Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

11-Jun-2008

English - Or. English

ENVIRONMENT DIRECTORATE
CENTRE FOR TAX POLICY AND ADMINISTRATION

Environmentally Related Taxes and Tradable Permit Systems in Practice

This document, written by Prof. Stephen Smith of University College, London, discusses the economic efficiency and practical use of environmentally related taxes, with some differentiation in tax rates, versus tradable permit systems, with some element of grandfathering of permits.

For further information, please contact Chris Heady, tel: +33 (0) 1 45 24 93 22,
email: Christopher.Heady@oecd.org;
or Nils Axel Braathen, tel: +33 (0) 1 45 24 76 97, email: Nils-Axel.Braathen@oecd.org.

JT03247683

COM/ENV/EPOC/CTPA/CFA(2007)31/FINAL Unclassified

English - Or. English

FOREWORD

When they are applied in a practical setting, environmentally related taxes and tradable permit systems often differ from simple text-book recommendations that only focus on economic efficiency. This note, prepared by Prof. Stephen Smith of University College, London, contains both a theoretical discussion of "real-world" constraints on policy formulation, and an empirical discussion of the Climate Change Levy vs. the domestic greenhouse gas trading system in the UK, as well as of the Landfill tax vs. the Landfill allowance trading system applied in the same country.

TABLE OF CONTENTS

ENVIRONMENTALLY RELATED TAXES AND TRADABLE PERMIT SYSTEMS IN PRACTICE

1. Introduction

1. Tradable permits have attracted growing attention in recent years as a supplement or alternative to environmentally related taxes. While many OECD-countries have had environmentally related taxes for decades, the use of tradable permits is a more recent development. One early example was the nation-wide SO_2 trading scheme introduced in the United States in 1995 as a result of the 1990 Clean Air Act Amendments (Ellerman *et al.*, 2000; Burtraw and Palmer, 2004). Another large-scale example is the common European Union Emission Trading System (EU ETS) for CO_2-emissions permits that was introduced from 1 January 2005.

2. What is the significance of this apparent shift in policy emphasis from environmental taxes towards emissions trading? The economic properties of taxes and emissions trading are closely-related, as described below. Both exhibit the key merits of market mechanisms in environmental policy - flexibility, innovation incentives, robustness, and - potentially - revenues (Section 2.1). Indeed, under conditions of certainty, and with competitive, efficient, permit trading, the theoretical properties, in a "first best" policy setting, are very close indeed, and the two approaches would offer identical efficiency gains over non-market-based regulation (Section 2.2). Where, however, the policy context is one of substantial uncertainty about polluters' abatement costs, or where there is reason to believe that permit markets or other aspects of the transmission of economic incentives to decision-makers in firms are not efficient and costless, then it is well-known that the effects of regulating through taxes and trading differ, and there may be reasons for policy to prefer one approach over the other.

3. Moreover, there are other "real world" constraints and concerns in policy-making that go beyond the comparisons of instruments in a first-best setting. When implemented in practice, the design of both environmentally related taxes and emission trading systems is influenced not only by the aims of economic efficiency, but also by other aims such as sectoral competitiveness and income distribution.

4. How taxes and emissions trading are adapted to deal with these concerns may lead to real-world instruments which look rather different from the "first-best" instruments that the theory generally compares. To compensate for adverse effects on competitiveness, it has been quite common for environmental taxes to have low tax rates, sectoral tax exemptions, or other features that differ from the first-best instrument. Likewise, similar concerns frequently influence the design of tradable permit systems, for example leading to free distribution of permits rather than revenue-raising auctioning. The primary focus of this paper is on the comparison of taxes and emissions trading in this constrained, or "second best", context, taking account of these non-environmental factors that for both practical and political reasons dictate some significant modifications to the design of environmental taxes and emissions trading systems.

5. Compared to a permit system with grandfathering, a tax system has the advantage from an economic efficiency point of view of raising at least some revenue that could be used to reduce distortionary taxes. On the other hand, even a grandfathered permit trading system could have the

efficiency advantage of being applied to all industries and so providing an equal incentive at the margin to abate their emissions. It is a priori not clear which is the preferable instrument if the choice is limited to an environmentally related tax with different rates for different polluters and/or exemptions for certain products or users on the one hand, and a permit system with some degree of auctioning on the other hand. This is often the most relevant comparison policy makers have to make when choosing which measure to apply.

6. In addition to the two high-profile applications of emissions trading already noted - sulphur trading in the US and carbon trading in the EU – several European countries have also introduced domestic emission trading systems in recent years. In the United Kingdom, for example, domestic tradable emission systems have been introduced to address *e.g.* CO_2 emissions (separately from the EU-wide scheme) and the land-filling of biodegradable waste. Interestingly, both these trading systems are applied in combination with environmentally related taxes addressing the same environmental problem. Given the similarity in the economic properties of taxes and emissions trading, this parallel operation of both is perhaps unexpected. However, it reflects a widespread tendency in environmental policy more generally to rely on a mix of instruments, and for market mechanisms rarely - if ever - to be employed as the sole regulatory approach. Recent OECD work has reviewed the use of "instrument mixes" in a number of areas of environmental policy – municipal waste management, non-point source water pollution, regional air pollution, residential energy efficiency, and atmospheric emissions of mercury. The case studies on these areas, and the synthesis report *Instrument Mixes for Environmental Policy* (OECD, 2007) have shown the way in which instrument mixes respond to the environmental complexity of problems, and, also, the range of non-environmental reasons that may motivate policy packages combining different forms of regulation. Even where, in principle, the environmental problem is one which could be satisfactorily regulated using a single instrument, there may be a range of constraints on policy which mean that more complex instrument combinations have to be employed.

7. Again, these considerations are likely to lead to taxes and tradable permits that differ, both in scale and structure, from their first-best format, and different considerations will be relevant in making policy choices where the role of these instruments is within a package combining both, than where either is the sole regulatory mechanism.

