used above take the form of budget shares for deciles and quartile groups of gross household income. How great are likely to be the approximations and biases that would arise from the use of this published data to analyse the distributional incidence of a carbon tax in Community member states?

In Tables 6 to 8 we use micro-data on energy spending from the 1988 UK Family Expenditure Survey to look at the implications for distributional analysis of the various different bases for computing measures of distributional incidence.

Table 6 shows the pattern of household expenditures on domestic fuels and motor fuels in the UK, across decile groups of gross household income, and across decile groups of total household expenditure. The household expenditures are shown in three ways, first in pounds per week, second as a percentage of income, and third as a percentage of expenditure (budget shares). Comparison with Table 5 which summarises the results reported by Poterba (1991) shows that the percentages reported by Poterba correspond to the income shares where households are classified by deciles of gross household income, and the budget shares where households are classified by total household expenditure. It is thus possible to use Table 6 to assess the importance in the UK of these two differences in the Poterba calculations - first, the effect of using income or
expenditure as the denominator in calculations of distributional incidence, *given* a classification of households, and, second, the effect of classifying households by expenditure rather than income deciles, given the chosen basis for calculating the percentage burden.

It is clear that, of the two differences, the one that has the greater effect at low incomes is the choice of income or expenditure as the denominator for calculating the percentage burden. The budget shares tend in general to be somewhat higher in nearly all groups than the corresponding income shares (reflecting positive levels of saving by most households), and apart from this the choice of income or expenditure as the denominator makes little difference over most of the income distribution. There are however striking differences between income shares and budget shares at the bottom of the income distribution; in the bottom income decile, for example, the budget share of domestic fuels is only three fifths of the corresponding income share. A similar difference can be observed between the income share and budget share of domestic fuels in the bottom expenditure decile. Thus, it would appear that the choice between income and expenditure as the denominator in calculating percentage burdens is of some consequence.
### Table 6.

Average expenditures and budget shares for domestic fuel and motor fuel expenditure, by decile groups of gross household income, and total household expenditure, Great Britain, 1988.

<table>
<thead>
<tr>
<th>Deciles of total household income or expenditure</th>
<th>All</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spending on:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>motor fuels</td>
<td>6.39</td>
<td>0.43</td>
<td>1.23</td>
<td>2.54</td>
<td>3.90</td>
<td>6.17</td>
<td>7.29</td>
<td>8.36</td>
<td>8.66</td>
<td>8.28</td>
<td>11.52</td>
</tr>
<tr>
<td>(percent non-zero)</td>
<td>(57.0)</td>
<td>(5.6)</td>
<td>(19.3)</td>
<td>(37.1)</td>
<td>(49.9)</td>
<td>(63.6)</td>
<td>(77.8)</td>
<td>(81.4)</td>
<td>(85.0)</td>
<td>(85.0)</td>
<td>(82.0)</td>
</tr>
<tr>
<td>total spending</td>
<td>205.34</td>
<td>55.61</td>
<td>86.73</td>
<td>111.87</td>
<td>144.29</td>
<td>177.63</td>
<td>208.68</td>
<td>232.66</td>
<td>263.66</td>
<td>316.57</td>
<td>456.00</td>
</tr>
<tr>
<td><strong>As share of income:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>domestic fuels</td>
<td>7.2</td>
<td>25.6</td>
<td>11.9</td>
<td>8.5</td>
<td>6.1</td>
<td>4.9</td>
<td>4.2</td>
<td>3.4</td>
<td>2.9</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>motor fuels</td>
<td>2.3</td>
<td>1.1</td>
<td>1.6</td>
<td>2.3</td>
<td>2.5</td>
<td>3.0</td>
<td>2.8</td>
<td>2.6</td>
<td>2.4</td>
<td>2.4</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Budget shares:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>domestic fuels</td>
<td>7.3</td>
<td>15.5</td>
<td>11.6</td>
<td>9.1</td>
<td>7.2</td>
<td>6.3</td>
<td>5.7</td>
<td>5.1</td>
<td>4.7</td>
<td>4.2</td>
<td>3.9</td>
</tr>
<tr>
<td>motor fuels</td>
<td>2.9</td>
<td>0.5</td>
<td>1.2</td>
<td>2.1</td>
<td>2.7</td>
<td>3.5</td>
<td>3.7</td>
<td>3.9</td>
<td>3.8</td>
<td>3.9</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>by deciles of total household expenditure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spending on:</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>motor fuels</td>
<td>6.39</td>
<td>0.18</td>
<td>1.01</td>
<td>2.28</td>
<td>3.90</td>
<td>5.43</td>
<td>5.51</td>
<td>5.39</td>
<td>5.07</td>
<td>12.10</td>
<td>14.10</td>
</tr>
<tr>
<td>(percent non-zero)</td>
<td>(57.0)</td>
<td>(3.8)</td>
<td>(17.5)</td>
<td>(35.4)</td>
<td>(53.4)</td>
<td>(61.7)</td>
<td>(70.8)</td>
<td>(77.8)</td>
<td>(80.1)</td>
<td>(84.8)</td>
<td>(85.0)</td>
</tr>
<tr>
<td>total spending</td>
<td>205.34</td>
<td>41.84</td>
<td>70.86</td>
<td>96.22</td>
<td>122.75</td>
<td>150.08</td>
<td>179.44</td>
<td>215.16</td>
<td>259.86</td>
<td>327.95</td>
<td>589.78</td>
</tr>
<tr>
<td><strong>As share of income:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>domestic fuels</td>
<td>7.2</td>
<td>21.7</td>
<td>10.2</td>
<td>8.6</td>
<td>6.9</td>
<td>5.4</td>
<td>5.0</td>
<td>4.1</td>
<td>3.8</td>
<td>3.4</td>
<td>2.9</td>
</tr>
<tr>
<td>motor fuels</td>
<td>2.3</td>
<td>0.3</td>
<td>1.1</td>
<td>1.8</td>
<td>2.4</td>
<td>2.5</td>
<td>2.7</td>
<td>2.8</td>
<td>3.0</td>
<td>3.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Budget shares:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>domestic fuels</td>
<td>7.3</td>
<td>16.5</td>
<td>11.0</td>
<td>9.0</td>
<td>7.4</td>
<td>6.6</td>
<td>6.1</td>
<td>5.3</td>
<td>4.8</td>
<td>4.0</td>
<td>2.7</td>
</tr>
<tr>
<td>motor fuels</td>
<td>2.9</td>
<td>0.4</td>
<td>1.4</td>
<td>2.3</td>
<td>3.2</td>
<td>3.6</td>
<td>3.9</td>
<td>3.9</td>
<td>3.7</td>
<td>2.7</td>
<td>2.7</td>
</tr>
</tbody>
</table>
Table 7.

Sensitivity of the results in Table 6 for the distribution of domestic fuel expenditures to the exclusion of five households with the lowest incomes, and to the use of shares calculated on the basis of average incomes and spending for the decile, rather than the average of shares calculated for each household. Great Britain, 1988.

Weekly expenditures in pounds, budget shares as percentages of total household expenditure

<table>
<thead>
<tr>
<th>Deciles of gross household income</th>
<th>All</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>As in Table 6:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income shares:</td>
<td>7.2</td>
<td>25.6</td>
<td>11.9</td>
<td>8.5</td>
<td>6.1</td>
<td>4.9</td>
<td>4.2</td>
<td>3.4</td>
<td>2.9</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Budget shares:</td>
<td>7.3</td>
<td>15.5</td>
<td>11.6</td>
<td>9.1</td>
<td>7.2</td>
<td>6.3</td>
<td>5.7</td>
<td>5.1</td>
<td>4.7</td>
<td>4.2</td>
<td>3.9</td>
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<tr>
<td><strong>Excluding the five lowest-income households from the bottom decile:</strong></td>
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<tr>
<td>Income shares:</td>
<td>6.3</td>
<td>16.6</td>
<td>11.9</td>
<td>8.5</td>
<td>6.1</td>
<td>4.9</td>
<td>4.2</td>
<td>3.4</td>
<td>2.9</td>
<td>2.5</td>
<td>2.0</td>
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<tr>
<td>Budget shares:</td>
<td>7.3</td>
<td>15.5</td>
<td>11.6</td>
<td>9.1</td>
<td>7.2</td>
<td>6.3</td>
<td>5.7</td>
<td>5.1</td>
<td>4.7</td>
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<tr>
<td><strong>Shares computed on the basis of average income and average spending for the decile:</strong></td>
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<tr>
<td>Income shares:</td>
<td>3.7</td>
<td>16.2</td>
<td>11.8</td>
<td>8.5</td>
<td>6.0</td>
<td>4.8</td>
<td>4.2</td>
<td>3.4</td>
<td>2.9</td>
<td>2.5</td>
<td>1.8</td>
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<tr>
<td>Budget shares:</td>
<td>5.1</td>
<td>13.3</td>
<td>10.1</td>
<td>8.2</td>
<td>6.5</td>
<td>5.7</td>
<td>5.2</td>
<td>4.6</td>
<td>4.2</td>
<td>3.8</td>
<td>3.2</td>
</tr>
</tbody>
</table>
### Table 8.

The effects of adjustments for household composition: Average spending and budget share for domestic fuel, by decile groups of gross household income, equivalent gross household income, total household expenditure, and equivalent total household expenditure, Great Britain, 1988.

**Weekly expenditures in pounds, budget shares as percentages of total household expenditure**

<table>
<thead>
<tr>
<th>Deciles of income or expenditure</th>
<th>All</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tr>
<td><strong>by deciles of total household income</strong></td>
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<tr>
<td>Budget shares (%)</td>
<td>7.3</td>
<td>15.5</td>
<td>11.6</td>
<td>9.1</td>
<td>7.2</td>
<td>6.3</td>
<td>5.7</td>
<td>5.1</td>
<td>4.7</td>
<td>4.2</td>
<td>3.9</td>
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<tr>
<td><strong>by deciles of equivalent total household income</strong></td>
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<tr>
<td>Spending (£ per week)</td>
<td>10.40</td>
<td>9.01</td>
<td>8.73</td>
<td>9.08</td>
<td>9.80</td>
<td>11.05</td>
<td>10.75</td>
<td>10.81</td>
<td>10.71</td>
<td>11.62</td>
<td>12.40</td>
</tr>
<tr>
<td>Budget shares (%)</td>
<td>7.3</td>
<td>14.8</td>
<td>11.9</td>
<td>8.9</td>
<td>6.9</td>
<td>6.6</td>
<td>5.7</td>
<td>5.3</td>
<td>4.8</td>
<td>4.5</td>
<td>4.1</td>
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<tr>
<td><strong>by deciles of total household expenditure</strong></td>
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</tr>
<tr>
<td>Budget shares (%)</td>
<td>7.3</td>
<td>16.5</td>
<td>11.0</td>
<td>9.0</td>
<td>7.4</td>
<td>6.6</td>
<td>6.1</td>
<td>5.3</td>
<td>4.8</td>
<td>4.0</td>
<td>2.7</td>
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<tr>
<td><strong>by deciles of equivalent total household expenditure</strong></td>
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</tr>
<tr>
<td>Spending (£ per week)</td>
<td>10.40</td>
<td>7.53</td>
<td>8.80</td>
<td>9.10</td>
<td>9.50</td>
<td>10.06</td>
<td>10.87</td>
<td>11.34</td>
<td>11.65</td>
<td>12.06</td>
<td>13.05</td>
</tr>
<tr>
<td>Budget shares (%)</td>
<td>7.3</td>
<td>15.8</td>
<td>11.6</td>
<td>8.4</td>
<td>7.4</td>
<td>6.6</td>
<td>6.2</td>
<td>5.5</td>
<td>5.0</td>
<td>4.1</td>
<td>2.8</td>
</tr>
</tbody>
</table>
On the other hand, there seems little difference between budget shares whether the households are classified by income deciles or by expenditure deciles. A broadly similar pattern is observed across deciles, and in the case of domestic fuel expenditures the budget shares differ by no more than one percentage point in all deciles except the highest. In the top expenditure decile budget shares of both domestic fuel and petrol are unusually low, which may reflect the concentration in the top expenditure decile of households making large durables purchases in the survey fortnight; these households would, of course, have lower-than-usual budget shares on other goods.

Why does energy spending appear to be so much higher as a proportion of the income than of the spending of the poorest decile, when such large differences are not observed for any other decile? As Figure 4 shows, all four measures converge closely for the second and higher deciles. The reason could of course be that expenditure smoothing is much more significant for the bottom decile. In this data, however, it can be shown that much of the difference between the income share and the budget share of the bottom decile can be attributed to the influence on the average income share for the bottom decile of a very small number of households with incomes close to zero (and income shares consequently close to infinity). If these households are excluded, the income and budget shares for the bottom decile are found to be much closer (Table 7).

Table 7 also shows that a similar effect is found when the shares are calculated on the basis of group averages, rather than the underlying micro-data. The first two rows of Table 7 (and all of the results shown in Table 6) calculate average budget shares for the decile groups as the average of the budget shares for each household. Formally, the budget share for commodity j of the n households in income group k is calculated as:

$$B_k^j = \frac{1}{n} \sum_{i=1}^{n} \left( \frac{e_{ij}}{\sum_{j=1}^{N} e_{ij}} \right)$$  \hspace{1cm} (1)$$

where $e_{ij}$ is the spending of the ith household ($i = 1...n$) in income group k on commodity j ($j = 1...N$).

The alternative approach taken in the last two rows of Table 7 (and, unavoidably, in the analyses using the published Eurostat data in tables 1-4) is to calculate total spending for the households in the group as a percentage of total spending:

$$B_k = \frac{\sum_{i=1}^{n} e_{ij}}{\sum_{j=1}^{N} e_{ij}}$$  \hspace{1cm} (2)$$

In comparison with the results from the former calculation, use of the latter approach can be seen to understated average budget shares for the bottom income group, whilst being much closer to average budget shares for higher income groups. One reason for this is that the second approach has the effect of reducing the weighting given to the limited number of very high income shares amongst the households in the bottom decile. As noted above, a small number of such observations exert a disproportionate influence on the shares calculated from individual micro-data.
The above results suggest that the choice of income or expenditure in distributional analysis is of rather less consequence with UK data than Poterba (1991) has found for the USA. Whilst the UK results do show a difference in the distributional pattern of energy expenditures between an analysis based on household current incomes and an analysis, perhaps more consistent with a life-cycle income concept, based on current expenditures, the size of the difference is relatively small. Moreover the decomposition given in Table 6 suggests that the divergence largely reflects the use of expenditure rather than income as the denominator in calculating shares rather than the basis on which households are classified into income groups. One implication of this is that analyses using published groupings based on income are unlikely to be seriously at odds with analyses which can reclassify the underlying household micro-data on the basis of expenditure groups.

Whether a similar conclusions can be drawn for the other Community countries covered by the published Eurostat data used in this paper depends on the similarity of both the institutional arrangements which generate income instability (especially how frequent spells of temporary low income are) and the features of the data sources in each country (e.g. their treatment of durables). Nevertheless, if the Community countries are more similar to the UK than to the US, the difference between income and expenditure-based distributional analyses may be rather smaller than in Poterba's results.
6. Distributional aspects of carbon/energy taxes

Table 8 considers the practical effect of further choices in the presentation of the results which are available when micro-data is used, namely the effect of adjustments for household size. It will be seen that over much of the income distribution it makes little difference whether households are classified according to deciles of total household income or equivalent household income, and likewise over much of the expenditure distribution it makes little difference whether the distribution is defined in terms of total household expenditure or equivalent household expenditure. At the top and bottom of the distributions, the effects are, however, more marked. Compared to deciles of total income, using deciles of equivalent income results in a higher expenditure but lower budget share for the bottom decile. The former reflects the fact that average total spending on all items will tend to be higher amongst those households who are classified in the bottom equivalent decile but not in the bottom non-equivalised decile, since the average number of household members will be higher in the bottom equivalent decile. The lower share, despite higher spending, probably reflects the fact that the increase in spending with increasing numbers of household members is less pronounced for fuels (which have a substantial "household public good" element) than for non-fuel spending. A similar effect can be seen in the bottom decile in a comparison of total expenditure and total equivalent expenditure.

1.4 Estimates allowing for changes in energy consumption

Whilst calculations based on the existing pattern of consumer spending can indicate the approximate distributional incidence of taxes on particular goods or services, the approximation is poorer where households respond to the imposition of the tax by changing their pattern of spending away from the taxed items. Where behaviour changes, there are two types of distributional effect that may be of interest - changes in tax payments and welfare costs. The changes in tax payments will usually be less than the changes estimated on the basis of unchanged spending patterns, although they could be greater, if households substituted towards items that were already heavily taxed. The pattern of welfare costs may also be unevenly distributed across households, with poorer or richer households making a greater adjustment in their pattern of spending. The welfare costs will lie below the level of additional tax payments at unchanged spending. If a single tax were involved they would lie above the extra tax paid after changes in consumption are taken into account, although in the case analysed here this may not be the case, since domestic energy and motor fuels would be taxed by a carbon tax at different rates.

This section uses micro-data from the UK Family Expenditure Survey and an existing behavioural model of household spending based on this data to provide greater detail about the distributional impact of the proposed EC tax in the UK, and to assess the quantitative significance of the approximations made in the simple non-behavioural analysis of distributional issues in the previous section.

The model used is the IFS Simulation Program for Indirect Taxes (SPIT), as described by Baker, McKay and Symons (1990). This simulation program is based on micro-data from the UK Family Expenditure Survey (FES). The model which underlies the simulation program is a demand system of the Almost-Ideal type (Deaton and Muellbauer, 1980) estimated for eleven categories of
household expenditure using data from the period 1970-86 (see Blundell, Pashardes and Weber, 1989, for details of the estimation). The Simulation program uses this model and data from the 1988 survey to predict household budget shares for spending on each of the eleven commodities, given an initial vector of relative prices and then computes how these shares change, if specified tax changes are made, and the tax changes feed through fully into relative prices. Household expenditures, tax payments and fiscal revenues are then derived, on the assumption that each household's total spending remains unchanged. Unfortunately, since the model does not satisfy the conditions necessary for integrability it is not possible to present explicit measures of the effect on welfare, although some indication of the difference between tax payments and welfare effects may be gauged from the size of the estimated behavioural changes (which are generally small).

Table 9 illustrates the application of this model to compare behavioural and non-behavioural estimates of the distributional effects of a carbon tax on households' purchases of domestic energy and motor fuels in the UK.

The model of consumer behaviour used in this analysis has been estimated at a rather higher level of commodity aggregation than the underlying micro-data. Only eleven categories of expenditure are included in the simulation model, although domestic energy and petrol expenditures appear separately. The model does not, however, identify domestic energy of different forms - coal, oil, gas, electricity, etc. - and therefore cannot reflect differences in the composition of domestic energy spending of households in different income groups. The simulation of the impact of a carbon/energy tax therefore only reflects effects operating through the impact of the carbon tax on the average price of domestic fuels, and the simulation is thus not able to distinguish between the effects of the carbon/energy tax proposed by the Commission, and other possible taxes - such as a tax on carbon content alone, or a tax on energy content alone - having the same impact on the average price of domestic energy.
<table>
<thead>
<tr>
<th>Deciles of total household equivalent expenditure</th>
<th>All</th>
<th>1</th>
<th>2</th>
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<tbody>
<tr>
<td><strong>Non-behavioural estimate, based on data for individual domestic fuels</strong></td>
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<tr>
<td>£ per week</td>
<td>£2.00</td>
<td>£1.16</td>
<td>£1.42</td>
<td>£1.57</td>
<td>£1.71</td>
<td>£1.93</td>
<td>£2.15</td>
<td>£2.26</td>
<td>£2.43</td>
<td>£2.55</td>
<td>£2.83</td>
</tr>
<tr>
<td>(as % of total spending)*</td>
<td>(1.3%)</td>
<td>(2.4%)</td>
<td>(1.8%)</td>
<td>(1.4%)</td>
<td>(1.3%)</td>
<td>(1.2%)</td>
<td>(1.2%)</td>
<td>(1.1%)</td>
<td>(1.0%)</td>
<td>(0.9%)</td>
<td>(0.6%)</td>
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<tr>
<td>(as % of total spending)**</td>
<td>(1.0%)</td>
<td>(2.2%)</td>
<td>(1.7%)</td>
<td>(1.4%)</td>
<td>(1.2%)</td>
<td>(1.2%)</td>
<td>(1.1%)</td>
<td>(1.0%)</td>
<td>(1.0%)</td>
<td>(0.8%)</td>
<td>(0.5%)</td>
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<tr>
<td><strong>Non-behavioural estimate, based on total domestic fuel spending</strong></td>
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<tr>
<td>£ per week</td>
<td>£2.00</td>
<td>£1.16</td>
<td>£1.42</td>
<td>£1.58</td>
<td>£1.73</td>
<td>£1.93</td>
<td>£2.12</td>
<td>£2.27</td>
<td>£2.43</td>
<td>£2.56</td>
<td>£2.81</td>
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<tr>
<td>(as % of total spending)</td>
<td>(1.3%)</td>
<td>(2.4%)</td>
<td>(1.8%)</td>
<td>(1.4%)</td>
<td>(1.3%)</td>
<td>(1.2%)</td>
<td>(1.2%)</td>
<td>(1.1%)</td>
<td>(1.0%)</td>
<td>(0.9%)</td>
<td>(0.6%)</td>
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<tr>
<td><strong>Behavioural estimate from IFS Simulation Programme for Indirect Taxes</strong></td>
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</tr>
<tr>
<td>£ per week</td>
<td>£1.89</td>
<td>£1.03</td>
<td>£1.28</td>
<td>£1.45</td>
<td>£1.60</td>
<td>£1.80</td>
<td>£1.98</td>
<td>£2.14</td>
<td>£2.31</td>
<td>£2.46</td>
<td>£2.82</td>
</tr>
<tr>
<td>(as % of total spending)</td>
<td>(1.2%)</td>
<td>(2.1%)</td>
<td>(1.7%)</td>
<td>(1.3%)</td>
<td>(1.2%)</td>
<td>(1.2%)</td>
<td>(1.1%)</td>
<td>(1.0%)</td>
<td>(1.0%)</td>
<td>(0.8%)</td>
<td>(0.6%)</td>
</tr>
</tbody>
</table>

Notes: * average of the percentages for individual households, calculated from the micro-data
** average carbon tax for the group as a whole, as percentage of average spending
A carbon tax of $10 per barrel would have increased the price of petrol purchased by households in the UK by some 7% in 1988, and would have increased the price of domestic energy by on average 15%. Within this overall figure for domestic energy, the prices of individual fuels would however change by different percentages, reflecting differences between fuels in the price per unit of energy and in the carbon content per unit of energy. To the extent that the balance of spending on domestic energy between different fuels differs between households, individual households may perceive the carbon tax as increasing the price of domestic energy by a greater or smaller percentage than the average of 15%, depending on the weighting of individual fuels within their own consumption.