8. The structure of the paper is as follows. After this introduction, Section 2 assesses the comparative properties of environmental taxes and emissions trading, beginning with a brief review of the "conventional" analysis, which the emphasizes the theoretical similarities between these two instruments, and then moving on to consider relevant factors in the comparison that can only be assessed through practice - especially the functioning of the allowance market. What is known about this key aspect of the relative efficiency of taxes and TPs from the accumulating evidence of real-world applications of emissions trading? Section 3 considers revenue and revenue burden issues, and the way in which these shape the menu of feasible policy instruments - imperfect taxes, and free allocation of emission trading allowances. Section 4 discusses instruments in combination - especially combinations of taxes and TPs. Section 5 discusses these issues in the context of two case studies, of the UK ETS and the UK Landfill Allowance Trading Scheme. Section 6 draws conclusions.

2. Taxes and TPs in practice

Market mechanisms hold out the prospect of significant reductions in the cost of environmental protection, and other benefits in terms of innovation, robustness and revenues (Section 2.1). In principle, there are very close similarities between environmental taxes and emissions trading - they share these advantages, and have similar limitations. However, they operate very differently when there is uncertainty about abatement costs: it is well-known that one or other may then have an advantage, depending on the economic and environmental circumstances (2.2). There is accumulating evidence from "real world" applications that market mechanisms work, and work broadly as predicted, and clear ex post evidence (e.g. US acid rain program) that they can deliver substantial environmental improvements combined with cost-reducing flexibility - possibly well beyond what could be achieved with conventional instruments. In the real world, transaction costs and possible market power in allowance markets do not seem to be so excessive as to destroy the economic gains from emissions trading (2.3-2.5). Real-world emission taxes frequently depart from the "first-best" model, and are rarely-based on directly-measured emissions. In suitable applications this can save costs, while retaining efficient abatement incentives (2.6).

9. This section assesses the comparative properties of environmental taxes and emissions trading, beginning with a brief review of the "conventional" analysis, which emphasizes the theoretical similarities between these two instruments. It then proceeds to consider relevant factors in the comparison that can only be assessed through practice – especially the functioning of the allowance market.

2.1 Why use market mechanisms?

10. Environmental taxes and emissions trading are two most prominent and widespread categories of "economic instruments" (or "market mechanisms") in environmental policy. Other examples include per-unit subsides for pollution-abatement, liability provisions for environmental risks and accidents, and deposit-refund systems. Voluntary or negotiated environmental agreements are sometimes also categorised as market mechanisms, because they may exhibit some of the properties (especially the flexibility) of other market mechanisms, and so too are provisions for producer responsibility in waste management.

11. Like most market mechanisms in environmental policy, environmentally-related taxes and emissions trading share four attractive properties:

- ***Static efficiency***: The flexibility offered by market mechanisms has the effect of reducing the total abatement cost incurred in achieving any given emissions reduction. With an environmental tax, individual firms have the choice whether to abate more or less. More abatement reduces the tax they pay, so polluters that can reduce emissions at low cost will tend to do more, while those facing high abatement costs will choose to do less. Emissions trading offers similar flexibility. The implication is that market mechanisms can reduce the cost of environmental protection compared with less-flexible instruments. Box 1 illustrates how the gains from this flexibility can be quantified. A range of empirical studies suggest that, in some applications, the static efficiency gains from the use of market-based instruments can sharply reduce the cost of environmental protection (Tietenberg, 1991).

- ***Dynamic efficiency***: With market mechanisms, polluters face a continuing incentive for pollution-reducing innovation. The incentive arises because, even after taking all cost-effective abatement measures, polluters face a cost for each unit of residual pollution, in the form of the environmental tax on each unit of emissions, payments for the allowances needed to cover their remaining emissions, or foregone revenue from the sale of permits that would be "freed-up" through additional abatement. This creates an incentive to innovate, and develop new cost-

effective abatement methods, since these can further reduce the firm's outlay on pollution taxes or permits. Typically, with "command-and-control" regulation, in which firms are required to make specified abatement investments, or observe a quantitative limit of emissions, this innovation incentive is absent, because the firm has no reason to go beyond compliance with the requirements of the regulation.

- ***Revenue potential****:* Many different forms of environmental regulation, including many conventional "command and control" instruments as well as market mechanisms, have the effect of conferring windfall profits on polluters (Fullerton and Metcalf, 2001). By limiting pollution, they have the effect of making scarce the output that is produced by polluting production processes. As a result, firms are able to raise output prices above the competitive level, and earn additional profits (producer rents). The higher prices for output impose costs elsewhere in the economy, including an exacerbation of the inefficiencies caused by existing taxes on labour income[1]. While these effects arise with a wide range of instruments, tradable permits and environmental taxes have the attraction that they can raise revenue, and thereby recover the producer rents created by environmental regulation. If this revenue is used to reduce other, distorting, taxes in the economy, this can have the effect of counterbalancing the economic damage done by the higher product prices caused by the initial regulation.

- ***Robustness***: A great merit of market mechanisms, but one that is frequently overlooked, is their robustness in operation. They avoid the need for detailed source-by-source regulation, and for the regulator to seek to obtain detailed information about the abatement costs and opportunities of individual polluters. Seeking this information - which can only be provided by the firms themselves - tends to expose the regulator to the risks of regulatory capture, in which an implicit bargain has to be struck between the regulator and firms, in which the regulator obtains information, but on terms that may act against the public interest. By contrast, once a tax or aggregate cap on emissions is set, it applies to all firms on a basis set out in the relevant legislation, and the regulator has no need to enter into firm-by-firm bargaining over the terms on which it will be applied.

12. Some well-recognised drawbacks of these mechanisms should also be noted, which will limit the number of situations to which these instruments can be applied:

- ***Geographically-varying damage***. Typically, market mechanisms are likely to be less effective where damage varies across individual sources (*e.g.* because of geographical factors, or because damage is non-linear in source emissions). Where damage varies across sources, the efficient abatement incentive will also vary. In principle it would be possible to define different rates of environmental tax for each source, or to assign a different value to a tradable emissions allowance depending on the location where it is to be used (an allowance might, for example, permit one tonne of emissions in some locations, but only half a tonne in locations where emissions cause greater damage). However these provisions would increase administrative complexity and cost, and would also tend to undermine the "robustness" of market mechanisms to source-by-source lobbying and special pleading.

- ***Business behaviour***. The effectiveness of market mechanisms will depend on how polluters respond to the incentives provided by pollution taxes or emissions trading. To realise the potential gains in efficiency which in principle are offered by market mechanisms will require

[1] This interaction of higher prices for the output of regulated polluters and existing distortionary taxes on labour income is the key insight of the so-called "double dividend" literature [Pearce (1991), Bovenberg and de Mooij (1994), Parry (1995), Goulder (1995), Fullerton and Metcalf (2001), Schöb (2003), etc.].

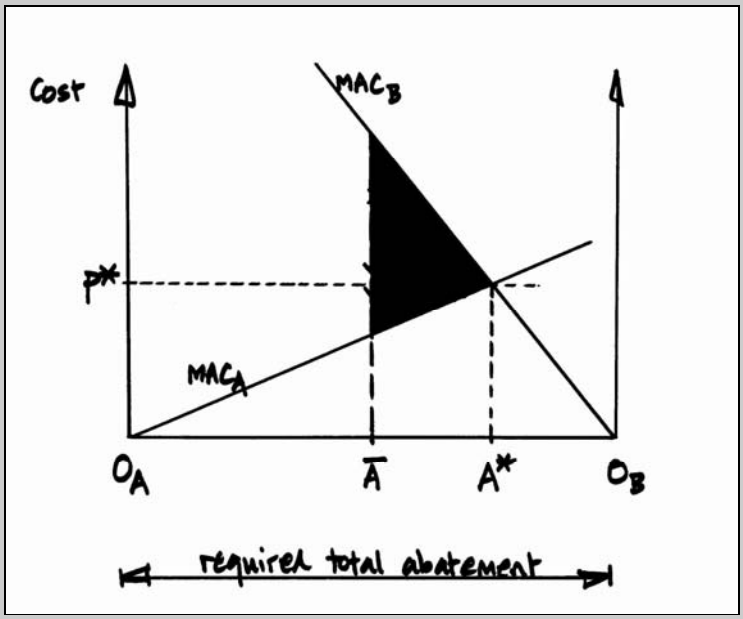
polluters to bring together production engineering and technology information about abatement options and costs, to compare with the savings that can be made in reduced tax or permit purchases. The existing organisational structure of firms may not always be well-suited to deal with such issues: taxation may, for example, be treated simply as a matter of accountancy, and not an issue involving pollution engineering. Efficient responses to market mechanisms may therefore require adaptations in the internal organisation and behaviour of businesses[2]. These changes may be costly to make, and are more likely to be prompted by high-profile policy instruments, imposing large costs, than by small taxes, for example, which may not make the organisational adjustment worthwhile. (Johnstone, 2007)

- ***Market functioning***. Where markets are created (as with emissions trading), these need to be low-cost and competitive. If pollution abatement is to be allocated efficiently between firms, all should face the same marginal incentive for abatement. If transactions costs or monopoly power in allowance markets drive a wedge between the marginal abatement cost of allowance buyers and sellers, some potential efficiency gains will be foregone. These issues are discussed further in Sections 2.3 - 2.5 below.

- ***Distributional and competitiveness problems***. A widely-perceived obstacle to greater use of market mechanisms such as environmental taxes and emissions trading are the effects on income distribution and international industrial competitiveness. To the extent that they raise the prices of certain goods which form a higher proportion of the spending of poorer households (domestic energy in particular), environmental taxes or permits would have a regressive distributional impact (a higher burden, relative to household income, on the poor than the rich). While compensating measures, using the revenue raised from environmental taxes or auctioned permits, could offset these effects, they have become an obstacle of considerable political significance in some countries. Similarly, there are major concerns in many countries about the (perceived) additional business costs imposed by environmental taxes or allowance costs in emissions trading schemes, and the effects of these costs on the competitive position of businesses in international markets. Again, it may be possible to identify strategies to offset much of this impact (for example, by using the revenue raised from environmental taxes to reduce other taxes), but there remain concerns - especially about the impact of energy taxes on energy-intensive sectors. These concerns explain the widespread use of sectoral exemptions from environmental taxes and free allocation of emissions trading allowances. These issues are discussed in more detail in Section 3 below.

[2] While it is clear that the effectiveness of market mechanisms may require changes in the internal organisation of firms, it should not be overlooked that similar requirements are a precondition for efficient response to any instrument, including command-and-control regulation. Imposing regulatory requirements on firms is no guarantee that they will comply. Non-compliance because firms are "poorly informed" is essentially a similar problem as non-responsiveness to regulatory incentives: in both cases, responsiveness to regulation requires that firms recognise the need to obtain relevant information, and to ensure that it is appropriately communicated within the organisation.