As in the previous section, it is possible for these household-specific consumption weightings to be reflected in a non-behavioural estimate of the distributional impact of a carbon tax, by applying the relevant price increases for individual domestic fuels to each household’s spending on each fuel. An estimate of this sort is made for Great Britain in the first of the three estimates shown in Table 9. This suggests that the average weekly payment of carbon tax would be £2.00, equivalent on average to 1.3 per cent of household spending. Amongst the households in the bottom decile the average carbon tax payment would be £1.16, three fifths of the average across all households, and on average this tax payment would be about 2.4 per cent of spending. In the top decile, the average payment of carbon tax, £2.83, would be 40 per cent higher than for the average household, but a much lower percentage of total spending - only 0.6 per cent.

These figures for the carbon tax as a percentage of spending cannot be directly compared with those in Table 2 because the budget shares in Table 9 are computed using data for each individual household to compute the budget share for each household, and then the average across households in the relevant group. Calculations made on the basis of group averages, as is unavoidable in the analysis of the Eurostat data, would tend to show slightly lower percentages for budget shares especially across all households and in deciles within which there is a substantial range of total spending, since households with lower spending (and hence, on average, higher budget shares) are given lower weight in such a calculation. Figures calculated on this different basis are also shown in Table 9, and show an overall percentage close to that calculated using Eurostat data (Table 2).

Given the level of aggregation at which the simulation model is estimated, it is not possible to reflect household-specific differences in the pattern of consumption of different domestic fuels in the estimates made using this model. Although households will, in practice, experience different changes in the average price of domestic energy, reflecting the weighting of individual fuels in their own consumption, the effects of changes in the relative prices of different fuels cannot be simulated. Regardless of whether household-specific or general price indices are used, some approximation will inevitably be involved. Given that the scope for substitution between fuels may be comparatively important, relative to the scope for substitution between domestic energy as a whole and other goods, the approximation errors may be smaller if the simulation uses general price indices, rather than those that reflect the household-specific pattern of energy consumption.
One implication of this is that the behavioural estimates from the simulation model cannot be directly compared with the non-behavioural estimates which appear as the first line of Table 9. A second non-behavioural estimate is therefore shown in Table 9, based on the same data, but applying the average price change for domestic fuels as a whole, rather than the price changes for individual fuels. In practice, it can be seen that across the groups shown this makes little difference to the estimates.

Comparing this estimate with the results from the simulation model shown at the bottom of Table 9 shows the effects of taking the behavioural responses of consumers into account in estimating the distributional pattern of carbon tax payments. Overall, the effect of allowing for consumption responses is comparatively small; carbon tax payments are some 5.5% lower than if no account is taken of behavioural responses. The percentage difference is greater (about 11 per cent) for the poorest decile than further up the income distribution.

Table 10 returns to the earlier discussion of the choice between income and expenditure in presenting distributional analyses. Here the behavioural estimates are shown on two bases, firstly (as in Table 9) using expenditures as the denominator in calculating the tax burden, and classifying households by deciles of equivalent household expenditure, and secondly, using gross household income both as denominator and to classify households to decile groups. Use of the latter basis tends to make the carbon tax appear somewhat more regressive than on the former, expenditure, basis, but the differences are far smaller than in Poterba's US estimates shown in Table 5.

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6 There is some evidence that poorer households in the UK are more likely than the average to use electric central heating, which is both more expensive and more carbon-intensive than gas central heating (Johnson, McKay and Smith, 1990). However, the overall pattern of energy use, and not just for domestic heating, displays relatively small variation across income deciles.

7 The results reflect the overall balance of substitution between domestic fuel, petrol and the nine other spending categories, and (since two different commodities, energy and motor fuels, are taxed by a carbon tax, and taxed at different rates) it is possible for the estimates to be less than or greater than the non-behavioural results; the latter result is found for the top decile.
6. Distributional aspects of carbon/energy taxes

Table 10.
Average carbon tax payments, based on a carbon tax equivalent to $10 per barrel: comparison of income and expenditure as the measure of household living standards. Great Britain, 1988.

Weekly expenditures in pounds, income shares as percentages of household gross normal income, budget shares as percentages of total household expenditure

<table>
<thead>
<tr>
<th>Deciles of total household income or expenditure</th>
<th>All</th>
<th>1</th>
<th>2</th>
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<th>10</th>
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</thead>
<tbody>
<tr>
<td>£ per week (as % of total spending)</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>£1.89</td>
<td>(1.2%)</td>
<td>£1.03</td>
<td>£1.28</td>
<td>£1.45</td>
<td>£1.60</td>
<td>£1.80</td>
<td>£1.98</td>
<td>£2.14</td>
<td>£2.31</td>
<td>£2.46</td>
<td>£2.82</td>
</tr>
<tr>
<td>£1.26</td>
<td>(1.7%)</td>
<td>(1.3%)</td>
<td>(1.2%)</td>
<td>(1.2%)</td>
<td>(1.1%)</td>
<td>(1.0%)</td>
<td>(1.0%)</td>
<td>(0.8%)</td>
<td>(0.8%)</td>
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<tr>
<td>£1.45</td>
<td>(1.7%)</td>
<td>(1.3%)</td>
<td>(1.2%)</td>
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<td>(1.1%)</td>
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<td>(0.8%)</td>
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<tr>
<td>£1.60</td>
<td>(1.3%)</td>
<td>(1.2%)</td>
<td>(1.2%)</td>
<td>(1.1%)</td>
<td>(1.0%)</td>
<td>(1.0%)</td>
<td>(1.0%)</td>
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by decile groups of gross household income

| £ per week (as % of gross income)               |     |     |     |     |     |     |     |     |     |     |     |
| £1.89                                          | (1.1%) | £1.01 | £1.26 | £1.42 | £1.56 | £1.82 | £2.00 | £2.07 | £2.19 | £2.52 | £3.03 |
| £1.01                                          | (3.4%) | (1.7%) | (1.3%) | (1.0%) | (0.9%) | (0.8%) | (0.7%) | (0.6%) | (0.5%) | (0.4%) | (0.4%) |
| £1.26                                          | (1.7%) | (1.3%) | (1.0%) | (0.9%) | (0.8%) | (0.7%) | (0.6%) | (0.5%) | (0.4%) | (0.4%) | (0.4%) |
| £1.42                                          | (1.7%) | (1.3%) | (1.0%) | (0.9%) | (0.8%) | (0.7%) | (0.6%) | (0.5%) | (0.4%) | (0.4%) | (0.4%) |
| £1.56                                          | (1.3%) | (1.0%) | (0.9%) | (0.8%) | (0.7%) | (0.6%) | (0.5%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) |
| £1.82                                          | (1.0%) | (0.9%) | (0.8%) | (0.7%) | (0.6%) | (0.5%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) |
| £2.00                                          | (0.9%) | (0.8%) | (0.7%) | (0.6%) | (0.5%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) |
| £2.07                                          | (0.8%) | (0.7%) | (0.6%) | (0.5%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) |
| £2.19                                          | (0.7%) | (0.6%) | (0.5%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) |
| £2.52                                          | (0.6%) | (0.5%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) |
| £3.03                                          | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) | (0.4%) |

Note: results from the IFS Simulation Programme for Indirect Taxes.
1.5 Wider distributional effects of carbon/energy taxes

In addition to the direct distributional effects working through the prices of household purchases of domestic energy and motor fuels, a carbon tax applied to all fuels would have a number of indirect distributional effects, as a result of the taxes imposed on industrial purchases of energy. These indirect effects reflect the fact that the ultimate incidence of all taxes is on households - the burden of taxes on business can in principle always be traced to the households or individuals who are the shareholders or owners of each business, or to its suppliers, employees or customers. Which of these various groups shoulders the ultimate burden of any tax, and what place they occupy within the income distribution, will thus determine the distributional incidence of taxes on industrial inputs.

If higher prices for industrial energy inputs are passed on to consumers in the form of higher prices for industrial outputs, there will be distributional effects amongst households of a similar sort to the direct effects discussed above. These effects have been studied, for example, by Common (1985) and Symons, Proops and Gay (1991) using input-output tables to translate changes in energy prices into changes in the relative prices of different outputs. This approach makes the strong assumption that there will be no factor substitution in production, although this may be a reasonable approximation in the short-term. Common (1985) uses input-output tables for 1974 to estimate the distributional impact of a doubling of primary energy prices in the UK. With the exception of the effects on the prices of fuels purchased by consumers, the effects on consumer prices are comparatively modest and even; only in the case of public transport and the category "other household goods" do the simulated price increases exceed 5 per cent, and the only prices to rise by less than 2 per cent are those for housing, communications services and domestic service. The increase in the price of domestic energy alone accounted for about half the overall increase in consumer prices, and also had a more regressive impact than the overall price change. Symons, Proops and Gay (1991) present estimates of the effects on consumer prices of a carbon tax at various levels, based on the 1984 UK Input-Output tables. These prices are then used as inputs to a microsimulation model of consumer spending to derive effects on household tax payments by income decile. A carbon tax of 6p per kilo (ECU 90 per tonne) has "dramatic adverse distributional effects" on low income households, although the extent to which these are due to the indirect effects rather than the direct effects is not discussed.

Unless all of the burden of the carbon tax on energy inputs can be passed on in higher prices, without any change in the pattern of consumers' expenditure, at least some of the burden of the tax will be borne by the owners of the different factors of production, including capital, labour and natural resources, especially energy resources. One obvious possibility is that at least part of the carbon tax on energy will be borne by the owners of reserves of carbon-based energy sources, as a result of lower pre-tax prices for carbon-based energy, and the profitability of existing extraction activities may fall. Changes in the profitability of extraction activities will affect the real incomes and wealth of the households owning shares in resource extraction businesses. The profitability of other firms may change too, especially if consumer demand switches away from energy-intensive goods and services, and this may affect the profits received by their owners, and the wages and
6. Distributional aspects of carbon/energy taxes

employment prospects of their employees. Depending on the complementarity or substitutability of different factors in production, effects could be felt on the return to capital and labour even outside the sectors directly affected.

The balance of these various effects on the distributional incidence of taxes on industrial energy inputs cannot be predicted a priori. Some important considerations affecting the strength of different effects include:

1. the degree of monopoly in factor and product markets.

2. international competition. Whether carbon taxes are introduced at the same time in competitor countries will affect both the ability of EC firms to pass the tax on in prices, and the impact of the carbon tax on the world price for energy, and hence on the incomes and wealth of the owners of energy resources.

3. the degree of substitutability of different factors in production. If firms are able to substitute away from carbon-based energy towards alternative factors of production, they will reduce the increase in the prices of energy-intensive products that would otherwise occur. The change in factor demands would then affect the relative prices of different factors, tending to reduce the returns to the taxed factor, carbon-based energy, and to increase the returns to its substitutes. Since the scope for substitution is generally believed to be quite low in the short-term, but to increase as existing plant is replaced, this suggests that the distributional incidence of a carbon-tax could change over time.

4. speed of adjustment. The more that consumption patterns change, the greater the necessary adjustment in the pattern of production, and the stronger are likely to be the distributional effects of reduced profits (quasi-rents) in existing firms, and possible temporary unemployment.

To quantify the full range of effects set out above would require a comprehensive general equilibrium model, based on detailed information about consumer demands, and the substitutability of different factors in production. Many of the key behavioural and technical parameters are unknown, and those estimates that exist are often subject to a wide margin of error.

2. Policy responses to the distributional effects of a carbon/energy tax

A carbon/energy tax at the full $10 per barrel level proposed by the EC would raise substantial fiscal revenues, equivalent to, on average, some 3% of total tax revenue in the member states. Introduction of a new tax on this scale would present fiscal policy-makers with considerable opportunities to use the revenues to facilitate major reforms in other aspects of the tax system, or

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8 There is an existing literature on whether co-ordinated energy taxation by energy-consuming countries can appropriate some of the rents being earned by energy-producing countries - see for example Eyckmans and Proost, 1991.

9 See for example Ingham and Ulph, 1990.
in public revenues and expenditures more widely. Thus, for example, in Sweden, carbon tax revenues were used to allow large reductions in marginal tax rates on labour income, and the carbon tax was seen as having both an environmental and a fiscal policy rationale (Bohm, 1993).

The revenues raised by the carbon tax also provide considerable scope for parallel policy measures to be taken to offset undesired distributional effects, where these would arise from the higher level of energy taxation.

The results presented in this paper indicate that the extent to which introduction of a carbon/energy tax would raise significant equity issues seems likely to vary amongst the member states of the Community. In broad terms, the distributional incidence of the tax is the sum of two components - an additional tax on motor fuels which appears to have a mildly progressive (or, at worst, broadly proportional) incidence across income groups and a tax on domestic energy which, in some member states, appears to be quite sharply regressive. The overall distributional incidence of the carbon/energy tax in each country depends on the relative weight of these two components, given by the importance of each in consumer spending. The overall distributional incidence of the carbon/energy tax appears to be broadly proportional to income in most member states, but in countries where spending on energy is large relative to spending on motor fuel, either because motor fuel spending is a relatively small part of total consumer spending, or because for climatic or other reasons domestic energy spending has more of the character of a necessity, the carbon tax would have an overall regressive distributional incidence.

On the basis of the estimates in the previous section, the EC carbon/energy tax would appear likely to have significant regressivity in both the UK and Ireland, whilst in the other five member states fewer - or, at least, more limited - distributional issues would appear to arise. The discussion of distributional issues in this section is largely directed at the policy issues in countries such as the UK and Ireland where the overall distributional incidence would be regressive, although some of the issues raised may be of wider applicability.

The overall distributional incidence of the introduction of an EC carbon/energy tax will depend both on the pattern of carbon/energy tax payments and on the use of the carbon/energy tax revenues. The appropriate incidence concept, in a situation where the tax would be introduced on a revenue-neutral basis, is the concept of differential incidence - in other words, the difference between the distributional incidence of the carbon/energy tax, and of the offsetting tax reductions. The choices that are made on the use of the revenues can have a critical impact on the overall distributional effects that would follow introduction of the EC carbon/energy tax.

### 2.1 Lump-sum revenue return

It is relatively straightforward to see that there are ways in which offsetting tax changes could be made that would, on average, return more to the poorest income groups in the population than they would pay in carbon/energy tax. Since the carbon/energy tax payments rise, in absolute (money) terms, with income, returning the revenues in the form of an equal lump-sum amount to all households would on average more than compensate low-income groups, in terms of tax
payments, for the carbon/energy tax. Thus, for example, in the case of the UK figures shown in Table 9, the average carbon/energy tax payment per household is estimated at £1.89 per week. The total revenue derived from the tax is thus capable of financing an equal payment of the same amount, £1.89 per week, to all households. Since the carbon/energy tax payments of the bottom decile are, on average, only £1.03 per week, this lump sum of £1.89 per week would exceed the average carbon/energy tax payments of this group. Similarly, the lump-sum return of revenues would exceed the average carbon/energy tax payments of the bottom five deciles. The overall distributional incidence of tax payments from a policy package consisting of the carbon/energy tax plus lump-sum return of revenues would be progressive.

It will be noted that the claim made for a policy involving lump-sum return of revenues is limited to the observation that it would be adequate to compensate poorer household groups, on average, in terms of the amount of tax they pay; the policy does not necessarily compensate poorer households sufficiently to ensure that the effect of the carbon/energy tax on their overall welfare is positive. The poorest deciles would be likely to experience both the largest increases in tax payments as a percentage of income, and also the largest volume reductions in energy consumption as a percentage of initial consumption. The economic costs associated with induced reductions in energy consumption are therefore also likely to higher for poorer households than for better-off households.

2.2 Problems with lump-sum revenue return

Nevertheless, whilst a policy package combining the EC carbon/energy tax and equal lump-sum return of revenues seems likely, in principle, to leave households in the bottom deciles of the income distribution better-off on average, in terms of tax payments and, probably, economic welfare, than before the reform, a number of difficulties may be observed with compensation through an equal lump-sum payments to all households.

(i) Failure to maximise potential efficiency gains

Firstly, using the revenues from the carbon/energy tax to pay for lump-sum compensation to each household will tend to require that the tax revenues are returned in ways which do not maximise the potential benefit in terms of greater economic efficiency in taxation.

If the distributional incidence of taxes is thought of in terms of a simple linearisation of the relation between income and tax payments, so that tax payments consist of a lump-sum component ("intercept") and an income-related component ("gradient"), then the relationship between distributional compensation and efficiency may be seen in the following way. Introduction of a regressive tax increases the intercept component in the relationship between income and tax payments. Offsetting the additional regressivity so as to leave the distributional incidence of the overall tax system no more regressive than before requires that the package of tax reductions should reduce the intercept component by at least as much as this initial increase. Returning all
of the revenues from a carbon tax as an equal lump sum per household would clearly satisfy this requirement, but any package of tax reductions achieving a gradient-to-intercept ratio at least as high as that of the carbon tax would suffice to offset the regressive incidence of the new tax.

**Figure 5**

**Distributional incidence of the use of carbon tax revenues**

Great Britain, 1988

The revenues from the carbon tax would have an opportunity cost, in the sense that if they are not used to offset the regressive distributional incidence of the tax, they could be deployed in ways which would reduce the overall efficiency costs of raising tax revenues. Whilst the existence of a "double dividend" from environmental taxes, in terms of both a reduction in environmental damage and a reduction in the distortionary cost of taxation has been contentious (Goulder, 1995), it should be clear that using the revenues raised from an environmental tax to reduce the rates of distortionary
6. Distributional aspects of carbon/energy taxes

taxes will reduce the deadweight costs of taxation, by comparison with a situation where the
revenues are simply returned as a lump sum to taxpayers\(^\text{10}\). Generally speaking, economic
efficiency would be maximised by the use of the revenues from environmental taxes to permit
reductions in the rates of other taxes, and hence in the gradient of the linearised relationship
suggested above, rather than in the lump-sum, "intercept" component of these taxes. However,
reducing the rates of other taxes in the system will generally be ineffective at compensating poorer
households for the additional environmental tax payments, since most tax payments are made by
better-off households. This should be clear from Figure 5, which contrasts the distributional effects
of two possible patterns of revenue return, which may perhaps be seen as representing a reduction
in the intercept term, and gradient respectively:

- In the first case, the revenues raised from the carbon tax are used to finance a lump-sum
  for each household (the horizontal line); this is more than sufficient to compensate for the
  carbon tax payments of households in the bottom five deciles.

- In the second case, the revenues are used to permit a general reduction in all tax rates.
  In Figure 5 the distributional incidence of a proportionate reduction in all rates of income tax,
national insurance contributions, VAT and excise duties is shown, with an aggregate revenue
cost equal to the yield from the carbon tax. This provides little compensation to the poorest
households, since they pay little tax to begin with, whilst providing better-off households with
a substantial reduction in their tax burden, more than offsetting the carbon tax they would
pay. Taken together with the carbon tax, this form of tax reduction would have a sharply
regressive distributional impact; the share of poorer households' incomes paid in tax rises,
whilst the share of richer households' incomes paid in tax falls.

The implication of this is that revenue uses which would maximise the scope for reductions in the
distortionary cost of taxation will generally require a pattern of tax adjustments which run counter
to those that would needed to rebalance the distributional incidence of the tax system. Using
revenues for compensation will then typically fail to maximise the potential efficiency gains that
would be available. It is, however, far from clear that there is much scope for efficiency gains
without accepting, at the same time, a more regressive distributional incidence to the tax system.
If initial policy optimises the tradeoff between equity and efficiency goals, the introduction of a
carbon tax does not significantly alter the attainable points on that tradeoff, and the scope for
"double dividend" efficiency gains may be small.

\(^\text{10}\) It is considerably less clear that levying an environmental tax, and reducing the rates of other taxes, will both improve
the environment and reduce the distortionary costs of taxation by comparison with the initial situation. As Bovenberg
and de Mooij (1994) have made clear, environmental taxes may, themselves, have effects on the labour market which
may be non-trivial.
(ii) Practical complexity of paying equal amounts to all households.

Second, it may be difficult in practice to achieve an exactly equal lump-sum return of revenues to all households; there is no single parameter of the taxation or social security system which can be adjusted so as to pay an equal lump sum to all households. Nevertheless, it may be possible to achieve a satisfactorily close approximation to an equal return of revenues through a package of measures involving increases in social security benefit levels, increases in the state pension level, and increases in income tax allowances; although some households would be affected by more than one of these, and others (such as single working adults with low incomes) may benefit from none, the overlaps and omissions would be relatively limited (Johnson, McKay and Smith, 1990).

However, it will almost certainly be impossible to make an equal lump-sum return of revenues in a way which conforms to the Commission's requirement of revenue neutrality through tax reductions alone; increases in income tax allowances will not benefit those households with insufficient incomes to be paying income tax, and it would be difficult, if not impossible, to design changes to VAT or other taxes on expenditures which would give an equal amount back to all households. It will be necessary, if an equal lump-sum return of revenues is to be made, that the return of revenues is in part made through increases in public expenditures on state pensions and other social security benefits. This is perhaps not a serious problem, except in a presentational or a semantic sense; there is little economic significance in the distinction between making transfers to households through a reduction in taxes or through an increase in benefits. Nonetheless, there may be political difficulties in deviating from the commitment that the Commission has made that the carbon/energy tax should not result in an increase in the overall burden of taxation in member states.

(iii) Compensating social security benefit recipients.

A third issue is the potential cost of a uniform lump-sum payment to all households. Since public policy is likely to be concerned more about some households (eg the poor) than about others, is it possible to target the return of revenues so that it does not absorb all of the revenue raised from the tax? One possibility would be to seek to limit the offset to existing recipients of social security benefits. This could then be provided by raising benefit levels by an amount that would compensate for the additional taxes on energy.

The precise effects of benefit changes on the resources provided to individual households will depend on the structure of the benefit system.

For example, if social security benefits take the form of some guaranteed minimum subsistence level of income, provided to those with no resources of their own, this subsistence minimum could be increased by an amount which would reflect the additional energy spending of a household living at the subsistence level. An adjustment of this sort would, in principle, provide full compensation for households wholly dependent on social security benefits.
However, in addition, many social security systems seek to provide some level of support to households with some resources of their own; thus, for example, households with low levels of earned income may benefit in the UK system from Family Credit, which provides a level of assistance, calculated on the basis of an income-related "taper". A household's entitlement is a function of the maximum amount payable, a threshold below which the maximum is paid, and a rate of withdrawal as income rises above the threshold level. If the system is adjusted to compensate for higher energy prices by increasing the maximum amount payable, whilst keeping the rate of taper constant (to avoid increasing the overall marginal rate at which income is withdrawn), the effect would be to compensate households receiving full and partial benefit by the full amount of the increase in the basic benefit level. In addition some households previously not entitled to benefit would now have an entitlement to a small amount of benefit providing partial compensation for the higher tax. If the density of the income distribution is high at this point, the rise in the benefit amount could lead to a substantial increase in the numbers of recipients entitled to benefit (and in the consequent administrative cost).

In part, social security changes of this kind may be achieved "automatically" if benefit levels are indexed to the price level. As Crawford, Smith and Webb (1993) discuss, in the context of policies to extend VAT to domestic energy in the UK, there are two main reasons why indexation of social security benefit levels would, in practice, be unlikely to provide adequate compensation to social security benefit recipients in the UK for their average additional energy spending.