Box 2.1 The static efficiency gain from the least-cost pattern of abatement compared with uniform abatement when two types of polluter differ in abatement costs



The diagram represents the range of options for dividing abatement between two groups of sources A and B. The two groups have marginal abatement cost schedules represented by MAC_A and MAC_B, measured rightwards from the origin O_A and leftwards from the origin O_B respectively. The pollutant is assumed to be "uniformly mixed", so that the environmental benefits are a function only of the total abatement achieved, and not of how this is divided between the sources. The least-cost division of this total abatement requirement between the two groups occurs at point A. Total abatement costs at this point are measured by the area under the two marginal abatement cost schedules. If, instead the two groups are required to contribute equal amounts of abatement (shown as point $\bar{A}$ in the diagram), higher total abatement costs will be incurred, because the additional abatement undertaken by B is more costly than the if this abatement had been made by A. The excess of total abatement costs compared with the least-cost pattern of abatement is shown by the shaded area.*

The shaded area could be interpreted as a measure of the cost saving from using economic instruments such as emissions taxes or emissions trading compared with conventional command-and-control regulation, if the use of market mechanisms would achieve point A (e.g. through emissions trading in a competitive market, with equilibrium allowance price equal to P*, or through an emissions tax set at a rate P* per unit of emissions), and if the informational limitations of command-and-control regulation compel the regulator to treat the two groups equally (i.e. to assign the two groups equal abatement requirements, as at point $\bar{A}$). However, this is an upper bound to the potential cost savings, if real-world market mechanisms perform less well than this assumes (e.g. because of transaction costs in permit markets), and/or if command-and-control is able to achieve an outcome better than $\bar{A}$. If the regulator is in possession of full information about the abatement costs of the two groups, then command-and-control regulation could achieve the least-cost outcome, point A*, by setting differentiated abatement requirements for the two groups. However, it would not be in the interests of a firm of type A to reveal its low marginal abatement costs to the regulator in this situation.*

A large number of empirical studies have used data on marginal abatement costs for a range of different sources to compare the costs of achieving a given abatement outcome using uniform and least-cost regulation. The cost savings are a function of differences in marginal abatement costs between sources. Where these are large, the efficiency saving from the least-cost pattern of abatement is correspondingly large (Newell and Stavins, 2003).

Tietenberg (1991, table 4.1) summarises the results from a number of empirical studies of the cost of air pollution control in various locations in the United States. The ratio of command-and-control cost to least cost abatement ranges from 1.07 to 22.0, with an unweighted average ratio across the eleven studies listed of 6 (implying that least-cost abatement could achieve the same environmental quality as the command-and-control measures studied, at only one sixth of the aggregate abatement cost).

2.2 The close similarity between taxes and TPs

13. Under conditions of certainty, the economic properties of emissions taxes and tradable emissions permits are very similar. This is illustrated in Figure 2.1, which shows the impact of these instruments on an industry with abatement opportunities represented by the marginal abatement cost schedule MAC.

1. If an environmental tax set at rate per unit of emissions T leads to an emissions level Q, then alternatively regulating the same problem by issuing a quantity Q of tradable emissions permits will lead to a permit price per unit of emissions T (if the permit market is competitive).

2. The level and pattern of pollution abatement will be the same under the two instruments. In both cases the incentive firms face for abatement at the margin is T per unit of emissions, and firms would undertake abatement where the cost per unit is less than this incentive. In the diagram, the abatement undertaken reduces emissions to Q from the pre-regulation level U.

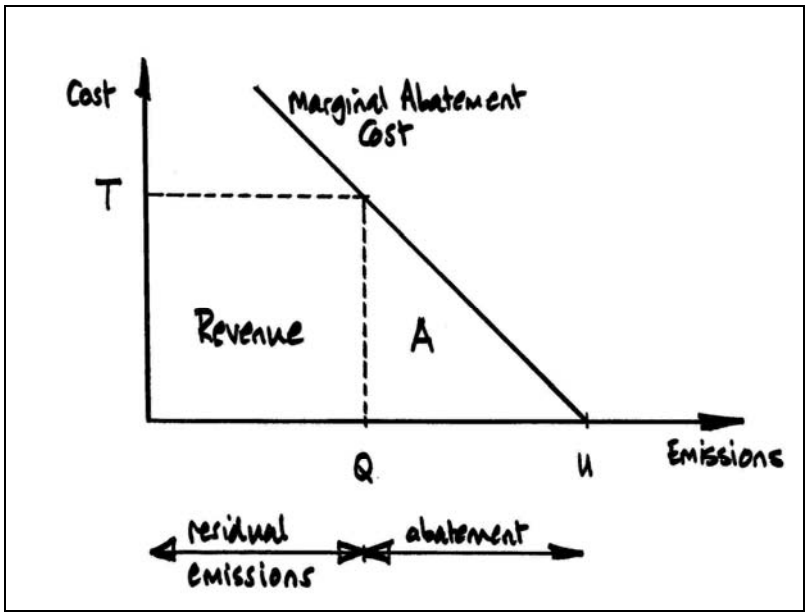
3. The abatement cost incurred by firms will be the same. The total abatement cost incurred by firms in reducing their emissions from U to Q is represented in Figure 2.1 by the area labelled A under the marginal abatement cost schedule.

14. It will be noted that properties 1-3 hold, regardless of whether the permits are distributed free, or sold (for example through an auction). In either case, the value of the last permit used is given by the abatement cost that would otherwise be incurred, and this is given by the marginal abatement cost at emission level Q, which is T per unit. The value of tradable emissions permits, therefore, is independent of the way in which the permits are distributed (so long as the permit market is competitive). Where permits are auctioned, there is a further point of similarity between an emissions tax and tradable emissions permits:

4. If the permits are sold in a competitive auction, then the auction revenue yield will be Q.T, which is the same as the tax revenue that would be collected from the environmental tax.

15. The implication of the above discussion is that, under conditions of certainty, emissions tax and tradable emissions permits are closely substitutable policy instruments, especially where permits are auctioned. They have broadly the same environmental and fiscal properties, and the policy choice between the two instruments can be made on the basis of other considerations, such as the administrative cost of the two forms of regulation, the competitiveness of the permit market, and so on.

Figure 2.1: Equivalence of tax and emissions trading under certainty



16. This equivalence does not however hold where the regulator faces uncertainty about polluters' abatement costs, and has to determine the tax rate or the quantity of permits to be issued, without accurate knowledge of the abatement costs that firms will incur. In this situation, the regulator will typically be unable to ensure that the level of pollution abatement maximises net social gains. Compared with the social optimum (*i.e.*, compared with the level of abatement at which true marginal abatement costs equal marginal damage cost) too much abatement, or to little abatement may be undertaken. Moreover, the extent to which the outcome differs from the optimum will generally differ between emissions taxes and tradable emissions permits. TPs guarantee the pollution outcome, but at uncertain marginal abatement cost, while the tax places an upper bound on the marginal abatement cost incurred, but does not guarantee a specific pollution outcome.