One is simply an issue of timing. If indexation is based on past, rather than current, price changes, social security benefit levels will not be adjusted immediately to reflect the higher price of energy. This lag is exacerbated in the UK system by making an annual indexation adjustment in April on the basis of the inflation rate over the twelve months to the previous September; thus price changes are not reflected in benefit indexation for at least 6 months, and on average 12 months, after they take place. It is clear that if the indexation lag were regarded as a problem, it could easily be dealt with, in the case of predictable price increases due to taxation changes, by some form of anticipatory inflation adjustment, to take effect at the same time as the tax increase.

The second deficiency of indexation is that social security benefits are indexed on the basis of a price index which does not reflect the importance of energy in the spending of benefit recipients. Benefit levels in the UK are indexed by the general index of retail prices, which is weighted by the average spending pattern of non-pensioner households. The index used therefore does not reflect the particular circumstances of benefit recipients, for at least three reasons: pensioners (who represent a large proportion of benefit recipients) are not included in the index; using an index which includes the spending of better-off households reduces the importance of energy in the index; and, because the spending of the poor is lower, their spending pattern is naturally under-weighted in an index weighted by average household spending.
(d) Adequacy of compensation based on average spending.

A fourth issue is whether compensation based on the average spending of households in a particular group should be regarded as adequate. The equal lump-sum amount paid to all households is more than enough to compensate households in the bottom decile of the income distribution for the additional taxes they would pay, on average. However, the adequacy of the lump sum as compensation for individual households within the decile will vary; households spending less than the average on energy will be significantly over-compensated, whilst those spending much more than the average on energy will find that the lump sum is less than the amount of the additional taxes they pay. The next section discusses how far the position of individual households around the decile averages should be a concern for policy, and, to the extent that it should be, what form of offsetting policy measures might be then be required to reflect the variation in the effects on individual households.

2.3 Differences between households and their relevance for distributional policy.

Table 11 shows that there would be substantial variation around the average in the adequacy of uniform lump-sum compensation, especially where the compensation merely returns the average carbon tax paid by the bottom decile (£1.03 per week) rather than the total revenues (equivalent to £1.89 per week per household). This reflects the range of energy spending of the households within each decile group.

Thus, for example, although compensation through a lump sum payment of £1.03 per week would on average exactly offset the additional tax payments of households in the bottom decile group, it would lead to appreciable gains or losses (in excess of 0.5 per cent of gross household expenditure) for about two thirds of households in the group. About one quarter of households would find that the compensation fell short of the additional tax by more than 0.5 per cent of their gross spending, whilst about 40 per cent would be over-compensated by more than 0.5 per cent of gross spending. A lump sum compensation payment of £1.89 per week, equal to the average additional tax payment over all households, would increase the proportion of households in the bottom decile gaining more than 0.5 per cent of total spending to some 85 per cent; only one household in twenty in the bottom decile would then be under-compensated by more than 0.5 per cent of total spending.

Four main issues are raised by these results:

(a) Seasonality and infrequency in the data.

Firstly, it is possible that at least part of the variance in tax payments may not reflect long-run differences in the underlying levels of energy spending of different households, but may arise from two features of the data. The data in the UK Family Expenditure Survey data used in this analysis do not show the fuel expenditures of households over the course of an entire year, and seasonal
6. Distributional aspects of carbon/energy taxes

### Table 11.


<table>
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<th>Ranges of net gain, as percentage of gross household expenditure</th>
<th>Percentages of all households in decile</th>
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<td>All</td>
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<tr>
<td>(a) Lump sum equivalent to £1.03 per week:</td>
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</tr>
<tr>
<td>Gain exceeds 5%</td>
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<tr>
<td>2%..5%</td>
<td>1</td>
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<td>3</td>
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<tr>
<td>-5%..-2%</td>
<td>2</td>
</tr>
<tr>
<td>exceeds -5%</td>
<td>0</td>
</tr>
<tr>
<td>(b) Lump sum equivalent to £1.89 per week:</td>
<td></td>
</tr>
<tr>
<td>Gain exceeds 5%</td>
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<tr>
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<td>Loss -1%..-0.5%</td>
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<tr>
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<td>3</td>
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<tr>
<td>-5%..-2%</td>
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</tr>
<tr>
<td>exceeds -5%</td>
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Note: estimates of carbon tax payments from the IFS Simulation Programme for Indirect Taxes (as in Table 5.2). "Second round" effects of lump sum return of revenue on consumer spending and hence on carbon tax payments are likely to be small, and are ignored.

variations in energy spending or a pattern of infrequent purchases could give rise to differences in the recorded spending of households in the survey that do not reflect underlying differences in their consumption of energy.

There are, however, reasons to believe that the amount of variation in spending arising from the period over which the data is recorded is likely to be relatively small. Certainly, in the case of household spending on domestic energy the length of the period to which data refer is generally rather greater than the two week period during which households keep diary records of most other spending.
Spending data in the FES relating to gas and electricity supplies is generally based on the most recent bill received; since households are normally billed quarterly in arrears this will be a bill for a three month period, ending at some time in the past three months. Some households also pay according to budget payment plans, in which energy spending is evenly spread throughout the year. As Crawford, Smith and Webb (1993) show, this pattern of billing is reflected in a small seasonal variation in total domestic energy spending in the UK, with month-by-month figures for total energy spending fluctuating within a band of ten per cent or so around the annual average.

Some households pay for gas and/or electricity through a slot-meter system. In the case of these households, the information recorded in the FES relates to their spending on the meter during the two week diary period only. Since, however, such meters frequently over-charge relative to the final bill due, an adjustment is made periodically, in the form of a refund. The FES records a weekly amount based on the refund for the previous year, and this is subtracted from the meter payments recorded over the diary fortnight. It is probable that there will be a clear seasonal pattern to meter payments, whilst the refund amounts will not reflect any seasonal variation in payments.

For spending on energy other than electricity and gas, such as purchases of motor fuel, and in the case of some households, purchases of domestic fuels such as bottled gas and coal, the data in the FES are based on spending during the diary fortnight. Spending on motor fuel is likely to show some spurious variation due to the short period for which the diary is kept, although this is probably relatively small; the size of motor fuel purchases is limited by the capacity of the fuel tank of motor vehicles. Spending on coal and other storable domestic fuels may however take the form of infrequent purchases of stocks of fuel intended to last for a period of time, and the two-week period may well be insufficient to record the average level of such spending. Many households will record no spending of this sort, even if at some time during the year they do make occasional large purchases. On the other hand, those households recording such spending will typically record large amounts, to cover more than just the diary period. On average, the correct amount of spending will be recorded, although there will be much greater variation in the recorded spending of individual households than there would be if the spending were recorded over the whole year. Any seasonal pattern in purchases of these fuels will be expected to be reflected in the FES data.

Crawford, Smith and Webb (1993) show that the effect of correcting for the seasonality in the recorded pattern of household purchases of domestic energy in the UK Family Expenditure Survey is rather small. Average household spending on domestic energy was £12.25 in 1991, with an unadjusted standard deviation of £7.70 and a seasonally-corrected standard deviation of £7.59. They conclude that most of the reasons for individual variation in spending arise due to factors other than seasonal fluctuations in spending; the reasons for the variation observed would therefore appear mainly to do with other factors, which could include infrequency of purchase and household differences in needs and preferences for energy consumption.

Infrequency will mainly affect purchases of coal and domestic heating oil. Unfortunately the data does not permit an assessment of the importance of such infrequency. It is not known how frequently the households recorded as making purchases in the two week period make purchases of fuels, and it is not therefore possible to gauge how many other households, recorded with low purchases in the two-week period of the FES, actually made large purchases in another period.
6. Distributional aspects of carbon/energy taxes

(b) The relative importance of needs and preferences in the variance of household spending.

Secondly, where there are genuine long-term differences in the level of spending of different households in the same decile group, the key issue for policy is to identify what gives rise to the variation. In particular, are the differences in household energy spending simply a reflection of different preferences, or a reflection of differences in needs for energy spending? Where the observed differences in household spending and carbon/energy tax payments reflect the former, it is difficult to see any case for households with above-average spending to be compensated for their above-average tax payments. If some households in the bottom decile spend more on the decile average on domestic energy, for example, simply because they have a stronger preference for warmth relative to other goods and services than other households in similar economic circumstances, there is no obvious for this to be treated any differently in distributional policy than any other difference in preferences between households.

On the other hand, household spending patterns may also reflect differences in needs, and a distributional policy aiming either to provide a given minimum standard of living or to narrow differences in standards of living between poor households and the average may need to provide greater assistance to households with higher needs. Thus, differences in energy spending may reflect various household characteristics affecting the need for energy spending. The elderly, for example, may have a need for more spending on heating, both because they are at home more of the day than the working population, and because of their greater vulnerability to the cold. There may be important regional differences in energy spending needs, reflecting both differences in climate\(^\text{12}\), and differences in the cost of supply in different areas\(^\text{13}\). Also, residential accommodation may differ in insulation and thermal efficiency; older houses may require greater energy inputs than new houses to reach the same internal temperature. Some of these differences between houses may reflect the operation of various possible market failures in energy efficiency, including a lack of information, poor incentives in rental property, current income constraints, "myopia" and, perhaps, "irrational" behaviour by certain consumers\(^\text{14}\).

The above arguments concerning the variation in needs for energy spending between households simply concern the provision of adequate financial resources to enable households to purchase sufficient energy, given their needs for energy. It is possible, however, that public policy may seek to do more than this, and may be concerned about the actual amounts of energy consumed by poorer households. Concern of this sort may arise for two reasons.

\(^{12}\)Climatic differences appear to underpin a substantial proportion of the variation in domestic energy consumption across member states of the Community.

\(^{13}\)Note that the cross subsidy obligations imposed in the past on nationalised industries tended to limit the variance in supply costs between households, with the effect that public policy did not, in most cases, need to address the issue of assessing the effect of differences in supply costs on defining differences in households' needs for energy and for the products of other nationalised utilities. In a privatised utilities industry it becomes more difficult for government to enforce such cross-subsidy obligations, and supply costs are likely to become increasingly divergent between different groups of customer.

\(^{14}\)See Chapter 8 and Brechling, Helm and Smith (1991).
6. Distributional aspects of carbon/energy taxes

One may be simply a "paternalistic" view of distributional policy; the objectives of society may not be formulated in terms of the provision of adequate income, but may take the form of concern about the actual consumption by poorer households of certain merit goods, one of which may be energy. Whilst economic policy-makers have tended to be sceptical about arguments for intervention taking this form (on the grounds that provision of income rather than the equivalent value of goods will always provide households with at least as much benefit, and possibly more), it is possible that the objectives of policy-makers could take this form (Dilnot and Helm 1987). Thus for example public policy might be concerned specifically with the amount of heating available to certain groups of the population such as the elderly, and with avoiding deaths from hypothermia, rather than with the provision of additional financial resources to the elderly more generally.

A second group of reasons for concern about the actual consumption of energy by poorer households is that the constraint on household consumption patterns which induces them to purchase inadequate amounts of energy may not be a direct income constraint at all. Thus, for example, low-income elderly households may be particularly averse to exposing themselves to the risk of unexpectedly high fuel bills, and may keep their energy spending low, not because they could not afford more energy, but because they wish to minimise the risk that their energy bills will turn out to be unexpectedly high. In these circumstances, merely providing poor elderly households with more income may not induce much increase in energy consumption; however, relatively inexpensive measures targeted at the underlying unpredictability of energy bills (such as provision of continuous slot-metering) may be more effective.

(c) Targeting and the observability of needs.

If there are indeed differences between households in the need for energy spending, and if the variation in needs is seen as a concern for policy, can the differences in need be compensated effectively through financial transfers? This depends, in practice, on the amount and type of information required to identify which households have above-average needs. If the factors governing household needs for energy are observable, then it is possible for social security to be targeted to those households with high need. On the other hand, if households' energy needs are cannot be observable (or can only be observed at prohibitive cost), a policy based on targeted compensation may be ineffective, and an alternative approach may be required.

In some circumstances, as Blackorby and Donaldson (1988) have shown, free (or cheap) supply of goods may lead to more effective targeting than the provision of cash compensation, as households with high needs effectively self-select for high levels of (subsidised) consumption. Of course, households with low needs but a strong preference for the good will also benefit from a policy of cheap supply. Public policy then has to weigh the potential efficiency gain from more efficient targeting against the efficiency loss from providing goods at less than their resource cost; only where the latter is small relative to the former will targeting through a low price and self-selection be worthwhile.
The practical relevance of this line of argument turns on whether the unobservable differences in household needs for energy are large relative to other factors which affect the energy consumption of individual households, such as income and preferences. Across the population as a whole, it is perhaps unlikely that this condition would be satisfied; it would seem plausible that much of the variance in household consumption could be related to observable factors, such as region, numbers of people in the household, their ages, and their employment status, all of which are already - or easily could be - used to target benefit payments. The remaining, unobservable, sources of variation are likely to be comparatively small, on average, and insufficient to justify the efficiency cost of providing energy at a price below its full social cost. On the other hand, there may be a case for suggesting that, amongst certain groups, unobservable sources of differences in energy consumption are rather larger; thus, for example, amongst the elderly the amount of energy required will be greatly affected by their degree of physical activity, which could be only partly observed by the social security system.

It would be possible to design systems of cheap energy supply targeted at the elderly, providing energy at below its full marginal social cost to households on the basis of the number of elderly residents. The low price could apply to all units of energy supplied to such households, or to all units up to some limit of \( n \) units per quarter, after which the standard price would apply. The latter might be appropriate if it is believed that very high spending mainly reflects preferences rather than needs. (Note, however, that unless \( n \) is set above the consumption of at least some households it is equivalent to a simple cash transfer.) Clearly there would be a substantial administrative cost in implementing such arrangements, which would have to be weighed up against the potential greater target efficiency of the overall social security system in this area.

Cheaper energy for individuals with high needs could be implemented through various forms of adjustment to the tariff structure for domestic energy supplies. Most utilities supply individual customers according to a tariff of charges which includes both a fixed "connection" cost, unrelated to the amount consumed, and a variable charge levied on each unit used.

From the point of view of environmental policy, externalities associated with energy consumption should be reflected in an increase in the cost of energy consumption at the margin. The distributional problem arises because higher energy taxes increase the cost of marginal consumption by increasing the cost of all units consumed. It might be possible to reduce, or eliminate the distributional problem by measures which increase the marginal cost of consumption, whilst reducing the average cost, either through a reduction in the fixed cost element, or by reducing the price for an initial "allowance" of a given number of units.

In countries where utilities are in public ownership under close government control, "non-commercial" objectives, including social objectives, may frequently enter decisions about utility prices and the tariff structure for utility supplies. One case, discussed by Maddock and Castaño (1991) where manipulation of the tariff structure has been employed specifically in order to achieve distributional goals is the case of electricity supply in Colombia, where supplies are charged according to a rising block structure, with a fixed connection fee and 5 rising marginal rates for successive blocks of consumption. Using data for about 1000 households in the city of
Medellin and an estimated behavioural model of household consumption behaviour, Maddock and Castañino show that this pricing system has achieved a considerable measure of redistribution. The poorest income group gain an amount equivalent to some 5 per cent of income, compared to the charges they would pay with a uniform tariff.

Compensation for environmental taxes on energy through a reduction in the fixed connection charge for energy supply, or through use of a rising block tariff in which the initial units of consumption were charged at a lower rate than the remaining units consumed would correspond to the equal lump-sum return of revenues discussed above, if the tariff reduction were applied to all customers. Alternatively, it might be possible to target the tariff reduction to particular groups of consumers, about whom there was particular concern.

Whilst superficially attractive as a means of compensating for higher marginal energy charges - and perhaps politically-attractive because it makes clear the linkage between higher energy prices and the compensation provided - the manipulation of utility tariffs as a means of compensating for environmental taxes on energy would involve a number of significant problems.

The first is that it raises the same problem of the information requirements for targeting as are raised in providing compensation through public transfer programmes. If it is intended to target compensation to elderly consumers, or to low-income consumers, then the utility company needs to have access to data about the characteristics of individual consumers of exactly the same sort as would be required by government social security agencies in providing compensation through direct transfers. In general, it is unlikely that utilities will have better access to information about the relative characteristics of consumers than government social security agencies, and they may have to duplicate many of the information-gathering activities already performed by the social security agencies for other purposes.

It might be thought that an effective way of targeting assistance with utilities bills would be to concentrate the help on low energy consumers. This will not, however, target help on a number of the groups of greatest concern, and may also provide considerable benefit to comparatively well-off groups. This is because household energy consumption is often closely related to working patterns and other "lifestyle" factors. Some of the consumers with high energy bills (in absolute terms), include the unemployed and the elderly, who are at home during the day, and therefore use much more energy for heating than richer consumers who are out at work.

A second problem (although one whose significance can be overstated) may be the impact of targeted tariff changes on the incentives for energy conservation. Reductions in the connection charge and an initial allowance of low-priced units are fully equivalent if the initial allowance corresponds to genuinely intra-marginal units of consumption, and little impact might be expected on the level of energy consumption (except for an income effect). However, if the initial allowance exceeds the consumption level of some consumers, then the marginal cost of energy use is reduced for those users, and the effectiveness of energy taxes in reducing energy related emissions may be more significantly reduced.
Other practical problems which may arise if utility tariff changes are used to compensate for energy taxes include problems relating to the divisibility of consumption units. If the allowance of low-priced consumption is large relative to the connection charge, there may be an incentive for artificial splitting of household units, to benefit from more low-priced consumption allowances. In a similar vein, there may be difficulties of achieving equity between households consuming more than one fuel (e.g., electricity and piped gas) and households consuming a single fuel, since the former could benefit from twice the compensation of the latter. More generally, there is a problem that the wedge which is driven between the tariff structure and the real costs of supply connection may induce inefficient decisions relating to household connection; households no longer would base their connection decisions on the real costs of connection.

Greater difficulties arise in providing compensation through utility tariff adjustments where the utilities companies are in private ownership. Requiring utilities to price according to a structure bearing no relationship to underlying supply costs would create new requirements for regulation. In particular, it would either be necessary to coerce utilities into supplying low consumers for whom charges would not cover connection costs, or to provide public subsidies to cover the costs of supplying these consumers (in which case issues of compliance monitoring would arise).

A related strategy, which has some practical attractions especially in a system of private utility suppliers, has been suggested in Poterba (1991). This would be to provide a tax credit for energy supplies, up to a certain limit. Consumers might be required to demonstrate their actual level of consumption to the income tax authorities, and would then have their income tax bill reduced by a corresponding amount, up to a given threshold. Of course, the tax credit would be only of benefit to taxpayers, but it would be possible to use a similar system, integrated with the income tax or public transfer systems, for providing payments to non-income taxpayers. The attraction of these arrangements over other tax or transfer adjustments is that they could target assistance both on particular groups, and in proportion to their consumption, so as to identify within the target groups households or individuals with particularly high energy needs.

(d) Policies to reduce variance in needs.

Fourthly, it may be possible - and more efficient - to try to reduce the causes of variation in needs, than to try to target compensation in proportion to needs. If, for example, differences in needs reflect market failures in energy efficiency bearing particularly heavily on certain groups of the population, then it may be possible to eliminate (or at least reduce) the underlying causes of the variation in need by measures to remove the source of the market failure. Whilst spending on such measures may have a resource cost, this could be outweighed by two corresponding resource savings. Firstly, the resource cost of making transfer payments to poor households with high needs would be reduced. Secondly, correction of the market failure should, itself, involve efficiency gains from a more efficient allocation of resources.
More generally, to rely solely on pollution taxes on energy will not be an efficient way of reducing domestic energy use if there are significant market failures in the energy market which prevent economically efficient projects for investment in fuel efficiency from being carried out. A carbon tax would remove one impediment to optimal investment in energy efficiency, that of the divergence between the private and social costs of energy consumption, and would increase the private profitability of marginal investments in energy efficiency. However, other possible market failures in energy efficiency may also present a \textit{prima facie} case for government intervention on efficiency grounds, targeted towards the specific sources of the market failure. As discussed in Chapter 8, elimination of these market failures may also contribute efficiency gains, and could also lead to reductions in energy use (although the latter effect is far from certain, and will depend on the character of the energy demand of the consumers subject to the market failure).

3. Conclusions

Two main issues have been explored in this chapter.

The first concerns the distributional incidence of a carbon/energy tax along the lines proposed by the European Commission. The distributional impact would consist of three main components - direct effects relating to the pattern of household spending firstly on domestic fuels and secondly on motor fuels, and indirect effects arising from the taxation of industrial energy inputs. It is the first of these that gives rise to distributional concerns, due to the greater proportions of total household spending devoted to domestic energy amongst poorer households. The incidence of a tax on domestic energy expenditure alone would then be likely to be regressive, and, at the levels under discussion would lead to a significant increase in the tax burden of poorer households. Where a carbon tax is applied to all fuels, however, the regressivity is likely to be less, since at low income levels a tax on motor fuels appears progressive, and because there are no strong reasons to believe that the indirect impact of a tax on industrial energy would be highly regressive.

However, the extent to which a carbon tax would raise significant distributional issues seems likely to vary between the member states of the Community. In some member states, notably the Mediterranean countries, the budget shares of domestic energy amongst poorer households are lower than elsewhere in the Community, and little higher than those of richer households in the same country. Taxation of domestic energy in these countries would be less regressive than in other member states, especially Ireland and the UK, where the proportion of spending of poorer households on domestic energy is high both in relation to other member states, and in relation to richer households. In Spain and Italy the weak regressivity of a tax on domestic energy would be more than outweighed by the progressivity at low income levels of a tax on motor fuels, whereas in Ireland and the UK, the regressivity of domestic energy taxes would dominate the overall impact of a carbon tax.

Overall, a carbon tax would have a regressive impact on the distribution of income in the UK, in the sense that the additional tax would be a greater percentage of the spending of poorer
households than of richer households. For the poorest 10 per cent of the population, the extra tax would be equivalent to more than 2 per cent of their total spending, compared to less than 1 per cent for the richest 10 per cent.

The second main issue addressed in this chapter concerns the possible use of the very large revenues raised from the carbon tax. These provide scope for actions by member states to offset distributional problems where they arise. Even where the tax burden is regressive, a lump-sum redistribution of revenues, for example, through increased social security payments and tax thresholds (income exempt from income taxes) would be sufficient to ensure that the net impact of a carbon tax on poorer income groups was on average positive. Nevertheless, the average may conceal wide variations, and specific targeted interventions, perhaps including reduced energy costs for the vulnerable elderly, or measures to improve the heat efficiency of their homes, may in some cases be required.

How the additional tax revenue is used will be critical in determining the overall distributional impact. If the revenue is used in a way which maximises the "double dividend" efficiency gains, it will tend to be used to reduce tax rates, and this will confer much greater benefits on better-off households, and the overall distributional impact of the carbon tax will remain regressive. The revenue could, however, be used in a way which returned at least as much, on average, to poorer income groups as they paid in carbon tax, by making a lump-sum return of revenues. In Figure 5 it can be seen that the weekly lump-sum per household which could be financed from the carbon tax revenues would be more than enough to compensate households in the bottom five deciles (on average) for the carbon tax. Designing an effective lump-sum redistribution mechanism within the existing tax and social security system is complicated (Johnson, McKay and Smith, 1990), but could be approximated through a package involving increases in state pensions, social security benefits and income tax allowances. It is clear, however, that these measures are not those that would be chosen if it was intended to maximise the efficiency gains from reductions in other taxes that the carbon tax would permit. There is thus a clear trade off between efficiency and equity in the use of the revenues, and the double dividend efficiency gains can only be achieved by sacrificing the distributional neutrality of the package.