- Emissions taxes (or other instruments which involve the authorities setting a price for emissions) will on average get closer to the optimal outcome if marginal abatement costs increase with extra abatement more rapidly than marginal damage costs increase with extra emissions.

- TPs will perform better if the reverse is true (*i.e.* if MDC costs are more steeply-rising than MAC).

17. Neither instrument is unambiguously superior in this situation. Which is likely to perform better will depend on the relative slopes on the marginal abatement cost schedules (*i.e.* the rates at which marginal abatement costs and marginal pollution damage change when emissions differ from the optimum). This is an empirical matter, and will vary from case to case. For some pollution problems, where marginal pollution damage costs rise sharply with changes in the level of pollution, TPs will be more attractive, while for other problems, where marginal abatement costs rise sharply with emissions, taxes should be preferred.

Price versus quantity regulation of fossil fuel energy use

18. A further consideration in choosing between environmentally-related taxes and emissions trading arises in the case of climate change policies. It has long been recognised that using price-based instruments

to regulate environmental problems resulting from the use of an exhaustible resource (*e.g.* fossil fuels) involves complications arising from the interaction between the regulation and the time profile of the price for the resource itself. Energy tax policy may, for example, accelerate the depletion of fossil fuel energy resources if it raises expected future energy prices by more than current prices (Sinclair, 1994). Revenue-maximising owners of the resource may wish to exploit the resource sooner rather than later, if the tax reduces the future net revenue. As Sinn has recently argued, these effects on resource pricing may operate distinctly differently if regulation takes the form of emissions trading instead of taxes. It will be apparent that emissions trading could be used to place quantity constraints on the use of the resource in each period, so that the inter-temporal shift in energy consumption is avoided.

2.3 Efficiency in permit markets

19. Real-world permit markets have various details and features that differ from the perfectly-competitive markets often assumed in the theoretical discussions of emissions trading. Typically, these include (i) features of market design (ii) forms of market activity, and (iii) market costs and inefficiencies.

20. Market design issues include:

- ***The definition of the traded commodity***. Generally this is specified in terms of physical quantities (*e.g.* tonnes or kilograms of a pollutant). As with many environmentally-related taxes, there are a range of practical considerations about the point at which the commodity is to be defined, which will affect the costs of measurement incurred in assessment and enforcement. It may, for example, be easier to measure transactions (*e.g.* purchases of fossil fuels) rather actual emissions.

- ***The allocation of allowances***. Issues relating to auctioning and the various forms of free distribution (grandfathering, output-based allocation, etc) are discussed further in Section 3.

- ***Rules on participation***. Some trading systems allow all comers to buy and sell allowances; others restrict participation in the market in various ways, limiting participation to certain categories of participant (*e.g.* firms with compliance obligations), or stipulating the minimum size of trades. Typically, decisions about participation reflect a trade-off between market efficiency (which tends to point towards unrestricted participation) and considerations of administrative cost and enforcement (which may create a case for excluding small firms or firms outside the industry concerned.)

- ***Requirements for pre-approval***. Some of the early emissions trading schemes in the US required prior approval from the EPA before trades could take place. More recent schemes have tended to avoid this requirement, for fear that it could inhibit vigorous trading activity. As discussed in the next section, emissions trading schemes which operate without pre-approval involve some risks that invalid allowances will be traded. In principle, either the buyer or seller could be held liable in such cases, but either way market participants bear some risk, which may affect their willingness to trade.

- ***Compliance regimes***. Schemes typically specify a compliance deadline, and some allow a period after the end of the accounting year for firms to make whatever trades are needed to ensure compliance. These deadlines affect the time pattern of trades, and can lead to significant peaks in trading activity. Concentrating trades in a fairly short period of vigorous activity can ensure maximum liquidity and competition for firms that need to buy or sell allowances, but may also have implications for processes of price formation and dissemination at other times of the year.

- ***Penalty regimes***. Typically schemes have rules to penalise non-compliant firms that fail to deliver the required allowances to the authorities by the end of the compliance period. As discussed in Section 4 below, these rules can affect market behaviour. Fixed financial penalties for non-compliance (*e.g.* a fixed dollar penalty per tonne of non-compliance) can set an upper bound to the range of allowance prices, while other schemes require non-compliant firms in one period to deliver the "missing" allowances, plus additional penalty allowances in a future period, making the penalty a function of the allowance price.

21. Forms of market activity can include various features of market microstructure which typically will have the effect of enhancing efficiency, offsetting inefficiencies or obstacles to trade which might otherwise arise in the market.

- Some markets exhibit active brokers and other intermediaries, who may play a role in facilitating trades in various ways. Brokers may, for example, play a role in disseminating market price information, ensuring more informed trading behaviour. Brokers may also break down large packages of allowances into smaller quantities for "retail" sale, giving firms that need only small quantities of allowances for compliance purposes access to the market at lower cost than if they were required to trade directly on their own account.

- Some markets which cover multiple periods include both spot and forward markets, enhancing the amount of advance information about market prices which is available to firms, and providing an opportunity to reduce firms' exposure to future price risks.

22. The following sections discuss two key issues which may affect the efficiency of emissions trading markets, the role of transaction costs which may directly inhibit some cost-reducing trades, and the presence of market power which may lead to inefficient pricing of allowances, so that some cost-reducing reallocations of abatement do not occur.

2.4 Transaction costs

23. Little has been written on the practical significance of transaction costs in emissions trading markets. In a study of the US lead credit trading scheme, which operated during the mid 1980s as a mechanism to accelerate the phase-down of lead in petrol (gasoline), Kerr and Maré (1998) provide both a useful taxonomy of the forms of transaction costs liable to affect the market, and an empirical estimate of the significance of transaction costs in this case.