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15 It will be noted that some of these measures constitute public expenditure rather than tax measures. We see no difference in principle between increasing public expenditures by increasing the level of social security benefits and increasing "tax expenditures" by raising tax allowances, and the former cannot be avoided if poorer households are to be adequately compensated.
Annex to Chapter 6.

Annex. Carbon tax rates and energy prices

This Annex sets out the detail of the carbon/energy tax rates assumed in the analysis of distributional effects in Chapter 6.

The overall level of the tax

The EC proposal made in 1991 was that non-renewable energy sources should be taxed according to their carbon and energy content. After an initial phased introduction, the tax would be set at a level of $10 per barrel of oil, of which half would be the carbon component and half the energy component. Other non-renewable energy sources would then be taxed on their carbon and energy content at the same rates per unit of carbon and per unit of energy as levied on the carbon and energy content of the reference barrel of oil. The tax rate specified for the reference barrel of oil, and the split of the tax between the carbon and energy components, thus define the rates of tax to be levied on other energy products.

The rates of tax per unit of energy and per unit of carbon which would be applied to other energy products may be derived straightforwardly from data on the carbon content and energy content of the reference barrel of oil. At its full $10 per barrel level, the tax would consist of a tax of $5 on the carbon content of a barrel of oil, and $5 on the energy content. Rates per tonne of carbon and per terajoule of energy can then be derived as follows:

On the basis that a tonne of oil comprises 7.5 barrels of oil, and that a tonne of oil contains 0.85 tonnes of carbon, a carbon tax rate of $5 per barrel would be equal to a tax rate of $44 per tonne of carbon. In turn, given the relative molecular weights of carbon (12) and carbon dioxide (12 + 2x16 = 44), and an assumption that all the carbon contained in the oil is converted into carbon dioxide, the tax rate of $44 per tonne of carbon is equivalent to a tax rate of $12 per tonne of carbon dioxide.

Similarly, using a figure of 0.0457 terajoules (TJ) for the energy content of a tonne of oil, the $5 per barrel energy-based component of the tax is equivalent to a tax of $821 per TJ.

How does the average level of the tax proposed by the European Commission compare with other carbon taxes which have been discussed and, in some cases, implemented? Here it is useful to consider the tax as a pure carbon tax, at a level equivalent to $88 per tonne of carbon, and to ignore the mixed carbon/energy structure of the EC proposal.

The proposed EC tax may be compared with the level of the carbon tax introduced in Sweden in 1991, which was levied at the basic rate of Skr 0.25 ($0.042) per kg of carbon dioxide (although higher rates were levied on motor fuels). This is equivalent to some $154 per tonne of carbon. However, it should be noted that the tax was in part a simple renaming of existing energy taxes; the general energy tax was halved at the same time as the carbon tax was introduced; also, extensive exemptions for industry and other provisions mean that only a relatively small proportion of total energy consumption was taxed at rates as high as the basic rate. Subsequent modifications to the Swedish carbon tax have narrowed still further the categories of energy consumption subject to the tax; the carbon tax burden on industrial production is now very low indeed.

In addition, the EC tax may be compared with the levels of carbon tax which have been estimated would be required to achieve various given targets for carbon dioxide emissions reductions. IEA projections suggest that carbon dioxide emissions from energy sources may grow from 6 billion tonnes of carbon in 1990 to 9.1 billion tonnes by the year 2005, a rise of about 50 per cent; within the OECD area, emissions may rise by some 25 per cent from 2.7 billion tonnes in 1987 to 3.4 billion tonnes in 2005. A number of countries in the OECD area, including Canada and Japan as well as the European Community, have adopted targets to stabilise emissions at 1990 levels by the year 2000, implying a cut of some 15 to 20 per cent compared to the uncontrolled baseline level in 2000. Looking further ahead, Cline (1992, page 288) projects that global carbon dioxide emissions would be reduced by 20 to 30 per cent below the 1990 level by the year 2010.

1 In practice, as discussed in Chapter 5, it is likely that individual specific tax rates would have been set for a number of energy products, at a level corresponding to that defined here, but without reference to carbon or energy content in the legal definition of the tax base. Also, the Commission proposal was unclear about the price level on which the figures of $10 per barrel would be based: in what year's prices is the $3 per barrel figure defined, and how would inflation over the period 1993-2000 be treated?
emissions could rise to some 14 billion tonnes of carbon by the year 2050 without new policy measures; maintaining emissions at the 1990 level of 6.7 billion tonnes (which would still result in a substantial increase in atmospheric concentrations of CO₂ over current levels) would thus require a cut of some 50 per cent in 2050 compared to the no-policy baseline.

The scale of policy intervention required to meet a target of emissions stabilisation at 1990 levels by the year 2000 varies substantially between countries; in the UK, a combination of prolonged recession and a substantial switch of electricity generation towards gas-fired power stations may well mean that year 2000 emissions remain below 1990 levels with little further policy intervention. A further complication in assessing the carbon tax required to meet short-term emissions targets is the very limited amount of short-term flexibility in energy use in many industrial processes. As Ingham and Ulph (1990) show, the energy tax required to achieve a substantial reduction in energy use is much lower, the longer the time horizon over which adjustment to the tax can take place. With a short deadline, much of the reduction in energy use has to come from changes in energy use with existing capital stock, and is consequently costly. Over a longer time horizon, there is greater scope for change in energy use as existing capital equipment wears out and is replaced.

Nevertheless, it is clear that if taxes are to be used to achieve a sustained lower level of carbon dioxide emissions from 2000 onwards, rather than merely fortuitous attainment of the target in the year 2000 itself, they would need to be levied at levels which are of at least a similar order of magnitude to the EC proposals. Using the OECD ‘GREEN’ model, Burniaux et al (1991) estimate that a carbon tax averaging $215 per tonne of carbon across all countries ($308 per tonne in the OECD countries) would be needed to keep aggregate global emissions at 1990 levels over the period until the year 2020.°

To achieve longer-term targets for emissions reduction or for stabilisation of atmospheric concentrations of carbon dioxide, substantial carbon taxes would again be required, although their level will depend critically on the prices at which new sources of non-fossil fuels eventually become available. Thus, for example, Manne and Richels (1990) estimate that in order to reduce carbon dioxide emissions by the US to a long run level 20 per cent below current emissions, a long-run carbon tax of $250 per tonne of carbon would be needed; over the first few decades of the policy the tax would have to be even higher, peaking at $400 in the year 2020. Other studies, including those of Edmonds and Reilly (1983), Nordhaus and Yohe (1983), and Jorgenson and Wilcoxen (1991), have suggested that carbon emissions might be more responsive to a carbon tax, and the required tax for any given emissions reduction therefore rather lower, than indicated by Manne and Richels. The estimates of Manne and Richels therefore perhaps lie towards the upper end of the likely range. Cline (1992) summarises the results of these four studies in terms of the marginal carbon tax required to achieve a one percentage point reduction in year 2050 emissions below their level in the absence of policy intervention; the marginal tax rates range from $5.9 per tonne of carbon (Manne and Richels), $4.9 (Edmonds and Reilly), $2.8 (Nordhaus and Yohe), to $1.2 (Jorgenson and Wilcoxen).

Carbon tax rates on different fuels

Different fuels would have been taxed by the proposed European carbon/energy tax more or less heavily according to their carbon and energy content. The relative weight of the carbon content is shown in Figure 6, which sets out the carbon content per unit of energy for each of a range of different fuels. The carbon component of the EC tax would levy the highest tax per unit of energy on coal, and the lowest tax per unit of energy on natural gas. The tax on oil would lie broadly in the middle of the range.

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2 The required carbon tax rates vary across regions because Burniaux et al specify separate emissions reduction targets for each region; for the OECD area they require that emissions are reduced to 80 per cent of 1990 levels by the year 2010, and are then held constant, for China and some LDCs emissions are allowed to rise by 50 per cent by 2010 and are then stabilised.

3 This figure is given by Manne and Richels' assumption about the relative costs of non-fossil fuel and fossil fuel "backstop" technologies in the long run.
A natural yardstick for assessing the relative level of the tax on different fuels is the "ad valorem equivalent" of the carbon/energy tax; in other words, the amount of tax as a percentage of the price of each fuel. If the tax is fully passed on in energy prices, then the ad valorem equivalent tax will show the percentage increase to be expected in the price of each individual fuel; however, as discussed in the next section, the incidence of the tax is likely to be complex, and is not likely to fall entirely on fuel prices.

The ad valorem equivalent of the EC carbon/energy tax reflects the relationship between the two taxed characteristics of each fuel, energy and carbon content, and the unit price. If before imposition of the carbon tax individual fuels were priced in proportion to their energy content, then the ad valorem equivalent of the energy component of the tax would be constant across all fuels, and the ad valorem equivalent of the carbon component of the tax would be proportional to the relative carbon content figures shown in Figure 6. In practice, the pattern of the ad valorem equivalent tax rates is more complex, because the price per unit of energy content of different energy products already varies, reflecting differences in the "quality" of different energy products (some energy products command higher prices because they are more convenient or cleaner to use), and also differences in the burden of existing taxes on different energy products (motor fuels, especially petrol, are taxed more heavily than other energy products). In addition, the unit price of energy frequently varies widely across categories of consumer, reflecting the fixed costs (standing charges, etc), or discounts for bulk supply to large consumers.
The ad valorem equivalent of the EC carbon tax is thus likely to be higher on fuels which are of low quality and on fuels which are not currently taxed; other things being equal it is likely to be lower on fuels supplied to small consumers, and especially on fuels supplied to households compared to larger-scale industrial users. These sources of variation underlie the pattern of predicted changes in fuel prices set out in an Annex to the Commission’s 1991 communication and shown in Table 12. The ad valorem equivalent tax on energy supplied to industry would be higher than on energy supplied to households, reflecting the lower unit price of bulk purchases, whilst the ad valorem equivalent tax rates would be lower on motor fuels than on other energy, reflecting the much higher initial taxation of petrol and, to a lesser extent, diesel fuel.

Table 12.
Commission estimates of the percentage increase in fuel prices, based on a $10 per barrel carbon/energy tax, fully passed on to the energy user.

<table>
<thead>
<tr>
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<th>Power stations and industry</th>
<th></th>
<th>Households</th>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Commission (1991), Annex 7

The figures in Table 12 are averages for the EC as a whole. In practice, ad valorem equivalent tax rates are likely to vary substantially between member states, reflecting the wide differences both in energy taxation and in pre-tax energy prices (sustainable due to the highly-regulated and non-competitive nature of large parts of the energy supply industry in most member states).

In this chapter, which considers the impact of the carbon tax on the fuel expenditures of individual households, the carbon tax levels on different fuels have been translated into equivalent ad valorem tax rates on the prices of individual fuels purchased by households in seven different EC countries. Tables 13 to 18 show the basis on which these estimates have been made. It has been assumed that the carbon tax is wholly incident on the price of energy products, an assumption which is discussed further in the next section.

The specific numerical assumptions made in the calculations about the energy content and carbon content of coal, domestic heating oil, gas and petrol supplied to domestic energy users are shown in Table 13, expressed in terms of the carbon and energy contents per (quantity) unit, and in terms of the carbon content per unit of energy. There are in most cases very minor differences between member states and within the same member state over time in the energy content per unit of these fuels supplied to domestic users; these have been ignored in the analysis.

A considerable proportion of household purchases of energy are made in the form of electricity. Electricity is a final fuel product which has involved substantial energy losses, of the order of some 60 per cent on average, during generation. It is desirable that the energy losses during processing, and the carbon emissions associated with them, should be reflected in the carbon/energy tax levied on electricity, so as to ensure that households are not encouraged to purchase energy in the form of electricity rather than in other, less refined, forms.

As Chapter 5 has described, there are two, theoretically-equivalent ways in which this could be done. Either the carbon tax could be levied on fuel inputs to electricity generation. Alternatively, the inputs could be left untaxed, and carbon tax levied on the electricity produced, at a rate determined by the carbon tax that would have been levied on the fuel inputs to generation.
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Table 13.
Assumptions about the energy and carbon dioxide content per unit quantity of domestic energy and motor fuel in seven EC member states.

<table>
<thead>
<tr>
<th>Units</th>
<th>Carbon content: tonnes CO₂ per unit</th>
<th>Energy content: TJ per unit</th>
<th>Emission factor (tonnes CO₂ per TJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>2.41</td>
<td>0.0254</td>
<td>95</td>
</tr>
<tr>
<td>Domestic heating oil</td>
<td>2.69</td>
<td>0.0363</td>
<td>74</td>
</tr>
<tr>
<td>Gas</td>
<td>2.26</td>
<td>0.0419</td>
<td>54</td>
</tr>
<tr>
<td>Petrol</td>
<td>2.44</td>
<td>0.0339</td>
<td>72</td>
</tr>
</tbody>
</table>

Sources: Energy content from International Energy Agency (1991), "Energy Prices and Taxes, Fourth Quarter 1990", Paris: OECD, pages 37-49; emission factors from EUROSTAT data (as in Figure 6); carbon content calculated on basis of energy content and emissions factors.

The pattern of electricity generation varies between member states, and consequently the rate at which the carbon/energy tax should be levied on electricity will differ. As Table 14 shows, about three quarters of electricity generated in France was generated by nuclear power stations in 1989, about one third in Germany and Spain, and a fifth in the UK. Two of the seven member states shown, Ireland and Italy, generated no nuclear power, and a third, the Netherlands, generated only about 5 per cent of electricity from nuclear sources. Hydro- and Geothermal electricity generation provided one fifth of all electricity in Italy and about one seventh in France and Spain, but negligible proportions in the Netherlands and the UK. There was also considerable variation in the fuels used by "conventional" fossil-fuel power stations: oil generated about half of all electricity in Italy, but was little used elsewhere, whilst gas power stations supplied more than half of the electricity generated in the Netherlands, and about one third in Ireland. Coal-fired power stations provided about two thirds of supply in the UK, and around half in Germany and Ireland.

Table 15 shows the basis on which estimates are made in this chapter of the level of the EC carbon/energy tax on electricity supplied to domestic consumers in different member states. It is assumed that each unit of electricity output would be taxed in proportion to the average input requirements of the electricity supply industry in the country as a whole; the taxation of electricity supplied to domestic consumers is assumed to be the same as the taxation of electricity to industrial consumers. The penultimate column of Table 15 shows the "conversion efficiency" of power generation in each country; the amount of output energy generated per unit of input energy. This averages around 0.45, showing the substantial energy losses during generation; conversion efficiency is higher in Italy, reflecting the high proportion of oil-fired plants which have relatively high conversion efficiency.

The final column of Table 15 shows emission factors (in terms of tonnes of carbon dioxide emitted per terajoule of energy supplied to energy users) which are comparable with those in the final column of Table 13. For electricity, these are substantially higher, in most cases, than the emission factors for other fuels, reflecting the emissions associated with the energy losses during generation. Thus, it can be seen that in comparison with a unit of energy in the form of domestic heating oil, which has an emissions factor of 74 tonnes of CO₂ per TJ, electricity generated in the UK would have an emissions factor nearly three times as high.

4 The proportion of electricity generated by coal-fired power stations in the UK has been declining rapidly since 1989, as deregulation of electricity supply has encouraged an expansion of smaller-scale gas-fired power stations by new entrants to the industry, and the privatisation of the state-owned electricity generators has encouraged a rapid run-down of relatively high-cost existing capacity.
However, there is wide variation in the carbon dioxide emissions factor between member states, reflecting the different mix of fuels used, and in particular the proportion of energy generated from non-fossil sources. The emissions factor for electricity generated in France is actually lower than the emissions factor for any of the fuels shown in Table 13, because of the high proportion of electricity generated from nuclear power, and the emissions factors for electricity are lower than the EC average in Spain and Germany, where a high proportion is also generated in the form of nuclear power. The emission factor for electricity is highest in countries such as Ireland and the UK where coal is heavily used for electricity generation.

### Table 14.

Electricity production in EC member states, by source of energy used for generation, 1989.

<table>
<thead>
<tr>
<th></th>
<th>Hydro and Nuclear</th>
<th>Coal</th>
<th>Oil</th>
<th>Gas</th>
<th>Other conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>4.6</td>
<td>34.3</td>
<td>47.7</td>
<td>2.5</td>
<td>9.9</td>
</tr>
<tr>
<td>Spain</td>
<td>13.8</td>
<td>38.6</td>
<td>39.9</td>
<td>6.0</td>
<td>1.3</td>
</tr>
<tr>
<td>France</td>
<td>13.0</td>
<td>74.5</td>
<td>7.8</td>
<td>2.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Ireland</td>
<td>7.5</td>
<td>0</td>
<td>56.6</td>
<td>5.1</td>
<td>30.8</td>
</tr>
<tr>
<td>Italy</td>
<td>20.0</td>
<td>0</td>
<td>13.2</td>
<td>48.5</td>
<td>17.8</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.1</td>
<td>5.4</td>
<td>30.4</td>
<td>4.5</td>
<td>58.4</td>
</tr>
<tr>
<td>UK</td>
<td>2.2</td>
<td>21.7</td>
<td>65.3</td>
<td>9.6</td>
<td>1.1</td>
</tr>
</tbody>
</table>


Note: Row totals do not necessarily add to 100 due to rounding.

### Table 15.

Assumptions for calculating carbon tax on electricity in seven EC member states.

<table>
<thead>
<tr>
<th></th>
<th>Carbon content:</th>
<th>Energy content:</th>
<th>Conversion efficiency:</th>
<th>Emission factor:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tonnes $\text{CO}_2$ per 1000 KWh</td>
<td>input energy (TJ) per 1000 KWh</td>
<td>output energy per unit of input energy</td>
<td>total tonnes $\text{CO}_2$ output per TJ</td>
</tr>
<tr>
<td>Germany</td>
<td>0.61</td>
<td>0.0109</td>
<td>0.38</td>
<td>170</td>
</tr>
<tr>
<td>Spain</td>
<td>0.51</td>
<td>0.0103</td>
<td>0.40</td>
<td>140</td>
</tr>
<tr>
<td>France</td>
<td>0.12</td>
<td>0.0105</td>
<td>0.40</td>
<td>33</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.84</td>
<td>0.0103</td>
<td>0.40</td>
<td>234</td>
</tr>
<tr>
<td>Italy</td>
<td>0.61</td>
<td>0.0082</td>
<td>0.50</td>
<td>169</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.68</td>
<td>0.0103</td>
<td>0.40</td>
<td>189</td>
</tr>
<tr>
<td>UK</td>
<td>0.76</td>
<td>0.0109</td>
<td>0.38</td>
<td>211</td>
</tr>
</tbody>
</table>

Sources: Data on fuel inputs to electricity generation and electricity generation outputs from EUROSTAT (1991), *Energy Statistical Yearbook 1989*, pages 108-112. Assumed carbon content of input fuels are coal, 95 tonnes $\text{CO}_2$ per TJ; gas, 54 tonnes $\text{CO}_2$ per TJ; oil, 75 tonnes $\text{CO}_2$ per TJ; nuclear, geothermal and hydro, nil. Calculations assume 15 per cent transmission losses to customers.
Table 16 shows prices per unit of energy for coal, heating oil, gas, electricity and petrol supplied to domestic customers in the seven EC member states in 1985 and 1992. The table is based on national currency data for the prices of each fuel to domestic customers given in the quarterly International Energy Agency publication, "Energy Prices and Taxes". The prices given in this publication are average prices for the supply of the quantities typically purchased by households, and where appropriate include an apportionment of any standing charge or fixed cost; they thus do not necessarily measure the actual marginal cost of fuel use. The IEA’s published figures have been converted to a common currency basis, and have also been expressed in common units, as a price per terajoule, rather than for the various quantity units (KWh, tonne, litres, etc) used for different fuels.

**Table 16**

Prices of domestic energy and motor fuel in seven EC member states.

<table>
<thead>
<tr>
<th></th>
<th>1985, 1000 ECU per TJ</th>
<th>1992, 1000 ECU per TJ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Germany</td>
<td>Spain</td>
</tr>
<tr>
<td>Coal</td>
<td>12.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Heating oil</td>
<td>9.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Gas</td>
<td>9.5</td>
<td>13.0</td>
</tr>
<tr>
<td>Electricity</td>
<td>30.0</td>
<td>31.4</td>
</tr>
<tr>
<td>Petrol</td>
<td>19.1</td>
<td>21.2</td>
</tr>
</tbody>
</table>

Sources: Calculated from national currency data in International Energy Agency (1993), "Energy Prices and Taxes, First Quarter 1993", Paris: OECD. Conversion to TJ based on coefficients in Table 13; for electricity, 1000 KWh= 0.0036 TJ.

Note: Prices for household purchases of coal in Spain and Italy were not available: the figures shown here for 1985 are estimates made for the purposes of the subsequent calculation of household carbon tax payments. For Spain a figure of 10 (approximately the average of the other countries) is simply assumed; for Italy the figure of 8.5 has been estimated from the 1983 price, increased in line with the rise in price of steam coal to industry over 1983-5.

There is substantial variation in the unit prices of the various fuels between countries, and in the price of the same fuel over time. Thus, for example, in 1985, gas was supplied to domestic customers in the UK at less than half the price in Ireland, and at a price per terajoule roughly two thirds of the price of heating oil. In 1992, however, the gap between natural gas prices in the UK and Ireland had narrowed, whilst the relative price of gas and heating oil in the UK had been reversed, as sharply declining world oil prices fed through into the price of fuel supplied to domestic customers.

In the final step of calculating the carbon/energy tax that would be levied on each fuel in particular years, assumptions have to be made about how price level and exchange rate differences between years should be treated. The assumptions adopted here and throughout this chapter are that the $10 per barrel figure should be understood as in 1991 prices (the year of the initial proposal), when it would have been equivalent to ECU 8.07. In calculating the carbon tax rates equivalent to this in the price levels of other years, the 1991 ECU figure (rather than the 1991 figure in US dollars)
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has been taken as definitive, and has been deflated by the EC average Consumer Price Index. National currency equivalents have then been calculated using the exchange rates relevant for the year in question. Thus, the 1991 tax of $10 per barrel is assumed to be equivalent to the ECU tax rates per barrel, per tonne of carbon and per TJ of energy shown in Table 17.

Table 17.
Assumptions about the carbon and energy tax rates equivalent to a tax of $10 per barrel in 1991 prices.