24. The system of inter-refinery trading in lead reduction credits began in November 1982, when the US EPA introduced a limit on the average level of lead in a refinery's gasoline production of 1.1 grams per gallon, subsequently lowered to 0.5 in July 1985, and 0.1 in January 1986. Between November 1982 and the end of 1985 a system of "inter-refinery averaging" allowed refineries to reallocate lead within the overall lead content limit, and credits could be banked through until the end of 1987. The system was designed to provide flexibility to refiners during this rather drastic phase-out, as refiners adjusted to the new lower lead limits which were to apply uniformly from the end of 1987. Without trading in lead credits it was thought that either a longer period would have to be allowed for the phase down, or else there would be a risk of short term disruptions to the supply of gasoline (Carlin, 1992). The scheme ended in 1987, once this adjustment was completed.

25. The initial allocation of lead rights to firms was determined by the amount of leaded gasoline produced by the firm and the current EPA standard required (Hahn and Hester, 1989). Trading could be internal or external: a firm could use lead rights itself by adding more lead to its gasoline at some point during the quarter than would otherwise be allowed, or it could sell its rights to another firm. Initially,

rights simply expired if they were not used or sold during the quarter in which they were created. However, starting in 1985, refiners were allowed to "bank" rights for their own future use through to the end of 1987, or for sale to other refiners until the termination of the lead trading program at the end of 1986. Transactions were reported to the EPA and each refiner was required to have a net balance of lead rights greater than or equal to zero for the quarter. Enforcement was largely operated through paper audit of the reported transaction statements, to identify discrepancies and inconsistencies between transactions reported by the buyer and the seller.

26. Several hundred refiners, constituting over half the total number, participated in the reduction credit market. The market was very active and trading activity generally increased throughout the life of the program. In particular the extensive use of banking helped to smooth adjustment to each stage in the reduction in lead-content limits: when a lower limit on lead came into effect it was exceeded for a while by refiners of all sizes who withdrew rights banked previously.

27. Ex ante it had been assumed that it would principally be smaller refineries that would need to take advantage of the flexibility that lead credit trading offered, and during the first six quarters of the trading program small refiners consistently exceeded the EPA lead limit by purchasing credits. Indeed, throughout the period to 1987 small refiners continued to add more lead to gasoline than did large refiners. Nevertheless, roughly equal proportions of small traders bought and sold rights indicating that they were not uniformly hard pressed to meet the new lead standards. However, the proportion of large refiners engaged in trading was generally greater than that of small refiners, and Hahn and Hester (1989) suggest that this may reflect the differential effect of information costs or other transactions costs.

Transaction costs: a taxonomy

28. In their study of transaction costs in this market, Kerr and Maré (1998) distinguish between five types of transaction cost that could affect the willingness of firms to trade:

- ***The cost of optimising***. Participants in the market needed to assess whether to abate or buy permits. This would require internal decision-making processes to assess the cost of various abatement options, and weigh them against the costs of permit trading.

- ***Search costs***, of two main sorts. First, firms intending to trade needed to obtain information about the distribution of market prices, in order to assess the going rate for credits. The prices at which trades were made were not reported publicly, and seem to have been treated as highly confidential by most market participants (Anderson, Hofmann and Rusin, 1989). Potential participants in the market may well have faced considerable costs in obtaining reliable price information. Second, firms would incur search costs in finding suitable trading partners. There are indications that some refiners at least were already accustomed to conducting transactions with each other for refinery feedstocks and products, and this experience may have reduced some of the costs of finding trading partners.

- ***Cost of assessing validity of rights***. A feature of the scheme was that there were no requirements for pre-approval of trades. As with other "baseline-and-credit" systems, permits are generated by abatement beyond each firm's baseline emissions, and the validity of permits which are traded therefore depends on the relationship between the seller's abatement actions and their baseline. The validity of permits can, in principle, be verified before trading or later (*e.g.* end-year). To avoid the risk that a bureaucratic process of pre-trade verification could introduce costly delays, the lead credit system operated on the basis of year-end verification and reconciliation. This, however, may introduce other transaction costs to the market. It opens up the possibility that invalid permits may be offered for sale, either through error or fraud, and purchasers therefore

face risk, and need to take steps to assess the validity of the credits they are purchasing. Kerr and Maré suggest that small, infrequent sellers, may have found credibility hard to establish.

- ***Cost of negotiation***, including legal charges, management time, etc.

- ***Cost of release of confidential information***. The act of trading releases information of value to competitors. To the extent that price information is confidential to the two parties in a transaction, the release of implied information about marginal abatement costs is confined to the two trading parties. The secrecy which surrounded price information in this market suggests that it was commercially-sensitive information. Information about quantities traded was more widely disseminated, but even this provides clues to other market participants about each refiner's technology and costs.

Transaction costs: evidence on scale

29. The particular focus of the Kerr and Maré study is one type of transaction cost in the US lead credit trading scheme, namely "first trade" transactions costs (in other words the cost of making one trade rather than not trading at all). They used data collected from 30 major oil companies, showing the trading partners and quantities traded for all permit trades carried out by each of 87 refineries over the two year period 1983-84. They estimate an econometric model of the probability of individual trades, relating observed trading behaviour to potential gains from trading, and factors that might affect transactions costs.

30. They find significant effects of transactions costs on the overall gains from trade, sufficient to reduce the overall achieved gain from trade to some 10 to 20 per cent below the total potential gain. Some of this loss comes from the transaction costs themselves (in trades that do take place), and other losses are the potential trading gains that are foregone (for trades that do not take place). For some oil companies, especially the smaller and less sophisticated operations, the losses from transactions costs were of considerably greater significance.