<table>
<thead>
<tr>
<th>EC consumer price index, 1985 = 100</th>
<th>Total tax, ECU per barrel of oil</th>
<th>Carbon component: ECU per tonne CO₂</th>
<th>Energy component: ECU per TJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>135.4</td>
<td>8.47</td>
<td>10.19</td>
</tr>
<tr>
<td>1991</td>
<td>129.0</td>
<td>8.07</td>
<td>9.71</td>
</tr>
<tr>
<td>1990</td>
<td>123.0</td>
<td>7.69</td>
<td>9.26</td>
</tr>
<tr>
<td>1989</td>
<td>116.4</td>
<td>7.28</td>
<td>8.76</td>
</tr>
<tr>
<td>1988</td>
<td>110.7</td>
<td>6.93</td>
<td>8.33</td>
</tr>
<tr>
<td>1987</td>
<td>106.9</td>
<td>6.69</td>
<td>8.05</td>
</tr>
<tr>
<td>1986</td>
<td>103.5</td>
<td>6.47</td>
<td>7.79</td>
</tr>
<tr>
<td>1985</td>
<td>100.0</td>
<td>6.26</td>
<td>7.53</td>
</tr>
</tbody>
</table>

Sources and assumptions: EC Consumer Price Index from EUROSTAT Basic Statistics of the Community, 1992, Table 2.43; 1991 ecu:US$ exchange rate, 1.23916; assumed carbon dioxide content of a barrel of oil, 0.4156 tonnes; assumed energy content of a barrel of oil, 0.006093 TJ.

Table 18 shows estimates for the ad valorem equivalent tax on energy supplied to domestic consumers in the seven member states, based on the data and assumptions set out in Tables 13 to 17. Estimates are shown for two years, 1985 and 1992, and reflect the impact of the proposed EC carbon/energy tax at its full level of $10 per barrel.

The variation in prices across countries leads to corresponding variation in the ad valorem equivalent of the EC carbon/energy tax on each fuel. As observed earlier, the EC tax is likely to be much smaller as a percentage of price on petrol, which is already taxed heavily, than on supplies of domestic energy; on petrol the tax would have averaged about 6.2 per cent in 1992, whilst the tax would almost always have been over 10 per cent, and in some member states over 20 per cent, on household purchases of coal, gas and oil. For individual fuels, there is substantial variation across countries in the ad valorem equivalent tax rates; domestic heating oil would be taxed at an ad valorem rate of some 31 per cent in the UK, some four times the corresponding figure in Italy, whilst the ad valorem equivalent tax rates on electricity would range from 7.1 per cent in France to about 15 per cent in Ireland, the Netherlands and the UK.

The ad valorem equivalent tax rates to the EC carbon tax on different domestic fuels also vary widely across time, reflecting the changes in unit prices shown in Table 16. As Table 18 shows, ad valorem equivalent tax rates on most forms of domestic energy tended to be higher in 1992 than in 1985; the difference is particularly marked in the case of heating oil.

5 There is no "right" answer to the choice of deflation procedure. The approach adopted here has been chosen to avoid the carbon tax level in ECU in different years varying widely due to changes in the dollar:ECU exchange rate; this assumption may be justified on the grounds that the main determinant of the level of the tax is the political feasibility within the EC of a tax burden of a given level. The alternative approach, which could have been adopted, of denoting the EC tax in US dollars might be defended on the grounds that energy prices are denominated in dollars, and denoting the tax in dollars avoids the percentage burden of the tax on energy in different years being affected by fluctuations in the dollar:ECU exchange rate. This argument is perhaps not as persuasive as it appears at first sight; although energy prices are denominated in dollars, they are - over a period of time at least - determined by supply and demand in the world energy market, and fluctuations in the dollar exchange rate relative to other currencies would, in due course, be likely to be offset by changes in the dollar price at which energy is traded.
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Table 18
The EC Carbon Tax: Equivalent ad valorem tax rates on domestic energy and motor fuel in seven EC member states.

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>Spain</th>
<th>France</th>
<th>Ireland</th>
<th>Italy</th>
<th>NL</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>10.2</td>
<td>12.3</td>
<td>9.0</td>
<td>16.1</td>
<td>14.4</td>
<td>10.6</td>
<td>19.3</td>
</tr>
<tr>
<td>Heating oil</td>
<td>10.9</td>
<td>11.2</td>
<td>8.8</td>
<td>9.5</td>
<td>8.4</td>
<td>10.1</td>
<td>10.6</td>
</tr>
<tr>
<td>Gas</td>
<td>9.7</td>
<td>7.1</td>
<td>7.8</td>
<td>6.8</td>
<td>9.1</td>
<td>11.9</td>
<td>14.0</td>
</tr>
<tr>
<td>Electricity</td>
<td>9.4</td>
<td>8.1</td>
<td>5.5</td>
<td>9.9</td>
<td>7.6</td>
<td>9.0</td>
<td>12.8</td>
</tr>
<tr>
<td>Petrol</td>
<td>5.5</td>
<td>5.0</td>
<td>4.3</td>
<td>3.9</td>
<td>3.9</td>
<td>4.9</td>
<td>4.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>Spain</th>
<th>France</th>
<th>Ireland</th>
<th>Italy</th>
<th>NL</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>12.3</td>
<td>-</td>
<td>14.1</td>
<td>17.1</td>
<td>-</td>
<td>-</td>
<td>26.7</td>
</tr>
<tr>
<td>Heating oil</td>
<td>23.7</td>
<td>16.7</td>
<td>17.4</td>
<td>16.6</td>
<td>7.4</td>
<td>17.8</td>
<td>30.9</td>
</tr>
<tr>
<td>Gas</td>
<td>15.0</td>
<td>-</td>
<td>13.5</td>
<td>13.3</td>
<td>8.8</td>
<td>17.6</td>
<td>19.5</td>
</tr>
<tr>
<td>Electricity</td>
<td>10.4</td>
<td>-</td>
<td>7.1</td>
<td>14.5</td>
<td>8.4</td>
<td>15.0</td>
<td>15.9</td>
</tr>
<tr>
<td>Petrol</td>
<td>6.4</td>
<td>6.6</td>
<td>6.3</td>
<td>6.2</td>
<td>5.0</td>
<td>5.5</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Sources: Calculated from prices in Table 16, assuming carbon and energy content as in Tables 13 and 15. The 1985 figures for coal in Spain and Italy are based on the assumptions detailed in footnote to Table 16.

It is likely that the wide range of ad valorem equivalent tax rates to the proposed EC tax which have been quoted in public discussion of the proposals can be explained by the wide range evident in the tax rates shown in Table 18, both over time and across countries.

The calculations in this chapter of the distributional impact of the EC carbon/energy tax in EC member states use Eurostat data for household expenditures in 1985, and have consequently been made on the basis of 1985 prices. Whilst the data shown in Table 18 might suggest that using 1985 ad valorem equivalent tax rates would substantially overstate the impact of the EC tax, the analysis in this chapter proceeds from data on household energy expenditures, rather than consumption volumes, and using 1985 ad valorem equivalent tax rates thus effectively recovers the tax base quantities which underlie the expenditure figures.

The effect on fuel prices
As noted above, the estimates of distributional incidence have assumed that the European carbon/energy tax would be wholly incident on the prices of different energy products. This section briefly reviews the question of the incidence on energy prices in general, and then sets out some more specific issues concerning the incidence of the carbon tax on electricity prices.

(a) Incidence in general
How far is the price of energy in the EC likely to rise as a result of the imposition of the proposed carbon/energy tax? Would the prices of energy products in the EC be likely to rise by the amount of the tax, or by more, or by less?

Conventional partial equilibrium analysis of the incidence of an excise tax on a single commodity (Kotlikoff and Summers, 1987) suggests that a general tax on all forms of energy, imposed globally, would be incident partly on the consumers of energy, through higher after-tax prices for energy, but would also be incident partly on energy producers (particularly the owners of energy resources), through lower pre-tax prices for energy. The balance between the two effects would depend on
the relative elasticities of energy supply and demand; the more inelastic is energy supply, and the more elastic is energy demand, the more of the tax will be incident on energy producers rather than consumers.

In the case of the proposed EC carbon tax, incidence is likely to be complicated by three further considerations - the impact of substitution responses to the differential taxation of different energy products, the impact of locational substitution in circumstances where the tax is imposed by some countries but not by others, and general equilibrium effects not reflected in the simple partial equilibrium framework.

Thus, for example, by comparison with an energy tax imposed on all fuels, a carbon tax would encourage substitution between fuels; fuels taxed less heavily, or not taxed at all, by the carbon tax would tend to experience a rise in demand, and fuels taxed more heavily would tend to experience reduced demand. These substitution responses will tend to "even out" the price effects resulting from the differential increase in taxation.

Also, the impact of a carbon tax on the prices of energy products in the EC will reflect the international context within which the tax is applied; a carbon tax imposed unilaterally by the EC would be expected to have very different effects to a global carbon tax imposed on a coordinated basis in all countries. Locational displacement of energy-using activities - or "leakage" - in response to the imposition of the tax by a subgroup of countries would generally tend to reduce the increase in the price of energy in the region imposing the tax below the full level of the tax, because it would increase the elasticity of energy demand.

(b) Incidence on electricity prices.

Particular issues arise regarding the impact of the carbon tax on the price of electricity. Levying the carbon tax on electricity at the rates shown in the previous section does not necessarily imply that electricity prices in the different countries would rise by the level of the additional tax, or that electricity prices would rise by the same amount for all classes of customer. There are three main issues.

First, a distinction should be drawn between the average and marginal units of electricity generated. The carbon/energy tax on electricity shown in Table 18 is, in effect, calculated on the basis of the fuel mix used to generate electricity on average; the total carbon and energy content of inputs is divided by the total electricity output to determine the amount of carbon/energy tax per unit of electricity supplied. On the other hand, pricing of electricity outputs may be more likely to reflect the fuel mix used to generate electricity at the margin; in other words, the additional fuel used to generate one additional unit of electricity output. The marginal fuel mix in electricity generation will determine the additional carbon/energy tax paid in respect of one additional unit of electricity generated.

Thus, for example, in a country where all available opportunities for hydro-electric power generation have already been exploited, additional demand for electricity will have to be supplied from other sources. If the electricity industry prices the additional output at its additional cost, then the absence of carbon tax on intra-marginal units generated by hydro-electric power stations would not affect the price of electricity charged to customers. Instead, the absence of carbon tax on the units generated by hydro-electric plants would simply accrue as a rent to the electricity producers operating these plants.

It should be noted that the concept of "marginal" fuel used here is somewhat different to that usually employed in discussing pricing of utilities outputs. The relevant marginal fuel for considering the impact of the carbon tax is the fuel which would be used if capacity was expanded to supply additional long-run demand. This capacity may or may not also constitute marginal capacity on an hour-by-hour basis, in other words, the power stations used to meet peak loads, but not used during off-peak periods. The carbon tax may change the "merit order" of power stations used to determine which stations should be used to supply the base load, and which should be operated only at peak periods; the changed merit order may, in turn, affect the relative discount that should be applied to off-peak supply relative to peak supply. However, the marginal power station, and marginal input fuel, in this hour-by-hour sense is a different issue to the question of the fuel used for increasing generation capacity in the long-run.
Second, the analysis underlying Table 18 has assumed that domestic and industrial users of electricity will be supplied on the same basis. However, just as it may be inappropriate to assume that marginal electricity supply will be based on the average pattern of fuel use, so it may also be inappropriate to assume that the same fuel will count as marginal supply to domestic and non-domestic customers. In particular, if it is not possible to operate an optimal scheme of peak-load pricing, industrial users of electricity with a steady demand may be supplied with electricity on different terms to domestic users with fluctuating demand, placing greater demands on peak capacity. It may then be appropriate for the electricity supplied to these two different classes of user to reflect the carbon tax paid on the respective different types of (marginal) generation capacity.

Thirdly, much will depend on the structure of the electricity supply industry, and in particular on the extent to which there is a common market across the Community for electricity supply. Table 18 assumes that electricity is supplied to national markets by national electricity generators, and that the pattern of fuels used in national generation will determine the extent to which the carbon tax increases electricity prices in each national market. If each national market is closed to outside suppliers then this is an appropriate assumption (although, as noted above, it may be more appropriate to look at the pattern of fuels used in generation at the margin rather than on average). Member states where (marginal) electricity is generated from carbon-intensive inputs will then face a greater increase in electricity prices than those where (marginal) electricity is generated from nuclear power or other low-carbon sources.

However, if it is possible for generators in one member state to supply consumers in another member state, then the relevant marginal fuels are no longer those of the generators within a member state, but could include generators in other member states. With a completely free trade in electricity, electricity would be priced at the same level in all member states, and the impact of the carbon tax on prices would be given by the marginal generation capacity with the lowest price inclusive of the carbon tax.

These issues are of particular relevance in considering the likely impact of the carbon tax on the price of electricity in France, where a much higher proportion of electricity is generated from nuclear sources than in other member states. Is this likely to mean that electricity prices will rise by less in France than in other member states? The possibility that a carbon tax could confer a competitive advantage on industrial consumers of electricity in France has been much debated, and appears to have been a reason for the 50% energy component in the tax base under the Commission's proposals.

Whether the carbon tax should be expected to confer this benefit is, however, unclear. Much will depend on the identification of the marginal fuel used for electricity generation for each class of electricity consumer, and on the degree of competition in the electricity market. If nuclear power constitutes the marginal source of electricity generation in France, and nuclear power plants can be freely constructed by a number of potential entrants, then electricity prices in France might rise by the relatively small amount of the carbon tax levied on nuclear generated electricity. However, if French electricity can be traded across frontiers, then the availability of low-tax nuclear-generated electricity from France would tend to depress electricity prices in other member states where all domestic electricity is generated from non-nuclear sources. On the other hand, if some other fuel constitutes the marginal source of electricity generation in France (for example because public opposition prevents further nuclear plants being constructed) then electricity prices might be expected to rise by an amount reflecting the tax burden on electricity generated using the marginal fuel, and owners of the existing nuclear power stations would simply enjoy substantial rents.

All of the above discussion is, of course, greatly complicated by the absence of a competitive market for electricity supply, and by the rules by which national electricity supply industries are regulated. The extent to which the tax would be passed on in electricity prices by a profit-maximising monopoly electricity producer will differ from the proportion passed on in a competitive market; a nationalised industry pursuing objectives other than profit maximisation may also respond

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6 Again, the relevant sense of "marginal" relates to the expansion of generation capacity; here the issue is whether different fuels might be used to expand capacity to supply peak demands and to supply baseload or off-peak demands.
Annex to Chapter 6.

differently to the tax. Similarly, a regulated industry may face incentives regarding both pricing and capacity expansion which differ from those which would face firms in a competitive market, and may consequently respond differently in pricing its output after imposition of a carbon tax.
Chapter 7

Distributional Aspects of Household Water Charges.
Chapter 7

Distributional aspects of household water charges

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Introduction

In the past, charges for water and sewerage services have generally formed a relatively small and stable proportion of total household income - on average around 1 per cent - and the incidence of these charges on households rarely provoked much discussion. This situation has changed, however, as charges have substantially increased since the mid 1980s, a rise which has coincided with the politically-controversial privatisation of the water utilities in 1989. In 1987-88, the average household charge in England and Wales was £97.67 but by 1991-92 this figure had risen to £155.67, a real increase of 22 per cent. Increases in the average level of charges are, moreover, likely to continue, as water customers are required to bear the costs of infrastructure renewal, and of expenditures required to meet tighter standards for environmental quality.

Continued controversy over the level and structure of domestic water charges is to be expected as water companies look for an alternative to the existing system of charges, which is based largely on rateable values. The 1989 Water Act prohibits the continued use of rateable values for levying water charges after the end of the century. The switch which will therefore have to take place to a new system of charges is likely to only amplify public awareness of water charges, and of the distributional effects of water charging policy.

This paper examines the distributional aspects of household water charges and models the impact of a switch to several new charging schemes. Section 1 describes the current system of charges in England and Wales. Section 2 considers two aspects of efficiency relevant to the choice of water charging systems - allocative and administrative efficiency. In Section 3 estimates are presented of the distribution of water charges across households under a number of the charging schemes that have been suggested as possible successors to water rates, and the distributional implications of a switch from the current system to each of these proposals are analysed. Section 4 considers the role that distributional considerations should play in water pricing policy. Finally, Section 5 draws some brief conclusions.

1 The policy context in England and Wales

The overwhelming majority of households in England and Wales - some 95 per cent - pay for supplies of water and for sewerage services through water and sewerage rates. Payments for these services are thus made on a basis which relates the amount each household pays to the "rateable value" of the property occupied¹ - in other words, to the tax base used for the system of domestic rates, the local government taxes levied until the introduction of the poll tax in 1990. Where rateable values are not available (for example, in the case of houses built since the abolition of the domestic rating system for local taxation), a variety of charging schemes are used, including

¹ Rateable value is defined as the imputed market rental value of domestic properties; the values in use are based on the 1973 revaluation. The average rateable value of domestic properties in England is about £200.

flat-rate charges, charges related to certain property characteristics, or water metering. Metered charges may also be levied at the householder's request. Overall, some 2 per cent of households pay for water on the basis of metering.

In most cases, water and sewerage charges based on rateable value have two parts, a fixed standing charge, which is the same for all households served by a particular water company, and a variable element for which the charging base is rateable value. Both the level and structure of water charges varies widely between different water companies. Table 1 shows standing charges and rate poundages for 1991/92 for water and sewerage services provided by the ten large companies which provide both water and sewerage services in England and Wales. These companies together provide water supplies to some three quarters of all households; the remainder are covered by a larger number of water-only companies. The average domestic water and sewerage charge ranges from £131 to £204 across the ten companies. The proportion of this charge accounted for by the part based on rateable values is generally about 75 per cent, but one company levies only about one third of the total charge in the form of the rateable value element, whilst for another this element constitutes 100 per cent of the charge levied.

Table 1

Unmeasured Water Supply and Sewerage Services Charges, 1991/92

<table>
<thead>
<tr>
<th>Company</th>
<th>Standing Charge, Water &amp; Sewerage (per annum)</th>
<th>Rate Poundage, Water &amp; Sewerage (pence)</th>
<th>Average domestic bill (per annum)</th>
<th>Rateable value-based share of average bill (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anglian</td>
<td>£52.10</td>
<td>74.81</td>
<td>£204</td>
<td>75 %</td>
</tr>
<tr>
<td>Welsh</td>
<td>£122.70</td>
<td>58.47</td>
<td>£195</td>
<td>37 %</td>
</tr>
<tr>
<td>South West</td>
<td>£52.00</td>
<td>81.10</td>
<td>£192</td>
<td>73 %</td>
</tr>
<tr>
<td>Wessx</td>
<td>£35.00</td>
<td>74.20</td>
<td>£176</td>
<td>80 %</td>
</tr>
<tr>
<td>Southern</td>
<td>£38.00</td>
<td>58.90</td>
<td>£163</td>
<td>77 %</td>
</tr>
<tr>
<td>Yorkshire</td>
<td>£39.00</td>
<td>82.60</td>
<td>£154</td>
<td>75 %</td>
</tr>
<tr>
<td>North West</td>
<td>£24.10</td>
<td>67.60</td>
<td>£143</td>
<td>83 %</td>
</tr>
<tr>
<td>Northumbrian</td>
<td>£54.00</td>
<td>55.90</td>
<td>£142</td>
<td>62 %</td>
</tr>
<tr>
<td>Severn Trent</td>
<td>None</td>
<td>68.65</td>
<td>£138</td>
<td>100 %</td>
</tr>
<tr>
<td>Thames</td>
<td>£33.00</td>
<td>37.49</td>
<td>£131</td>
<td>75 %</td>
</tr>
</tbody>
</table>

Note: rate poundages for Severn Trent and Thames are averages for the company area.

Changes to the way in which households are charged for water and sewerage services are inevitable over the next decade. As a result of the 1988 Local Government Finance Act, domestic rates in England and Wales were abolished as the basis for local taxation, and arrangements for maintaining and updating the register of domestic rateable values discontinued. New domestic properties built after 1 April 1990 do not have rateable values. Furthermore, the use of rateable values for water and sewerage charges after the year 2000 has been explicitly prohibited in law; although water companies are being given the responsibility for choosing an appropriate basis for charging domestic customers, the government appears to have taken the view that they should not be allowed to continue with a charging base derived from an obsolete system of local government finance. Water companies are therefore compelled to look for some alternative method of charging domestic customers.

The replacement for water rates could be an alternative unmetered charge, based on characteristics of the household (or even simply a lump sum per household). Alternatively, it would be possible to charge for water on the basis of water metering. The possible advantages and disadvantages of charging for water on the basis of metered consumption are set out clearly in OECD (1987). The Office For Water Services (OFWAT), the economic regulator for the water industry, has advocated greater use of water metering. Selective metering of properties is being encouraged, where the costs of metering are justified by the savings in water supply costs (OFWAT, 1991). However, as the installation of water meters in some properties would be very costly, metering is unlikely to be feasible as a complete replacement for water and sewerage rates. A non-metered substitute for water rates is still therefore required, and a number of alternatives have been suggested including a flat rate licence fee, charges based on house types, current property values and the number of people per household.

2 Efficiency issues and water charging

This section discusses two aspects of efficiency relevant in designing a system of water charges. One is "pricing efficiency" - the extent to which water charges provide appropriate incentives for water customers to change their use of scarce water resources. The second, and equally important, is efficiency in administration - minimising the deadweight costs of assessing, collecting and enforcing household water charges. The two aspects of efficiency arise in the case of all public pricing and taxation questions. Here, however, they have a particular interaction with questions of the distributional burden of water charges; how non-metered water charges are distributed across households may have an important role in promoting efficiency, in circumstances where households have the option of paying charges based on metered consumption.

2.1 Pricing Efficiency

Allocative (or pricing) efficiency in the water industry will be promoted where customers face a price for marginal water use which equals the marginal cost of water supply. The current basis of charging for water does not promote efficiency of this form; at the margin, consumers charged for water on the basis of rateable value pay a zero price for water use, and water is consequently
liable to be used well beyond the point at which its value to water consumers warrants the resource costs of water supply. Similarly, any other system of water charging based on household characteristics would face households with a zero price for marginal water use. A system of water charging based on water metering would, in contrast, face consumers with a positive price for each unit of water used, discouraging consumption in situations where the value to the consumer was less than the price. If the price charged for water was equal to the costs of water supply at the margin, consumers would then be discouraged from using water where its value to them was less than the resource cost of supplying water.

There are in practice a number of difficulties in implementing marginal cost pricing in the water industry. First, water is supplied to a number of different groups of customers using common facilities; the substantial element of joint production involved makes it difficult in practice to determine how much of the costs of water supply should be attributed to household customers. Second, marginal costs vary, both across time and between areas; there may be substantial political difficulties in appropriately differentiating charges according to the relative costs of supplying different households. Third, the large element of capital in the costs of water supply means that marginal costs have to be based on a large amount of judgement about depreciation rates, and the consequent amounts that should be raised from current prices to reflect the needs for infrastructure maintenance and renewal. Fourth, there are a number of externalities which should be reflected in socially-optimal levels of water charges, including the public health benefit from a certain level of individual water consumption (for washing, sewage disposal, etc). Fifth, whilst in a competitive industry, market pressures might tend to lead to pricing policies close to marginal cost, in a natural monopoly such as the water industry marginal cost pricing could only be enforced through public regulation, which may operate with a very limited information base.