31. Kerr and Maré conclude that their results show that tradable permit markets can still be a more cost-effective instrument of environmental regulation than non-market instruments, in reasonably promising contexts. Nevertheless, transaction costs do reduce the efficiency savings below the maximum level theoretically available, and they warn that this effect may be particularly severe in contexts where potential traders are unsophisticated and where they have few existing connections, so that search costs are high.

2.5 Market power

32. A second requirement for emissions trading to work as efficiently as the corresponding environmental tax is that the permit market should be competitive. Firms should be willing to buy and sell allowances at prices reflecting their marginal abatement costs, so that all abatement-cost-reducing emissions trades take place. Where firms' willingness to trade allowances is affected by considerations of market power, some opportunities for trades to reallocate abatement to lower-cost sources will be lost (Hahn, 1984).

33. Market power can arise either on the buyer or seller side of the market, and reflects the initial allocation of allowances and the distribution of marginal abatement costs around the competitive market price. It is obvious that an initial allocation of allowances that concentrates allowance holdings in a small number of firms will give those firms monopoly power in any subsequent trading. But a degree of market power may also arise as a result of the distribution of marginal abatement costs around the market price. Where the pattern of abatement costs is such that one firm accounts for a substantial proportion of the

allowances offered for sale, and where the marginal abatement costs of other firms are steeply-increasing so that a higher market price would not encourage other firms to sell allowances, then the seller may possess some market power. The seller may be able to make higher profits from the allowance market by limiting the number of allowances offered for sale, rather than by selling as many allowances as possible. In doing so the seller foregoes the opportunity of revenues from some allowance sales in order to obtain a higher price, and hence higher profits, on the remaining allowances sold. Offering allowances for sale at a price higher than the seller's marginal abatement cost will mean that some potential abatement-cost-reducing trades do not take place, and hence there will be a welfare loss.

34. Similarly, a monopoly buyer of allowances may restrict the amount purchased in order to drive down the equilibrium price of allowances. The buyer foregoes some opportunities to reduce abatement costs, but may nevertheless profit by making its remaining allowance purchases at a lower price. Again, there is an efficiency cost to the economy as a whole, in terms of abatement inefficiency.

35. Willingness to trade may also be affected by the presence of market power in markets other than the allowance market, if firms trading in these markets also interact in the allowance market. Product market considerations may, for example, influence allowance trades. Firms may forego allowance trades in order to drive up the costs of their product market competitors, or in order to constrain their output. This strategy could be encountered where the allowance seller has a degree of market power in the allowance market (since otherwise there is no point in denying allowances to competitors, since they can buy from other sellers), and where the product market is not perfectly competitive (so that driving up the costs of a competitor affects the product market equilibrium). The case where product market considerations may affect the functioning of emissions trading is discussed by Misiolek and Elder (1989).

36. Empirical evidence on the significance of market power in allowance markets is sparse. Major emissions trading applications such as the US Acid rain Program and the EU ETS have a sufficiently large number of potential participants and sufficiently dispersed allowance allocations that problems of market power do not arise. However two emissions trading applications do appear to have raised market power issues:

37. One is the early emissions trading application on the Fox River in Wisconsin. The Wisconsin Department of Natural Resources (WDNR) introduced a scheme in 1981 to allow point sources on a highly-polluted stretch of the river to transfer permits to discharge wastes that increase biological oxygen demand (BOD), at the same time as introducing more stringent discharge limits for individual sources. The scheme covered two main groups of dischargers - municipal dischargers and a small number of pulp and paper mills. Despite ex ante estimates that there was considerable potential for water treatment costs to be reduced through trade, only one trade took place. There has been considerable discussion of the reasons that may account for the lack of trading. One, noted by Hahn (1991) is that the oligopolistic structure of the pulp and paper industry may have discouraged trades. Firms may have been reluctant to offer allowances for sale to product market competitors, either because this implicitly revealed cost information to them, or because it would have the effect of giving their competitors cost-saving opportunities.

38. A second emissions trading application where issues of market power may be relevant is the UK Emissions Trading Scheme for greenhouse gases, introduced in 2002 (see Section 5.1 below). The initial auction of abatement subsidy payments allocated a substantial proportion of the subsidy to a small number of firms; one firm was allocated 20%, and three firms together accounted for 43 per cent, of the subsidy budget. These firms took on correspondingly-large abatement commitments, and yet subsequently succeeded in achieving abatement levels well above their targets. As a result these firms are major suppliers of allowances in the UK ETS, and despite the large number of potential traders (over 6000 firms in Climate Change Agreements) and the large number of firms (about 1400) which have participated in the market, the seller side of the market has been highly concentrated. Smith and Swierzbinski (2007) show

that the four-firm concentration ratio (*i.e.* the fraction of total sales accounted for by the four largest sellers, a common measure of market concentration) is 65.7% in the first four years of trading in this market, a value generally regarded as high in analyses of market power. Whether this concentration has affected trading outcomes in this particular market is difficult to judge, because the market has been dominated by substantial excess supply and close-to-zero allowance prices for much of the time. However, it highlights the difficulty of ensuring a fully-competitive emissions trading market when abatement opportunities arise through costly large-scale one-off investments. Almost inevitably this leads to concentration of supply in the market.

2.6 Real-world environmentally-related taxes

39. Most real-world environmentally-related taxes take the form of taxes on the sale of a market good that is related to emissions or pollution. Goods and services associated with environmental damage in production or consumption may be taxed more heavily (*e.g.* tax on batteries and fertilisers). Goods believed to benefit the environment may be taxed less heavily than their substitutes, as with reduced tax on lead-free petrol (Hammar and Löfgren, 2004). These environmentally-related taxes may take the form of rate differentiation within an existing system of excise duties, sales taxation or VAT, or the introduction of new, separate environmental excise.

40. Occasionally, though much more rarely, taxes are levied on emissions, with tax payments directly related to metered or measured quantities of polluting effluent. Practical examples of such taxes include Sweden's charge on Nitrogen Oxides emissions (Millock and Sterner, 2004), and emission charges for water pollution in the Netherlands (Bressers and Lulofs, 2004).