Taken together, these various reasons might explain the choice of a relatively simple yardstick such as commercial profitability in preference to marginal cost pricing as the basis for regulating the water industry in the UK. In this situation, whilst charges for metered water consumption might no longer reflect the precise cost of water supply, charging for water might nonetheless improve efficiency in water consumption, so long as the unit prices that the water companies would set did not deviate too far from the correct marginal costs.

2.2 Efficiency in administration

The second aspect of efficiency relevant in choosing from the range of possible bases for water charging is administrative efficiency. Costs of administration and compliance constitute deadweight costs of the system of water charges. Other things being equal, a system of water charging with low administration and compliance costs should be preferred to one with higher costs. Moreover, the level of administration and compliance costs will be relevant in choosing whether to adopt a system of water charges which promotes pricing efficiency, or whether to choose instead to levy water charges on a quasi-tax basis (as under the present system of water rates). If greater pricing
efficiency can only be achieved at the cost of greater administrative complexity and cost, the choice of charging basis will then have to weigh up the benefits of pricing efficiency against the deadweight losses associated with more costly administration.

Generally, simplicity will be an important determinant of the relative costs of administration and compliance for different systems of water charges. Where the charging base is unambiguous and easily observed, the costs both of obtaining information about the charging base, and of errors and disputes about charging, will tend to be minimised. For example, where water companies are able to use an existing charging base, costs will be considerably lower than where they have to obtain from individual households the information required to operate the charge. This has been a strong attraction of the existing water charges based on rateable value; the register of rateable values established to operate the system of domestic rates has provided an immediate and definitive basis for levying water charges. Similarly, using the valuation bands for the new Council Tax would tend to be relatively inexpensive.

On the other hand, obtaining new information on household characteristics, and verifying its accuracy, will tend to be much more costly. Thus, levying a tax based on the characteristics of the property (terraced, detached, etc) requires the water companies to compile a new register of this information, since there is no existing source from which it can be derived. Such property characteristics are, in the main, unambiguous and relatively easily verified. On the other hand, charging for water according to the number of members of a household would be a much more costly base. The experience of operating the Community Charge (the poll tax) has shown how difficult and costly it is to obtain up-to-date and accurate information on the number of occupants of a house; there are ambiguities in definition (for example regarding visitors, temporary absences, and mid-year moves), and the information needed to verify the accuracy of the numbers reported by households is almost impossible to obtain. Thus, although charges according to the number of household members would have been cheap to operate if the Community Charge had continued (since water companies could have made use of the Community Charge register), now that the Community Charge has been abolished, the costs of charging according to the number of individuals would become much higher - and most likely prohibitive.

Although in terms of pricing efficiency, charges based on water metering have clear advantages over the various unmeasured charging bases (the licence fee, or charges banded according to household characteristics), metering is likely to be costly to operate. The gain from pricing efficiency would therefore need to be weighed up against the deadweight losses from operating the system of water use measurement. Universal metering is unlikely to be warranted by the efficiency gains, at least in the immediate future, since the installation of meters in many existing properties will tend to be costly. On the other hand, the costs of some metering may be warranted by the efficiency gains; in particular, metering households with high discretionary water consumption (e.g. on watering gardens) could produce significant savings in water supply costs through the behavioural changes induced by metered charging. The problem is how to identify which households should be metered.
In a system of partial, selective metering, the optimal pattern of metering will be one where households are metered if the savings from metering are greater than the cost of meter installation and operation. Where selective metering is introduced on a voluntary basis, so that households have the right to choose to be charged on the basis of metered consumption, it is important that the financial incentives faced by households encourage the right households to volunteer for metering. One aspect of this is that the charges levied for the installation and operation of the meter should not exceed the costs of metering. Another important consideration is the structure of the non-metered charge; this should not encourage households to volunteer for metering, simply because they face a high burden of charges under the non-metered existing system. In designing the structure of financial incentives to ensure the optimal voluntary take-up of metering, a non-metered charge that is based on some characteristic that proxies water consumption can have an important role.

Non-metered charges that lead to the same pattern of household payments that would have occurred if charged on the basis of their current level of consumption will encourage the efficient pattern of take-up of metering. If households are paying unmeasured charges which correspond to the level of charges they would pay if metered and charged on the basis of their current consumption, then they will only switch to water metering if they believe that they could reduce their water consumption by enough to justify the costs of installing and operating a meter. Other systems of non-measured charges which do not approximate the payments which households would make if charged for their consumption, will tend to encourage some inefficient metering take-up by households whose non-metered charge is high relative to current consumption, and also an equally inefficient failure to adopt metering by households which would reduce their consumption if metered, but which pay very low non-metered charges. A non-metered charge which "proxies" current water consumption in this way may thus have an important role in ensuring administrative efficiency in a system of selective, voluntary, water metering. In the analysis of the distributional implications of various charging options, one of the issues considered in evaluating the various possible non-metered bases for charging is the extent to which they are likely to promote efficient decisions where households can choose to be charged on the basis of metered water use.

3 Distributional effects of various options

In this section of the paper the distributional implications are considered of introducing five possible replacements for the existing rateable value-based water and sewerage charges in England and Wales. The replacements considered are first, a flat rate licence fee applied to all households, second, charges based on universal metering, and third, three possible systems of charges based on household or house characteristics - charges based on dwelling type, the number of occupants, and property values.
The analysis is based on households in England and Wales covered by the Family Expenditure Survey (FES). This is a representative sample of UK households, covering approximately 7,000 households each year, which contains detailed information on household characteristics, expenditures and incomes.

The analysis has been based on data for the FES households surveyed in England and Wales in the 1984-5 financial year. Although some more recent years of the survey are available, the later years of the FES after 1985 do not contain information on the type of dwelling occupied by households and it would therefore not have been possible to model one of the options under consideration, a water charge banded by house type. The income distribution changes slowly, and using data for 1984-5 is not a severe limitation in an analysis which aims to reflect the current position. All of the income and expenditure variables have been uprated or indexed so that they reflect those in 1991-92, and the actual levels of water and sewerage charges for 1991-92 have been imposed for each household in the data sample.

Estimates for property values and for water consumption were added to the data set for every household in the sample, based on reduced-form regression equations estimated using other data sets. The variables used in estimating the reduced form models were confined to those common to both the FES and the external data set, so that the reduced form equations could then be used to predict property values and water consumption for each household in the FES.

The model of house prices used to impute capital values is drawn from Giles and Ridge (1993). This was estimated on the Department of Employment's 5 per cent Sample of Building Society Mortgages. Data from the last quarter of 1987 and from 1988 was used, giving a sample size of about 13,000 observations. The equation related the log of the sale price to the number of rooms (in logs), domestic rateable value (in logs), dummies for dwelling type and the possession of a garage, standard UK regions, and quarters. Predictions were then uprated to 1991 levels on the basis of regional house price trends. The average predicted house price in England and Wales in the FES sample was approximately £60,000.

The estimates of the water consumption of each household in the FES used in this study are based on the reduced form employed by Pearson, Rajah and Smith (1993). This equation was estimated on metered consumption data and other household characteristics information from the Severn Trent Domestic Water Consumption Monitor, a survey of the water consumption of some 1500 volunteer households supplied by the Severn Trent company. The equation was estimated on a sample of some 3800 observations over the period 1988 - 1990. The model, estimated using Ordinary Least Squares, related the log of annual water consumption (in litres), to 24 explanatory variables common to the Monitor and the FES, including the number of household members (in logs), domestic rateable value (in logs), the type of house, tenure type, age and job-status of the head of household, and the household's possession of water-using durables. Average predicted consumption across the households in the FES was some 127 thousand litres per annum.
In comparing the different charging schemes, it has been assumed that each water company would continue to raise the same total revenue from domestic water charges as under the present rateable-value based system of charges; revenue neutrality is thus assumed with respect to the system of charges.

It has also been assumed that the existing two part tariff structure of charges, based on a lump sum standing charge and an element which varies across households, would continue to apply under each of the alternatives. The standing charge element has been assumed to continue at its current level, and the different charging systems to apply only to the element currently related to rateable values. Different assumptions about this could of course equally well have been adopted, and changes in the standing charge element would be liable to have a considerable influence on the results. The assumption made here has the merit that it separates the discussion of the distributional effects of different charging systems from the question of the distributional effects of changes in the level of the standing charge. The distributional implications of increasing or reducing the standing charge element may be gauged from the results for the licence fee option, which may be seen as the introduction of a 100 per cent standing charge in place of the second element of the existing charging system.

3.1 The Licence Fee

Under this method of water charging, all households served by a water company would pay the same charge. Charges would vary between water companies reflecting the difference in their costs, but within each area the licence would be uniform. Within the FES sample the average annual combined water and sewerage licence fee in 1991/92 in England and Wales would have been £153.

The distributional impact of moving to a flat-rate licence fee is immediately apparent from Figure 1, which shows average water rates payments under the existing system by households in different income groups, and the corresponding licence fee. Across income groups the level of water rates rises steadily, although relatively slowly. The average payment of the poorest ten per cent of the population was about £126, whilst the average water rates payment of the richest ten per cent was some £195. A flat rate licence fee would, in contrast, be a broadly constant cash amount across the income distribution. Although the averages for each decile vary slightly, reflecting the variation in water charge levels across water company areas, the average licence fee payment for each decile would have been within the narrow range £149 to £155 in 1991/92.

The pattern of water rates across income groups reflects the pattern of rateable values, and the organisation of the water industry.

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2 Throughout the analysis households are classified to income groups on the basis of equivalent incomes - that is, on the basis of incomes adjusted for the numbers of members of the household, and their ages. Using equivalent incomes to classify households takes account of the fact a given total income may have different implications for the household's standard of living, depending on the number of individuals which the income has to support. The adjustment factors used are the widely-used McClements equivalence scales (McClements, 1977).
Rateable values tend to be higher, on average, amongst better-off households, although the relationship between household incomes and rateable values is relatively weak. Rateable value rises less than proportionately with household income, and rateable value is affected by many other factors besides household income.

Rateable values also vary across the country, reflecting the differences in property values. However, the implications of this for water charges are very different to its implications for local taxation. When domestic rates were abolished, there was a major geographical redistribution of the local tax burden; however the abolition of water rates is not likely to lead to a corresponding geographical redistribution of the level of water charges.

The reason for this difference between the two cases is as follows: In the case of local taxation, regional differences in rateable values were translated into differences in the average level of local taxes in different regions, with average domestic rates bills much higher in the south of the country than in the north. This situation arose because the system of central government grants to local authorities under the rating system acted to neutralise the effects on local authorities' tax base of differences in the average value of properties, so that a uniform tax rate could be levied for a uniform standard of spending in all authorities. Abolition of domestic rates in favour of a tax unrelated to property values led to a large regional redistribution of local tax payments, with local taxes rising particularly sharply in the north of England. In the case of water charges, however, this effect would not operate; the water companies charge the level of water rates required to cover their costs, and rateable value thus simply acts to divide the burden of paying for the water company between the
Figure 2

Water charges as a proportion of household income: revenue-neutral comparison of water rates and a licence fee.

customers of that area. If average rateable values in a water company’s area are low, the poundage levied is correspondingly high, and the average bill is unaffected. This means that a shift away from water rates to a charging base unrelated to property values will have a less uneven impact across regions, and consequently across income groups than in the case of similar changes to local taxation.

Although water rates payments rise with household income, they rise less than proportionately with income, and the proportion of household income taken in water rates thus falls as household incomes rise. For the poorest ten per cent of the population, water and sewerage rates constitute approximately 3 per cent of household income whereas for the richest ten per cent of households the equivalent figure is about 0.4 per cent. As Figure 2 shows, both water rates and a licence fee have a regressive distributional impact on household incomes, meaning that the proportion of household income paid in water charges falls as household income rises. A switch from water rates to a licence fee would increase the regressivity of water charges, although the effect is relatively small; households in the poorest decile would pay on average about £24 per annum more in water charges, increasing the proportion of income taken in water charges to some 3.7 per cent. At the upper end of the income distribution, slightly larger sums are involved; the richest decile would gain approximately £45 per annum on average, reducing the proportion of income taken in water charges to 0.3 per cent.
Figure 3 summarises the pattern of "gainers" and "losers" by household type from a revenue neutral switch to a licence fee. The figure shows the proportion of households in each category that would either gain or lose and, the average amounts of the gains and losses. The households that would lose the most from a shift to a household licence fee are those consisting of one individual; over 70 per cent of households consisting of a single employed or unemployed person lose, paying on average around £45 extra per year. Correspondingly, the largest number of gainers appear in households consisting of two earners with children where almost 60 per cent of such households gain. These figures partly reflect the position of these various groups in the income distribution, and also the tendency for larger households to occupy larger - and hence more highly-rated - properties.

3.2 Metered Charges

This section considers the distributional implications of charging for water on the basis of metered water consumption. The estimates given are calculated on the basis of unchanged water consumption - in other words, it is assumed that current water consumption patterns are not affected by the introduction of water charges based on the amount of water consumed. Some changes in the pattern of household water consumption are likely to take place in response to metered water charges (and, indeed, there would be no point in choosing this administratively expensive option unless behavioural changes did take place), but the evidence summarised in OECD (1987) suggests that they are likely to be relatively small. They may, however, be unevenly distributed...

across the population; in the similar case of energy taxation, Pearson and Smith (1991) show, for example, that a large part of the total behavioural response to higher energy taxes would take place amongst the poorest income groups. Also, if metered charging reduced the level of water consumption, it would be liable to reduce the marginal costs of water supply, and hence could reduce the unit price of water supply. The assumption made here of no change in water consumption therefore means that the results of this section should be interpreted with caution.

Although there are many possible structures of charging based on water metering that could be introduced, the analysis here considers a relatively simple tariff structure based on a fixed service charge plus a constant unit price for each unit of consumption. The fixed charge, as with the other charging schemes, is based on the sum of the existing water and sewerage standing charges. The volumetric charge is then calculated so that company revenues are maintained at the current level. Across the FES sample, the average combined water and sewerage volumetric charge for England and Wales which would have raised the same total revenue as was raised from water and sewerage rates in 1991/92 was £0.918 per cubic metre.

Figure 4

Metered Charges as a Proportion of Income

Figure 4 shows that a switch to water metering would have a very similar distributional incidence across income groups to the incidence of water rates. The average proportion of household income taken in water charges would be almost the same amongst the poorest income groups, would be slightly higher than with water rates for middle-income groups, and slightly lower for the richest income group. However, the differences are very small indeed.
The pattern of changes in water charges for individual households can be estimated only imprecisely from our data. This is because the data on water consumption which are being employed in the analysis are statistical estimates based on a reduced form model of household water consumption. Whilst the model used explains a substantial proportion of the variation in water consumption between households, and is likely to provide reasonable accurate estimates of the average consumption of groups of households within the data, it does not contain all factors affecting individual consumption, and therefore tends to understate the amount of individual variation between households. This limitation should be borne in mind in interpreting Figure 5, which is less reliably determined than the corresponding figure for the licence fee option.

However, Figure 5 suggests that there is a distinct pattern of gainers and losers across household types as a result of the introduction of universal metering. Large households tend to lose whereas smaller households tend to gain. The highest proportion of losers can be found in the household type consisting of unemployed couples with children whereas 93 per cent of single pensioners gain. This pattern of gainers and losers is to be expected since there is a clear correlation between household size and water consumption. Overall, 47 per cent of households would either gain or remain unaffected by a revenue neutral switch to universal metering.
3.3 "Banded" Charges Based on Household Characteristics

Within this category of charges results are given for the distributional impacts of a switch to three schemes of water charging where the charge levied is related to certain household characteristics - a charge based on the number of people in the household, a charge varying according to the type of property occupied, and a charge based on the property value bands used in the new Council Tax.

These banded charges may be considerably cheaper to operate than universal water metering. On the other hand, banded charges are likely to be more expensive to operate than the licence fee, since they require the collection (and verification) of the information needed to allocate households to charging bands. However, they also have two possible attractions when compared to the licence fee. One is that they may be perceived as more equitable than the household licence fee, which pays no regard to household income or other characteristics. The household characteristics used to differentiate household charges in the banded schemes may proxy aspects of household "ability to pay" (although in each case they are likely to be quite weak proxies). A second possible attraction of the banded charges is that they may bring the unmeasured water bills of households closer into line with the charges which they would pay if metered and charged for their current water consumption. As discussed in section III, a system of unmeasured water charges could be designed to approximate the charges households would pay if charged for water services on the basis of current water consumption. It would then tend to encourage efficiency in the pattern of household take-up of water metering, where voluntary metering was on offer.

There is, naturally, a tendency for these two objectives to point in opposite directions in the design of charging structures. Thus, for example, in considering the design of charges related to the numbers of household members, ability-to-pay considerations might point towards a charge based on the numbers of adults of working age, whilst a more accurate approximation of water consumption might be given by including all household members, including children. Here the effects of the latter option are shown, and the effects of a revenue-neutral switch to a charge based on the number of household members has been modelled; across England and Wales as a whole, the charge per household member in 1991-92 would have been £44.68.

Similarly, the structure of charges based on house type which has been modelled has been designed to approximate the levels of water consumption of households in each type of accommodation. Table 2 shows the average water consumption of households in the sample occupying each type of property. The charge structure has been set so that the scale of charges paid reflects the average water consumption of each household type. For example, households occupying detached accommodation consume on average 26 per cent more water than households occupying semi-detached accommodation, and it has been assumed that they would pay a correspondingly higher charge.

The charge modelled based on capital values bears some similarities to the local government tax, the council tax, in that the bills that households receive depend upon the value of the property they occupy. Under the Council Tax, dwellings are allocated to one of the eight bands shown in Table
Table 2

Charges based on house type: water consumption and relative charge levels for the four categories of dwelling.

<table>
<thead>
<tr>
<th>Charge Category</th>
<th>Water Consumption (litres per day)</th>
<th>Charge Weight (semi-detached=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detached</td>
<td>421</td>
<td>126</td>
</tr>
<tr>
<td>Semi-detached</td>
<td>334</td>
<td>100</td>
</tr>
<tr>
<td>Bungalow/Terraced</td>
<td>300</td>
<td>90</td>
</tr>
<tr>
<td>Flat/Other</td>
<td>246</td>
<td>73</td>
</tr>
</tbody>
</table>

3; the relative tax rates applied to each of the Council Tax bands are set by central government and are applied uniformly throughout the country. These relative tax rates have the effect that a dwelling in Band H pays twice as much Council Tax as a dwelling in Band D in the same authority, and three times as much as households in Band A. Whilst it would be possible to use these relative tax rates for operating water charges based on the Council Tax bands, the results reported here show the effects of a charging structure along the lines of the charges by property type, where relative charge levels reflected the relative average water consumption of each band. As Table 3 shows, these relative charge levels are very close to the relative Council Tax levels for households in the lower bands, but households in the higher bands would pay rather less in water charges than if the Council Tax structure of relative tax levels had applied.
Table 3

Valuation bands for the Council Tax, and estimated relative water consumption

<table>
<thead>
<tr>
<th>Band</th>
<th>Capital value bands, England</th>
<th>Council Tax relative to band D</th>
<th>Average water consumption relative to band D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>up to £40,000</td>
<td>0.67</td>
<td>0.68</td>
</tr>
<tr>
<td>B</td>
<td>£40,000 up to £52,000</td>
<td>0.78</td>
<td>0.84</td>
</tr>
<tr>
<td>C</td>
<td>£52,000 up to £68,000</td>
<td>0.89</td>
<td>0.89</td>
</tr>
<tr>
<td>D</td>
<td>£68,000 up to £88,000</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>E</td>
<td>£88,000 up to £120,000</td>
<td>1.22</td>
<td>1.09</td>
</tr>
<tr>
<td>F</td>
<td>£120,000 up to £160,000</td>
<td>1.44</td>
<td>1.20</td>
</tr>
<tr>
<td>G</td>
<td>£160,000 up to £320,000</td>
<td>1.67</td>
<td>1.32</td>
</tr>
<tr>
<td>H</td>
<td>£320,000 plus</td>
<td>2.00</td>
<td>1.41</td>
</tr>
</tbody>
</table>

Figure 4 illustrates the distributional incidence of the three banded charging schemes, compared to the current system of charging based on rateable values. All three banded schemes are a little more regressive than water rates, although the differences are very small indeed.

Table 4 shows how closely each of the banded charges approximates to the pattern of household water consumption, and hence to the charges that households would pay if charged on the basis of current water use. Households are classified into five groups. The central group are those for whom the water charges that would be levied for current consumption are within £25 per year either way of the banded charges levied on the household. For these households, the gap between the banded charge and the charge they would pay if metered does not provide them with any significant encouragement or discouragement to choose metering. This group of households may be regarded as those able to make efficient decisions regarding the take-up of voluntary metering; only if they would reduce their consumption by enough to make metering worthwhile, will they be liable to choose the metering option. The other households face incentives for inefficient choices about metering. In the two right hand columns, households face a fiscal incentive to choose metering. Even if they make no change in their water consumption, metering would save them substantial amounts compared to the banded charge. In the two left hand columns, households
face a disincentive to choose metering. Even if they would reduce their consumption substantially when metered, they would not wish to choose the metering option, since the banded charge is so favourable to them.

Table 4 thus shows the proportion of households likely to be affected by two different types of inefficiency in the voluntary take-up of metering. For a particular banded charge, the higher the proportion of households in the central category, the more efficient are likely to be the choices regarding metering take-up. Charging according to the number of household members would, on this evidence, appear to be most likely to encourage efficient take-up of voluntary metering, whilst each of the other three non-metered charging bases would provide a significant proportion of households with "fiscal" reasons for making inefficient decisions regarding metering take-up.³

To summarise the conclusions from these results, a non-metered charging system which proxies the charges that would be levied for current consumption may encourage greater efficiency in the pattern of take-up of voluntary metering, where this option is on offer. Unfortunately, the best of

3 The results in Table 4 should be interpreted with particular caution, since, as noted earlier in the paper, the consumption figures used are predictions from a reduced form model, and are likely to understate the amount of household variation. In addition, to the extent that variables included in the consumption equation include the household variables used to calculated the various banded charges (such as the number of household members), and that in the consumption equation these variables may have partly proxied the effects of other, omitted, factors, the water consumption estimates may be "closer" to the bases of the banded charges than would be true consumption figures. The "unchanged" category may therefore contain a higher proportion than it should, and this error may differ between the different banding options. Although the results in Table 4 are not implausible, the figures given should best be regarded as illustrative, rather than as precise estimates.

Table 4

The incentive for household take-up of metering, under four non-measured charging systems: excess of non-measured charges over metered charge (£ per year).

<table>
<thead>
<tr>
<th></th>
<th>Households facing fiscal disincentive to choose metering</th>
<th>Households facing fiscal incentive to choose metering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered charge saves:</td>
<td>-£50 or more</td>
<td>-£25 to -£50</td>
</tr>
<tr>
<td>Licence fee</td>
<td>16%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>17%</td>
<td>20%</td>
</tr>
<tr>
<td>Charge based on</td>
<td>1%</td>
<td>11%</td>
</tr>
<tr>
<td>number of household</td>
<td>48%</td>
<td>28%</td>
</tr>
<tr>
<td>members</td>
<td></td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>13%</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td>18%</td>
<td>21%</td>
</tr>
<tr>
<td>Charge based on</td>
<td>13%</td>
<td>18%</td>
</tr>
<tr>
<td>house type</td>
<td>18%</td>
<td>24%</td>
</tr>
<tr>
<td>Charge based on</td>
<td>13%</td>
<td>16%</td>
</tr>
<tr>
<td>capital value bands</td>
<td>18%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>16%</td>
<td>30%</td>
</tr>
</tbody>
</table>
| Note: due to rounding, rows do not necessarily add to 100.

4 How far do the distributional effects of water charges matter?

There is a more fundamental question which needs to be addressed by public policy makers in response to results of the sort which have been presented in the previous section - namely, why is this an issue at all? Why should we care about the distributional effects of adopting any particular system of water charges? The question raises a series of complex, and linked, questions. Many of the same issues arise in the pricing of other household utilities such as electricity and gas (Dilnot and Helm, 1987).
Firstly, we should address the objection that the status of water charges as a price for water services directly disposes of the need for the concern that we would have regarding, say, the distributional incidence of a tax. Why, it might be argued, are we concerned about the distributional effects of the price of water, any more than we are concerned about the distributional effects of the prices charged for other goods and services which households buy?

A similar line of argument was used by the UK Government in presenting the case for a poll tax, to replace the local property tax (domestic rates) as the basis for financing UK local government. In this case the new tax was named the “Community Charge”, a title which was intended to stress the similarity of the tax with a price (for the services provided by local government), rather than with taxation. The mere choice of a name quite clearly did not dispose of the issue, and in our view significant - and closely related - distributional concerns arise in the case both of water supplies and local taxes.

What is critical is the absence of any real opportunity to decline to purchase the product for which the price is being charged. In the case of local taxation, individuals were compelled to pay so long as they lived in the area; moving to another area where services and taxes might be lower was an option which could not be exercised costlessly, and without accepting various other features of different residential areas. Similarly, in the case of water charges, there is little opportunity for a household to avoid the charge levied, since at least some level of water consumption is a necessity; only where water is charged according to use does the opportunity of reducing spending exist.

It will be observed that this point of view can lead to a long list of goods and services for which pricing policy raises at least some distributional issues; the scope for households to decline to purchase at least some quantity of many basic necessities may be quite limited. This, in our view, is quite correct; distributional characteristics are one dimension in the design of policy towards indirect taxes such as VAT and consumer excises.

Nevertheless, the circumstances in which the taxation or pricing of particular commodities needs to be adjusted to reflect distributional considerations are in practice rather limited. What matters in designing an equitable tax system is the distribution of the burden of taxation as a whole, not of each individual element of the system. A highly regressive indirect tax structure could, therefore be compensated by other, more progressive, elements elsewhere in the tax system. Where efficiency considerations in pricing or indirect taxation lead to an excessive burden on particular income groups, it would be possible to adjust other elements of the tax system to compensate these groups.

Thus, the regressive burden of water charges could be compensated by greater progressivity in income tax and in the social security system, through higher income tax allowances and higher levels of social security benefits. Higher benefit levels could, for example, provide poor households with sufficient money to leave a household with average water consumption unaffected by the introduction of metered water charges at the efficient level, whilst ensuring that those households with wasteful water use faced the full marginal cost of their use of water.
The circumstances in which this response will be inadequate are of two sorts. One is where differences between households in water consumption reflect differences in "needs" for water rather than simply differences in tastes or preferences. A certain level of water consumption may be regarded as a "merit good", or, at the very least, the water consumption of households of different sorts might be a factor in determining how much redistribution through taxation and social security is needed to meet public objectives of equity. Poor households differ in various respects which might affect their water consumption needs; the presence of young children, for example, might substantially increase the amount of water consumption needed to maintain an adequate standard of living. Where the factors determining the relative needs for water of different types of households are easily observed, it may be possible to design the compensatory adjustments to the tax and social security systems to take these differences into account. However, where the factors underlying differences in needs cannot be sufficiently clearly identified to allow appropriate targeting of extra social security benefits or tax adjustments, it may be appropriate to supply water at lower prices, so as to ensure that households with higher than average needs for water are able to afford adequate quantities. As Weitzman (1977) demonstrates, policy must then choose between the lesser of two evils, in the form of either poor targeting in relation to needs, or of encouraging excessive consumption by households without high needs; the choice turns on the extent to which the unobservable differences in water needs are large relative to other factors affecting household water consumption, such as income and preferences. Whilst this is a matter of judgement, it would seem to us that, in the case of water consumption in a developed country such as the UK, this line of argument does not constitute a major reason for providing households with water at less than the efficient price; most of the reasons for differences in households "needs" for water would seem likely to be reflected in straightforward characteristics of the household, such as the number and ages of household members, which could easily be reflected in targeted adjustments to the average level of social security benefits.

A second qualification to the argument that adequate compensation can be provided through adjustments to income tax and social security arises due to the presence of local variation in water charge levels. Although it is possible to compensate households through charges to the tax/benefit system for the average level of water charges, this compensation would be inadequate for households living in areas where the level of water charges is well above the average. Since households living in a particular area cannot realistically be expected to move house simply to reduce the higher-than-average water charges that they pay, it may be appropriate for public policy to try to provide households in high-charge areas with more compensation than households in areas where water charges are lower.

The issues are complex, and closely analogous to the case of local government taxation. Thus, for example, it might be appropriate to consider whether long-standing and predictable local differences in water charge levels might have become capitalised into property prices, and therefore not constitute a burden on the current owner or occupier; also, consideration should be given to the possibility that differences in water charge levels might reflect differences in the quality of service provided. However, in the current context, much of the variation in water charge levels would appear to reflect differences in the condition and cost of maintaining the capital infrastructure.
Distributional Aspects of Household Water Charges. 

Inherited by the water companies, and in the cost of meeting pollution control obligations placed on the water companies. To the extent that some of these costs, especially the pollution control costs, have increased sharply as a result of recent government policy decisions they will not have been capitalised into the prices at which current property owners bought their properties. For this reason, and because they do not reflect differences in service levels, there may be a case for seeking to compensate households for differences in these costs that does not necessarily apply to some of the differences in the cost of providing local government services.

In the local government case, compensation for local taxes takes the form of rebates related to the level of the local tax a household pays, thus ensuring that the amount of compensation is related to the level of the tax levied. A similar need for compensation related to the level of water company charges could therefore perhaps be met by a system of water rebates, or "water benefit", providing support related to the average level of water charges levied by each water company, and ensuring that households in areas where the water companies bear particularly heavy burdens of pollution control and infrastructure renewal are not unduly burdened, in relation to similar households where the burdens on water companies are less.

Alternatively, of course, it would be possible to deal with this problem by taking measures to reduce the extent of variation between companies in the level of water charges. Since one source of variation is the differential burden on water companies of actions required by public legislation on pollution and environmental improvement, household water charges appear to be taking on the role of taxes, levied on particular geographical groups, to finance these improvements. There is certainly an argument that household water charges should not be used to finance environmental improvements properly financed out of general taxation; if this argument also helps to reduce the variation between areas in the level of water charges, it may help to reduce the need for complex, locally-differentiated, levels of social security compensation for the burden of water charges.

5 Conclusions

This paper has looked at five possible replacements for the present system of water rates. In terms of their relation to household income, the differences between any of the various alternatives to the current rateable value based water charges are small. Compared to water rates, a uniform household licence fee would be more regressive, and also other non-measured charges somewhat more regressive; universal water metering would have much the same overall distributional incidence across income groups as water rates. The relatively stable picture across income groups, however, conceals rather greater variation across household types.

This variation is the source of the distributional concerns that would be raised by a system of water charges based on metered consumption. To the extent that it reflects differences in household preferences for water, it is benign; however, if it reflected differences in household needs for water which could not be adequately compensated by targeting social security to the relevant affected
households, it would be of more concern. In practice, most of the reasons for differences in water needs would appear to reflect factors which could be used to target social security changes - such as for example, the number of children and adult household members.

The degree to which it is possible to compensate households through changes to the tax system will also depend upon the extent to which charges vary between water companies. If charges are uniform across the country, then it would be relatively simple to compensate households through changes to existing taxes and social security.

This study has emphasised the potential value of a system of non-metered water charges that closely proxies household water consumption. The reasons for interest in this have nothing to do with equity; there is nothing intrinsically "fair" or equitable about non-metered water charges which are proportional to consumption. However, a non-metered charging system which proxies the charges that would be levied for current consumption may encourage greater efficiency in the pattern of take-up of voluntary metering, where this option is on offer. Unfortunately, the best of the non-metered charges from this perspective, charges based on the number of household members, would appear also to be likely to be the most administratively expensive, since it would require the collection and verification of a register of the number of household members.
Chapter 8

Market failures in household energy efficiency in the UK
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Market failures in household energy efficiency in the UK

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Energy Efficiency

1 Energy taxation and energy efficiency.

Over the past five years, policy towards the taxation of energy has been debated vigorously. In 1991 the European Commission proposed a new carbon/energy tax as part of a package of measures intended to reduce energy use and to help the Community meet international targets for reducing emissions of carbon dioxide and other "greenhouse gases". This would have applied to both domestic and industrial users of energy and motor fuels. Also, in the area of UK domestic policy, the Chancellor's 1993 Budget announced the phased extension of the standard rate of Value Added Tax to domestic energy, which had hitherto been zero-rated in the UK. The extension of standard-rate VAT to domestic energy was primarily motivated by the need for increased tax revenues, but, at the same time, the government maintained that the measure would have the valuable by-product of reducing energy consumption, and hence contributing to achievement of targets for reducing greenhouse gas emissions.

One common issue raised by both the proposed EC carbon/energy tax and the extension of VAT to domestic fuel is the likely distributional impact. This, indeed, formed the focus for much of the political opposition in the UK to VAT on domestic energy. Domestic energy forms a much larger part of the budgets of poorer households than of population as a whole; as Chapter 6 has shown, domestic energy accounts for some 16 per cent of the non-durable spending of the bottom decile group of households, but only 7 per cent of household spending on average. Additional taxes on domestic energy will thus tend to have a regressive distributional incidence, in the sense that the extra energy tax payments will be a higher percentage of income (or of total spending) for poorer households than for the better-off.

In addition to the burden of extra taxation, a second issue has been the distribution of the burden of reductions in energy consumption in response to higher energy prices. It appears likely that the reduction in energy consumption induced by the imposition of VAT on domestic energy will be appreciably greater amongst poorer households; Crawford, Smith and Webb (1993) estimate that the energy spending of the bottom quintile would fall by 9 per cent in volume terms, whilst the average reduction in the volume of energy consumption would be of the order of 6 per cent.

The aggregate economic cost of adjustment to higher energy prices will be higher, where energy consumers are prevented by market failures from making optimal adjustments in energy use. An efficient pattern of adjustment to higher energy prices might include both reductions in energy consumption, and also greater levels of investment in various measures to increase the efficiency with which energy is used. In the domestic sector, measures which households can take to improve

1 Under the 1993 Budget proposals, standard rate VAT was to have been phased in over two years. An 8 per cent rate of VAT was applied to sales of energy to households from 1 April 1994, and it was planned that this would then be increased to the full 17.5 per cent standard rate of VAT from 1 April 1995. Political opposition to the extension of VAT to domestic energy led to the eventual abandonment of the second stage of the policy, so that VAT on domestic energy remains at 8 per cent.

2 However, once the use of the additional revenues from energy taxation is considered, a revenue-neutral package of measures, including higher energy taxes combined with higher transfers to poorer households, could be designed which, overall, would on average leave poorer households better off (Johnson, McKay and Smith, 1990).

3 Smith (1992) shows that in the UK the EC's carbon tax would be likely to have a regressive distributional impact too; the regressive effect of higher taxation of domestic energy would outweigh the progressive distributional incidence of higher taxes on motor fuels.
domestic energy efficiency may include such things as loft insulation, double glazing, and wall insulation. It has been suggested that markets for these investments may be subject to various forms of market failure, possibly including credit market failures, informational failures, and certain market failures related to housing tenure. Where households are prevented by market failures from adjusting efficiently to higher energy prices, their reductions in energy consumption in response to higher energy prices will tend to be smaller, and more "painful" in terms of their welfare cost.

The social and distributional costs of higher energy prices may be exacerbated if market failures in energy efficiency investment are particularly concentrated amongst low income households, or other vulnerable groups (Smith, 1992). Thus, for example, income related market failures, such as those related to the credit market, or to housing tenure, may tend to amplify the distributional cost of reducing energy consumption through pricing instruments. Measures to rectify the underlying market failures would then have the twin merits that they would tend to reduce the aggregate economic cost of achieving a given reduction in consumption, and at the same time would also help to reduce the social and distributional cost of higher energy taxation.

Policies to promote greater energy efficiency have been pursued by many governments in the OECD area since the oil shocks of the 1970s, initially for balance of payments reasons. A range of policy interventions have been used, including financial incentives through taxes and subsidies, policies to improve the information available to private decision makers, and building regulations which set standards or specify technologies that have to be used in new or existing houses (Brechling, Helm and Smith, 1991).

The initial rationale for these measures was set out in terms of the potential reduction in energy imports that could be achieved if energy was used more efficiently. More recently, attention has shifted to the contribution that greater energy efficiency could make to environmental policy, especially to the control of carbon dioxide emissions. Greater energy efficiency, it is suggested, would allow reductions in energy use, and hence lower levels of carbon dioxide emissions. A number of studies have sought to demonstrate that a large proportion of the reductions in carbon dioxide emissions required to meet internationally-agreed targets for greenhouse gas abatement could be achieved through the greater use of existing energy-efficient technologies.

These arguments take for granted a linkage between energy use and energy efficiency. However, consideration of the individual behavioural context for domestic energy efficiency investments makes it clear that the relationship between energy efficiency and energy use may well be more complex than these arguments tend to assume. It is unlikely that energy use would fall proportionately with the improvement in energy efficiency; some households may choose to take at least part of the benefits of increased energy efficiency in the form of greater comfort, rather
than in reduced energy bills\textsuperscript{4}. Indeed, in the absence of evidence about how households would respond to higher levels of energy efficiency, it is not even possible to be certain that greater energy efficiency would lead to a reduction in energy use, and hence to lower carbon dioxide emissions\textsuperscript{5}.

The possible impact of energy efficiency improvements on energy consumption does not, however, in itself constitute a justification for government policy interventions to promote energy efficiency. The rationale for policies to promote energy efficiency rests on the existence of some form of market failure - the presence of some impediment to the efficient functioning of the market in the absence of policy. One source of market failure which is relevant here is, of course, the external environmental costs of energy consumption, in particular the impact on global warming. Other market failures may also be present in the market for energy efficiency investment, quite independently of the environmental dimension to energy consumption. This latter group of possible market failures has attracted considerable attention in recent policy debate, because of the uncertainty and political complexity surrounding climate change policy.

Policy on global warming is being formulated in the context of considerable scientific uncertainty regarding the probability of climate change occurring, and the eventual scale of the economic costs of climate change. The benefits of climate change policies are thus uncertain; moreover, as far as individual countries are concerned, the contribution that their own measures would make to any benefits that they might experience from climate change policies will be negligible, and thus the incentive for free-riding, or at the least, backsliding, will be large. In this context, it has appeared a particularly attractive feature of policies to promote energy efficiency that they may constitute "no regrets" measures - in other words, measures that would be of benefit, even if the economic costs of global warming turned out to have been overstated, or turned out not to arise at all. By correcting market failures which inhibit energy efficiency investment by individual households they may improve the functioning of the economy, regardless of whether reduced energy use confers any future environmental benefits.

The belief that market failures must be important has been reinforced by studies, based on technical data, which show substantial rates of return to investments in domestic energy efficiency in typical properties. For example, Pezzey (1984), estimates that the net present value per unit of capital cost of loft insulation is of the order of 3.5 - 7.5, and of cavity wall insulation between 1.8 - 4.7. Installing double glazing, by contrast, appears to be unjustified on grounds of energy saving\textsuperscript{6}.

\textsuperscript{4} If energy efficiency investments and energy spending are not desired by households in themselves, but only desired as inputs to the efficient production of "warmth", then a fall in the energy price and an (exogenous) increase in energy efficiency would be expected to have very similar effects on household energy use. Both would reduce the relative price of warmth, and households would therefore normally be expected to choose to consume more warmth than before (Barnett, 1986).

\textsuperscript{5} Indeed, in a study of households in Belgium, Jaumotte, Meunier and Dauex (1987) found that households with energy efficiency measures actually had higher energy use, on average, than households without such measures. Cross-tabulation results are, however, little more than suggestive of the possible influence of energy efficiency on energy consumption, and can be misleading. The group of households with energy efficiency investments are self-selected, and will presumably include those for whom the returns to energy efficiency investments are higher, for both observable and unobservable reasons.

\textsuperscript{6} This issue has also been studied extensively in the US. A summary of some conclusions from the US literature is given in Levine et al (1995); see also Anderson (1995).
8. Energy Efficiency

Figure 1.
Percentages of the housing stock in England with energy efficiency measures.

![Graph showing energy efficiency measures](image)

Source: Henderson and Shorrock (1989)

Note: The figures are calculated as the percentage of the housing stock in which it would be possible to install the energy efficiency measure concerned.

The proportion of the UK housing stock with the principal energy efficiency measures has risen substantially over the past two decades (Figure 1). The proportion of properties with loft insulation has risen from about 43 per cent in 1974 to 89 per cent in 1989; the proportion with double glazing from 8 per cent to 47 per cent, and the proportion with wall cavity insulation from 3 per cent to 18 per cent over the same period. The data for hot water tank insulation (for which diffusion had reached more than 90 per cent by 1989) and draught proofing (about 40 per cent in 1989) are only available over shorter time periods. It is difficult to identify any relationship between either energy

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7 A similar upward trend is reported for Belgium by Jaumotte, Meunier and Daue (1987), although diffusion rates for certain measures differ from those in the UK. 38 per cent of properties in Belgium had loft insulation in 1986, a similar percentage had some form of glazing insulation (mainly double glazing), and 28 per cent had wall insulation, 64 per cent of the households with loft insulation, 73 per cent of the households with glazing, and 46 per cent of the households with wall insulation had installed the measures in the period 1980-86, and further proportions of 24 per cent, 22 per cent and 38 per cent respectively had installed the measures in the period 1973-79.

8 For all of the measures except draught proofing diffusion rates have been rising steadily upwards. Sharp fluctuations, and especially sharp reductions in diffusion rates would be unlikely; rates of diffusion in existing properties would tend to be non-decreasing if measures were left in place once installed. The one exception to the steady upward trend is the case of draught proofing, for which diffusion rates peaked around 1986 and then fell back; this appears to reflect a tendency for draught insulation to be viewed as an inferior substitute for other measures (such as double glazing), and the installation of double glazing to result in the removal of existing draught proofing.
prices or policy measures and the timing of the diffusion of energy efficiency measures; the trend in loft insulation shows no evidence of sudden jumps in diffusion during the 1970s and early 1980s, when energy prices were highest and UK policy most active.

Nevertheless, despite the steady increase in the proportion of households with each of the principal measures shown in Figure 1, many households still have not taken all or some of the measures which the studies based on technical data suggest would be cost-effective. It is suggested that the fact that there is less than 100 per cent take-up of measures estimated to be cost-effective on the basis of NPV calculations may reflect the influence of various market failures.®

Nevertheless, despite the role that such arguments have played in the formulation of policy, evidence about the practical importance of market failures in domestic energy efficiency in the UK is lacking. This paper provides evidence on the pattern of energy efficiency investments amongst private households in the UK, based on economic modelling. The results provide some pointers to the relative significance of some forms of market failures in energy efficiency investments.

The plan of the remainder of the paper is as follows. Section 2 discusses various forms of market failure which could arise in the energy efficiency sector. Section 3 reports an empirical study of factors affecting household take-up of energy efficiency measures. Section 4 draws some brief conclusions about the policy implications of the results.

2 Domestic Energy Efficiency Decisions.

The main focus of the paper is on the actions households can take to prevent energy loss from energy-using activities, principally domestic space and water heating, through various energy efficiency investments, including loft insulation, wall insulation and double glazing. In each case, the energy efficiency measures have the character of investments; money spent on them in one year yields benefits over a number of subsequent years.

The demand both for energy and for energy efficiency investments is a derived demand (Hausman, 1979); consumers seek energy services, in the forms of heat, light or power, from a combination of energy inputs (electricity, gas, etc) and capital investments. The choice of how to meet any given demand for energy services will reflect the costs of energy inputs and insulation, and the efficiency with which they are transformed into energy services. In some cases (open fires, and double glazing, perhaps) consumers may derive utility from how the chosen level of energy services is achieved, but usually consumer choices will simply reflect the relative costs of energy and insulation inputs in supplying the chosen level of energy services.

An alternative explanation, reviewed in detail in Brechling and Smith (1992) would be that the calculations do not take account of the full range of costs involved in installing the energy efficiency measures, or that they make inappropriate assumptions regarding the rate of discount, or about future energy prices. Also, there may be differences between households which are relevant in determining take-up of energy efficiency measures, but which are not reflected in the calculations for "typical" properties. Households whose members are rarely at home may have low heating needs, and consequently low energy consumption; for such households, the savings from energy efficiency investments may fall well short of the savings for a "typical" household in the same property.
Market failures arising from a number of sources could, however, prevent households choosing an optimal mix of energy consumption and investments in energy efficiency (Jochem and Gruber, 1990; Brechling, Helm and Smith, 1991):

- **Information.** Some consumers may fail to undertake cost effective measures because they are poorly informed about the technological possibilities for energy efficiency investments, and about the likely impact of such investments on their fuel use and costs\(^\text{10}\).

- **Benefits cannot be appropriated.** Cost effective investments may not be undertaken if the investor cannot appropriate the subsequent energy savings. Owner-occupiers who expect to move at some time in the future may not be able to recoup the full value of investment in energy efficiency through a higher sale price\(^\text{11}\). Also, there may be problems in tenanted housing, where the landlord may be responsible for making any structural improvements which would reduce energy use, but where tenants pay the energy bills\(^\text{12}\). Although, in principle, a higher level of rents could be charged to reflect the benefits of greater energy efficiency, this may be prevented by rent control legislation, or if tenants are unable to observe accurately the energy efficiency of the dwelling.

- **Credit market failure.** Poorer households tend to be less energy efficient (Boardman, 1991). However, it is not clear whether poverty as such, or other characteristics of the household (such as low energy use or tenure) should be seen as the underlying reason for this. One possible source of low rates of energy efficiency investments amongst poorer households could be credit market failures. Poorer households, and other groups of the population with limited collateral, may be severely restricted in their access to credit at the market rate of interest (see, for example, Weber, 1990).

- **Uncertainty.** Uncertainty may be a source of market failure in household investment decisions, where households are unable adequately to insure against future risks\(^\text{13}\). In the present context,

\(^{10}\) Jaffe and Stavins (1994) claim that the diffusion of energy efficient technologies in newly-contructed housing in the USA has been impeded by information problems.

\(^{11}\) See Laquatra (1986) and Horowitz and Haeri (1990) for a discussion of the capitalisation of energy efficiency measures in house prices in the USA.

\(^{12}\) 92% of owner-occupiers with accessible lofts have loft insulation but the proportion amongst tenants of private landlords is only 62% (Henderson and Shorrock, 1989a).

\(^{13}\) The position may be somewhat better in the case of industrial energy users, for whom energy management contractors may be able to absorb some of the risks of energy efficiency improvements, in return for a share in the potential gains. The difference between the two cases which allows energy management contractors to operate in the case of industrial energy use, but not in the case of domestic energy use may be partly a matter of scale; the potential savings in energy use by an industrial energy user may be much greater than by a private household, and therefore more likely to warrant incurring the fixed costs of a contract. In addition, there is a key difference in the predictability of the pattern of demand for energy services in the two cases. The energy use pattern of a household may depend on a whole range of factors, and households may choose to take much of the benefit from greater energy efficiency in the form of a higher level of energy services, rather than reduced energy inputs. It is difficult to see how an energy management contract could be written which would allow a contractor to share in the risks and gains from energy efficiency investments by a household, but such contracts may be comparatively easy to write in the case of industries using energy in industrial processes, where the services provided by energy inputs can be defined and monitored, and hence the energy saving for a given level of energy services can be calculated.
such risks could arise from uncertainty about the effectiveness of particular measures, about the household's future circumstances and energy needs, or about the future energy price (Hasset and Metcalf, 1992).

In addition to the above market failures, inefficiency may arise through individual failures in decision-making. The choices made by individual households are unlikely to be determined simply by the results of an optimising calculation of the installation costs and potential benefits from energy efficiency investments. Consumers may rely on inappropriate decision rules, and may make mistakes. There is also survey evidence that attitudes and other subjective factors affect the diffusion of energy efficiency measures (Jaumotte, Meunier and Daue, 1987; Hedges, 1991).

3 The Empirical Analysis

This section describes an analysis of the pattern of household take-up of energy efficiency measures, using data from the 1986 English House Condition Survey (EHCS) to model the pattern of take-up of three key energy efficiency measures, loft insulation, wall insulation and double glazing, by a sample of nearly 7,000 households in England. This data set is particularly suited to examining the interaction between energy efficiency decisions and the socio-economic factors likely to reflect market failures, in that it includes data on specific physical features of the dwelling, socio-economic data about the current occupants, and, for a sub-sample of the data, fuel consumption information from both gas and electricity board records.

Table 1 reports logit reduced form models which explain household possession of each of the three energy efficiency measures - loft insulation, cavity wall insulation and double glazing - as a function of the features of the property, and the socio-economic and demographic characteristics of its current occupants. Each model excludes households that are unable to install the measure concerned; thus, in modelling loft insulation, households without lofts have been omitted. "Don’t Know" replies have also been excluded.

To give an indication of the strength of the effects of the various variables in the estimated models, Table 2 shows how predicted probabilities of possession, based on the estimated models, vary with changes in household characteristics (income, tenure, etc).
8. Energy Efficiency

<table>
<thead>
<tr>
<th></th>
<th>Loft Insulation</th>
<th>Wall Insulation</th>
<th>Double Glazing</th>
<th>Mean (double glazing sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coeff</td>
<td>s.e.</td>
<td>coeff</td>
<td>s.e.</td>
</tr>
<tr>
<td>Constant</td>
<td>0.24</td>
<td>0.87</td>
<td>-4.55</td>
<td>0.94&quot;</td>
</tr>
<tr>
<td>Perimeter of dwelling</td>
<td>-0.25</td>
<td>0.07&quot;</td>
<td>-0.10</td>
<td>0.05&quot;</td>
</tr>
<tr>
<td>Area of dwelling</td>
<td>0.006</td>
<td>0.002&quot;</td>
<td>0.002</td>
<td>0.002&quot;</td>
</tr>
<tr>
<td>Semi-Detached</td>
<td>0.03</td>
<td>0.14</td>
<td>-0.56</td>
<td>0.12&quot;</td>
</tr>
<tr>
<td>Terraced</td>
<td>-0.28</td>
<td>0.15&quot;</td>
<td>-0.71</td>
<td>0.14&quot;</td>
</tr>
<tr>
<td>Flat</td>
<td>-0.98</td>
<td>0.20&quot;</td>
<td>-1.16</td>
<td>0.21&quot;</td>
</tr>
<tr>
<td>Built 1900-18</td>
<td>0.22</td>
<td>0.13</td>
<td>-0.22</td>
<td>0.18</td>
</tr>
<tr>
<td>Built 1919-44</td>
<td>0.50</td>
<td>0.12&quot;</td>
<td>0.02</td>
<td>0.13</td>
</tr>
<tr>
<td>Built 1945-64</td>
<td>0.97</td>
<td>0.16&quot;</td>
<td>0.56</td>
<td>0.14&quot;</td>
</tr>
<tr>
<td>Built 1965+</td>
<td>0.48</td>
<td>0.19&quot;</td>
<td>0.77</td>
<td>0.15&quot;</td>
</tr>
<tr>
<td>Household Income (Log)</td>
<td>0.30</td>
<td>0.09&quot;</td>
<td>0.34</td>
<td>0.09&quot;</td>
</tr>
<tr>
<td>Head of household aged 26-39</td>
<td>0.17</td>
<td>0.20</td>
<td>0.14</td>
<td>0.23</td>
</tr>
<tr>
<td>Head of household aged 40-59</td>
<td>0.07</td>
<td>0.20</td>
<td>0.24</td>
<td>0.24</td>
</tr>
<tr>
<td>Head of household aged 60+</td>
<td>0.09</td>
<td>0.25</td>
<td>0.48</td>
<td>0.27</td>
</tr>
<tr>
<td>Head of household is pensioner</td>
<td>-0.08</td>
<td>0.19</td>
<td>-0.38</td>
<td>0.19&quot;</td>
</tr>
<tr>
<td>Head of household is unemployed</td>
<td>0.03</td>
<td>0.24</td>
<td>0.18</td>
<td>0.26</td>
</tr>
<tr>
<td>Head of household is Unoccupied</td>
<td>0.02</td>
<td>0.19</td>
<td>-0.27</td>
<td>0.24</td>
</tr>
<tr>
<td>Local Authority Rented</td>
<td>0.06</td>
<td>0.12</td>
<td>-0.10</td>
<td>0.12</td>
</tr>
<tr>
<td>Private Rented</td>
<td>-1.10</td>
<td>0.12&quot;</td>
<td>-0.36</td>
<td>0.20&quot;</td>
</tr>
<tr>
<td>Central Heating</td>
<td>1.12</td>
<td>0.09&quot;</td>
<td>0.58</td>
<td>0.11&quot;</td>
</tr>
<tr>
<td>Main heating fuel: electricity</td>
<td>-0.42</td>
<td>0.13&quot;</td>
<td>-0.08</td>
<td>0.16</td>
</tr>
<tr>
<td>Main heating fuel: other fuel</td>
<td>0.48</td>
<td>0.10&quot;</td>
<td>-0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>Main heating fuel: shared heating</td>
<td>-1.82</td>
<td>0.72&quot;</td>
<td>-0.24</td>
<td>0.49</td>
</tr>
<tr>
<td>Midlands</td>
<td>-0.14</td>
<td>0.11</td>
<td>-0.03</td>
<td>0.12</td>
</tr>
<tr>
<td>East Anglia</td>
<td>0.00</td>
<td>0.19</td>
<td>0.16</td>
<td>0.19</td>
</tr>
<tr>
<td>South East</td>
<td>-0.01</td>
<td>0.13</td>
<td>0.25</td>
<td>0.12&quot;</td>
</tr>
<tr>
<td>London</td>
<td>-0.33</td>
<td>0.13&quot;</td>
<td>-0.82</td>
<td>0.16&quot;</td>
</tr>
<tr>
<td>West</td>
<td>0.08</td>
<td>0.14</td>
<td>0.38</td>
<td>0.14&quot;</td>
</tr>
<tr>
<td>Occupiers resident 2-5yrs</td>
<td>0.20</td>
<td>0.14</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>Occupiers resident 5-10yrs</td>
<td>0.10</td>
<td>0.14</td>
<td>0.46</td>
<td>0.14&quot;</td>
</tr>
<tr>
<td>Occupiers resident 10-20yrs</td>
<td>0.40</td>
<td>0.15&quot;</td>
<td>0.30</td>
<td>0.15&quot;</td>
</tr>
<tr>
<td>Occupiers resident 20+yrs</td>
<td>0.12</td>
<td>0.15</td>
<td>0.22</td>
<td>0.16</td>
</tr>
<tr>
<td>Likely to move in next 2 yrs</td>
<td>-0.05</td>
<td>0.11</td>
<td>-0.14</td>
<td>0.12</td>
</tr>
</tbody>
</table>

** denotes a significance level of 5%.
* denotes a significance level of 10%.

Number of observations = 5271
ch²(32) = 765.0
*pseudo* R² = 0.156
Mean of Dependent Variable = 0.825
Table 2
Predicted probabilities of having loft insulation, double glazing, and wall insulation, for households with various characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Loft insulation</th>
<th>Wall insulation</th>
<th>Double glazing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Household</td>
<td>.90</td>
<td>.11</td>
<td>.36</td>
</tr>
<tr>
<td>As reference household, but: half average income</td>
<td>.88</td>
<td>.09</td>
<td>.32</td>
</tr>
<tr>
<td>As reference household, but: double dwelling area</td>
<td>.86</td>
<td>.09</td>
<td>.38</td>
</tr>
<tr>
<td>As reference household, but: tenants in private rented sector</td>
<td>.75</td>
<td>.08</td>
<td>.12</td>
</tr>
<tr>
<td>As reference household, but: flat</td>
<td>.82</td>
<td>.07</td>
<td>.34</td>
</tr>
<tr>
<td>As reference household, but: electricity used for heating</td>
<td>.86</td>
<td>.10</td>
<td>.43</td>
</tr>
<tr>
<td>As reference household, but: no central heating</td>
<td>.75</td>
<td>.07</td>
<td>.21</td>
</tr>
<tr>
<td>As reference household, but: detached house, built 1945-64, in South East region; household income 50% above average.</td>
<td>.97</td>
<td>.40</td>
<td>.84</td>
</tr>
<tr>
<td>As reference household, but: private rented flat, no central heating, using electricity for heating; residence length under 2 years; household income 80% of average.</td>
<td>.17</td>
<td>.02</td>
<td>.05</td>
</tr>
</tbody>
</table>

3.1 Loft insulation.

The first columns of Table 1 report the reduced form for loft insulation. Fourteen of the explanatory variables are found to be significant at the 5 per cent level.

Many of the significant variables describe the physical characteristics of the dwelling. The most obvious interpretation of these variables is that they reflect differences in the cost of undertaking a particular measure. In general, the signs of the physical variables are consistent with this interpretation. Dwelling size, for example, tends to be negatively related to the probability of ownership of both loft and wall insulation.

In comparison, most of the socio-economic variables are not significant. This is perhaps unsurprising in the case of the "short-term" variables, such as unemployment, since the investment decisions being modelled will usually have occurred some time prior to the survey, and socio-economic variables will only be likely to figure in the results if they show some stability over time. Significant effects are found from two socio-economic variables, tenure and income. Properties occupied by private tenants are found to have lower levels of loft insulation than the
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base (owner occupiers); the difference is statistically significant and sizable. A statistically-significant effect of income is also found, but as Table 2 shows, its quantitative effect on the probability of having loft insulation is very small.

Interpreting the coefficients on these two variables in the reduced-form equations estimated here is difficult; they could reflect either some direct influence of income or tenure on the energy efficiency decision, or an indirect influence, through effects of tenure or income on household demand for energy services, which in turn would affect the returns to energy efficiency investments. The reduced-form models shown here cannot separately identify these two types of effect. To the extent that the significant coefficients on income and tenure reflect the former channel of influence, however, this would tend to indicate the presence of market failures in household energy efficiency investments. Since loft insulation and some other energy efficiency investments are likely to be desired only as a means to achieving a given standard of energy services, and not desired in themselves, we would not expect to find any strong direct effect of socio-economic characteristics on household energy efficiency decisions in an efficiently-functioning market. A direct relationship between energy efficiency decisions and socio-economic characteristics might, however, be encountered where certain types of households (such as low-income households) faced significant market failures.

Large effects are found from the type of heating: loft insulation is more likely amongst households with central heating, and is less likely where households use electricity for heating than where they use gas (the base case). The role of central heating in the loft insulation model may be interpreted in various ways. One interpretation, which reflects the higher rates of return to energy efficiency investments in well-heated houses (Pezzey, 1984), is that the central heating variable proxies the standard of heating of different houses, and the positive sign on the central heating variable thus reflects a tendency for households to be more likely to undertake energy efficiency measures where the gains are greater. On the other hand, a relationship between energy efficiency investment and the possession of central heating could also reflect differences in awareness and attitudes to investments; households which have invested in central heating may be better informed than the average or may be the type of households that invest in home improvements more generally.

Figure 2 provides evidence about the extent to which the estimated model succeeds in explaining the differences between households which possess loft insulation and those which do not. This figure shows a histogram of the predicted probabilities obtained using the estimated reduced form model for each individual household in the data sample. These predicted probabilities lie between zero (the model predicts with certainty that the household will not have loft insulation) and one (the model predicts with certainty that the household will have loft insulation). If the model contained all of the factors affecting individual differences, the left-hand histogram would be concentrated at zero, and the right hand histogram would be concentrated at the value one. Comparison of the pattern of predicted probabilities for those households actually recorded as possessing loft

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14 Brechling and Smith (1992) report an attempt to estimate a "structural" model of energy efficiency investments in which these two effects are separately identified. They argue that the socio-economic variables in the reduced-form models can largely be interpreted as reflecting direct influences on household energy efficiency decisions, rather than indirect effects through socio-economic effects on energy consumption.
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Figure 2

The distribution of predicted probabilities for household possession of loft insulation from the reduced form model

![Histograms showing predicted probabilities for households with and without loft insulation.]

insulation with the pattern of predicted probabilities for those households who do not possess loft insulation provides an indication of the extent to which variables included in the reduced form model succeed in discriminating between those with and without the measure.

Although there are marked differences in the distribution of predicted probabilities between the two groups, it is clear that the variables in the model only explain part of the actual differences between households; and, in particular, the model contains few variables that enable us to identify with any great certainty those households without loft insulation. Variables omitted from the model (such as perhaps informational factors, and individual attitudes) thus clearly have an important role in behaviour.

3.2 Wall Insulation.

Given the large energy savings from wall insulation, the very small percentage of households which actually possess wall insulation (11 per cent in 1986) is perhaps surprising. Also, the variables available appear to explain less of the pattern of ownership of wall insulation than of the other measures, as shown by the pseudo-R²s.

As with loft insulation, physical factors play a more important role than socio-economic influences. There is rather more variation by type of house and by region than with loft insulation. The type of heating fuel does not contribute significantly to the explanation of the pattern of wall insulation, although, as in the loft insulation equation, the possession of central heating has a positive and significant impact. The probability of having wall insulation is higher amongst more recently-built dwellings than amongst older ones.
8. Energy Efficiency

The strongly significant negative effect of flats and semi-detached and terraced houses over the base detached house could reflect one of two influences. The "need" for insulation, and the individual energy saving for each household may be lower in semi-detached or terraced houses or in flats because they have fewer exposed walls. Alternatively, the lower probability of having wall insulation could arise from decision-making problems associated with the shared ownership of walls: organisation and information problems would tend to increase with the number of households participating in the decision.

Figure 3

The distribution of predicted probabilities for household possession of wall insulation from the reduced form model (full sample)

Figure 3 suggests that the predictive power of the estimated model is weak; few of the households recorded as having wall insulation are predicted to have a probability of possessing wall insulation of greater than 0.5. On the basis of the "percentage of correct prediction tests" sometimes used to evaluate binary response models, the model for wall insulation would thus predict poorly, failing to identify all but a handful of those households with wall insulation. However, closer examination of the distribution of predicted probabilities indicates a degree of explanation, in that the households with wall insulation are much less likely to be given a very low probability than those without. The model thus identifies some of the factors giving rise to differences between households, although clearly there are important omitted influences.

An important consideration is that some dwellings may face restricted choices over wall insulation. There are three ways in which walls may be insulated - internal solid insulation, external solid insulation, and cavity fill insulation. Of the three, cavity fill is the only type which can be installed without major reconstruction or redecoration of the inner or outer walls, and it therefore tends to be the only cost-efficient method of insulating walls except when other work is needed on the
dwellings (Pezzey, 1984). The results in Table 1 report the probabilities of possessing any type of insulation, and the sample of households on which estimation is based includes all households, and not just those with cavity walls.

The model is therefore based on a sample which includes households which are unable to install the main type of wall insulation; this may bias the estimates of the factors affecting the decisions of those households which do face a genuine choice regarding wall insulation. A second model was therefore estimated, based on a sub-sample of dwellings that can be identified with reasonably certainty as having cavity walls. Whilst many older houses do not have cavity walls, cavity walls have been required by legislation throughout the post-war period; selecting a sample of dwellings built since 1945 will thus select a sample that could install cavity walls.

The results of this exercise are not reported in detail here, since in practice most of the estimated coefficients are quite stable between the two models. A number of the significant coefficients, including the income coefficient, are somewhat larger in the post-1945 model; otherwise the main difference is that the central heating dummy has a smaller and less significant coefficient in this model. There are slightly fewer significant explanatory variables in the model estimated on the post-1945 sample (partly because of the reduced sample size), but the overall level of explanation of the variation in the data, as measured by the "Pseudo-R^2", is slightly higher.

3.3 Double glazing.

The double glazing equation has the highest explanatory power of all of the models in Table 1, with many significant variables. In most cases, the variables have the same sign as for the other insulation measures, but there is a clear difference in the impact of electric heating. Electric heating tended to reduce the probabilities of having loft insulation and wall insulation; in this model, households are more likely to possess double glazing if they use electricity for heating. The model also shows significant regional variation, with positive effects from dummy variables for London and the South East, perhaps reflecting the investment into home improvements during the 1980s housing boom.

The income coefficient reported in Table 1, while significant, is no greater than the income coefficient in the estimates for either loft insulation or wall insulation. This is perhaps surprising, since double glazing may be installed for various reasons other than energy saving (for example to reduce noise), and the demand for these other attributes of double glazing might have been expected to lead to a greater income elasticity than for the models where decisions reflect the effect of the measure on energy costs alone.

Figure 4 shows that the estimated reduced form model results in a considerably different pattern of predicted probabilities of possessing double glazing amongst those who actually have double glazing, compared to those who actually do not.

15 A full account of the model can be found in Brechling and Smith (1992).
The model shown in Table 1 estimates the probability of having at least one window in the dwelling double glazed. A second model was also estimated, for double glazing of the entire house. The reason for being interested in this is that partial double glazing could be undertaken for reasons unconnected with energy saving (eg. to cut out the noise of a nearby road), whilst full double glazing is generally an energy efficiency measure. The effects of the various explanatory variables are broadly similar over the two models. Income is no longer a significant variable in the model for full glazing; this partly reflects the reduction in sample size, but would also be consistent with the view that full glazing was undertaken to obtain benefits from reduced future energy costs, whilst partial glazing had more direct benefits, for which demand might be expected to be a positive function of income.

4 Conclusions.

Arguments about market failure play a key role in justifying government intervention in the market for domestic energy efficiency. Despite this, there has been little available empirical evidence about the practical importance of market failures in energy efficiency which could be used to assess the case for policy measures, or to target policy interventions on the most significant sources of market failure. This paper has sought to provide some indications based on economic modelling of factors affecting the pattern of possession of energy efficiency investments amongst UK households.

The paper has described the results of an analysis using cross-sectional data from the 1986 English House Condition Survey to assess the role of economic factors in contributing to the pattern of household take-up of energy efficiency measures. Reduced-form Logit models have been estimated of the factors influencing the pattern of possession of the three principal energy efficiency measures - loft insulation, wall insulation, and double glazing.
The results appear to be consistent with the view that there are certain areas in which market failures may deter households from making rational decisions regarding energy efficiency investments. In particular, there appears to be a strong tenure effect on the pattern of each of the three measures, with rates of possession much lower in private rented properties than in owner-occupied properties. This suggests that policies to reduce market failures in energy efficiency could usefully pay attention to the role of tenure-related market failures - especially to those relating to the private rented sector.

The very much lower rates of energy efficiency investment in private-rented properties than elsewhere may reflect the problems arising from the different interests of landlord and tenant; for example, if the landlord is responsible for investing in energy efficiency improvements, whilst the tenant is responsible for energy bills, landlords will only face efficient incentives for making investments if they can recoup the benefit through subsequent higher rents. Rent control legislation may impede rent adjustments of this sort; however, more fundamentally, there may be an asymmetry of information between landlord and tenant about the value of the measures installed which would prevent energy efficiency investments being fully reflected in rent levels, even in a completely free market. It may be possible to devise schemes (along the lines of the "home energy rating" schemes currently mainly directed at owner-occupiers) which would improve the quality of information available to private tenants about the likely energy costs of a property. Realistically, however, better provision of information is only likely to go part of the way towards eliminating the problems in the private rented sector, and other measures, including both subsidy and regulatory mandate, may be needed if energy efficiency levels in the private rented sector are to be brought closer to the levels in the rest of the housing stock.

In comparison to the strong role played by housing tenure in domestic energy efficiency decisions, there appears to be less indication of any major income related-market failure. This probably suggests that credit constraints amongst poorer households are unlikely to have been a major factor inhibiting energy efficiency investments, and that policies directed at credit market failures in the area of domestic energy efficiency should therefore be a low priority for policy. However, this strong conclusion is subject to two significant qualifications. First, as observed above, the income and other household characteristics relevant at the time of the insulation decision may differ from the income and characteristics of the household observed at the time of the survey. Second, the observed pattern of possession of energy efficiency measures will reflect the influence of past policies and incentives in various ways. To the extent that these policies have been targeted on low-income households, either by grants and financial incentives or through direct provision and intervention in certain parts of the housing stock predominantly occupied by lower-income households, they may have succeeded in eliminating income-related differences in the pattern of possession of energy-efficiency measures that would otherwise have existed.

These results may be contrasted with the findings of some US studies which observe a strong tendency for market failures to be associated with low incomes. In particular, Hausman's (1979) study of the pricing and purchasing of energy using durables appears to indicate that energy efficiency benefits are not fully reflected in product prices, and that low income households are particularly likely to purchase appliances with low levels of energy efficiency. One interpretation
of such results is that credit-constrained poorer households are not able to afford the higher capital cost of buying more energy-efficient durables. Another possible explanation of the observed pattern of purchasing may, however, not reflect market failure, but the effect of unobservable attributes correlated with energy efficiency. If, for example, newer models tend to be preferred by better-off consumers (who, unlike poorer consumers, are prepared to pay the premium for novelty), and, at the same time, designed to offer higher levels of energy efficiency because they were designed in a period (for example, in Hausman's data, the late 1970s) when energy prices where higher than when older models were designed (for example, the 1960s), then a correlation would be observed between income and durables purchasing patterns which did not reflect any underlying market failure.
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