41. Many of the so-called "environmental taxes" introduced in practice have been used primarily for revenue-raising (Opschoor and Vos, 1989), generally to raise earmarked revenues for particular public expenditures related to environmental protection. "Environmental taxes" of this sort have been used to recover the costs of administering environmental regulation, to pay for public or private expenditures on pollution abatement, and, in the US, to pay for Superfund clean-up of contaminated waste sites. The environmental effects of these taxes themselves may be limited. In some cases, their link to the environment is solely through the use of their revenues.

42. The first two types of environmentally-related tax identified above employ the tax system to provide incentives, but they do this in different ways, in the first case by taxing a transaction in goods associated with pollution, and in the second case by directly taxing measured emissions. Both forms of environmental tax may be appropriate in particular circumstances, and the choice between the two approaches needs to take account both of the administrative costs of different tax options and the extent to which different tax designs can achieve effective targeting of the environmental incentive. Typically there will be a trade-off between the lower administrative cost of taxes levied on transactions (especially if this simply involves changes to the rates of existing sales taxes), and the more efficient targeting of the incentive with taxes based on measured emissions. The balance between these two considerations is likely to differ from case to case.

2.6.1 Taxes based on emissions

43. Taxes based on measured emissions require, as a minimum, the additional costs of a system for the assessment or measurement of the emission quantities. These costs depend on measurement costs per source, the number of separate emission sources to be covered, and the extent to which measurement is solely incurred for regulatory purposes, rather than a part of normal business activities. These costs of measurement will vary from case to case, depending on the substances involved, the range of currently-available measurement technologies, and the technical characteristics of the emissions (*e.g.* flow,

concentration, stability). Recent scientific and commercial developments in measurement and control have substantially widened the range of technologies available for monitoring the concentrations and flows of particular substances in effluent discharges. Technological change has therefore expanded the range of pollution problems for which charging on the basis of direct measurement could be a feasible and cost-effective option. In turn, the future pace of development and commercialisation of such technologies will probably be stimulated if greater use is made of direct emissions charging.

44. Environmental taxes based directly on measured emissions can, in principle, be very precisely targeted to the policy's environmental objectives. When polluting emissions rise, the polluter's tax base rises, and the polluter pays additional tax directly in proportion to the rise in emissions. The polluter thus has an incentive to reduce emissions in any manner that is less costly per unit of abatement than the tax on each unit of residual emissions. That is, the actions the polluter can take to reduce tax liability are actions that also reduce emissions.

2.6.2 Environmentally-related taxes on goods and services

45. Where the additional administrative costs of a direct charge for measured emissions are high, restructuring of the existing tax system may provide an alternative way of introducing fiscal incentives to reduce environmental damage. Such "piggy-backing" of environmental incentives onto operations for existing taxes may be significantly less costly than wholly-new administrative apparatus and procedures. However, while differentiation in the rates of existing taxes may often cost much less than the administration of a new tax on measured emissions, it is unlikely to be wholly costless, and this may place a limit on the use of environmental differentiation of existing sales taxes. Greater complexity in the rate structure is likely to increase the administrative costs of existing sales taxes (especially, of value-added taxes).

46. New environmental taxes based on transactions could also be introduced. This option will be particularly attractive where differentiation of existing sales taxes to reflect the environmental characteristics of goods and services would be costly or impracticable. For example, where countries have introduced carbon taxes or environmentally-related taxes on energy these have generally taken the form of new excise taxes, charged on the volume of energy sold, and levied at some specified point in the supply chain. Introducing a new excise tax allows the tax to be based on the quantity of fuel sold rather than its value (as would be the case if the fuel were to be taxed at higher rates within a general system of sales taxes or VAT). The tax is, nevertheless, a proxy for an emissions tax rather than a tax levied directly on emissions, since what is being taxed is a transaction - the sale of a certain quantity of fuel.

47. For environmental taxes based on transactions to achieve efficient polluter responses, the tax should encourage taxpayers to reduce the processes or activities that give rise to polluting emissions, and as far as possible should avoid provoking behavioural changes that do not yield environmental benefits. The use of a sales tax as a "proxy" for taxing emissions will work best when the linkage between the tax base and pollution is stable. Unfortunately, relationships that are observed to be stable in the absence of policy measures can turn out to be unstable once a tax is introduced (Sandmo, 1976).

48. One important limitation on the use of such indirect environmental taxes is in the employment of taxes on production inputs associated with pollution - such as taxes on carbon-based fuels, high-sulphur coal, etc. Such taxes are unlikely, on their own, to achieve an efficient pattern of polluter responses when pollution abatement can efficiently be achieved 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 a "scrubber" (flue gas desulphurisation equipment, or FGD). In these cases, taxes on production inputs alone cannot effectively encourage an efficient pattern of pollution abatement. A tax on the sulphur content of coal, for example, may discourage the use of this polluting material in production,

but it provides no incentive to clean up effluents. Some pollution reductions may be achieved, but not in a way that is most effective or efficient. As possibilities for carbon capture and storage (CCS) become increasingly viable in commercial operations, a similar issue is likely to arise with taxes on carbon-based energy. In both cases, the input tax would only encourage efficient abatement choices by polluters if accompanied by an appropriate refund for end-of pipe abatement (acid "scrubbers" or CCS). Such a provision is included in the Norwegian tax on the sulphur content of fuels – firms are entitled to receive a refund if they can document end-of-pipe abatement.

49. More generally, while a tax on a "proxy" for emissions risks inefficient abatement responses, it may be possible to use a combination of such taxes to achieve a more efficiently-targeted environmental incentive. Fullerton and Wolverton (2000) show conditions under which a "multi-part instrument" of an advance disposal fee coupled with a disposal subsidy (as with a deposit on glass bottles plus a refund for recycling) can match exactly the effects of a hypothetical-but-impractical Pigouvian tax on waste, generating incentives to reduce consumption of waste-intensive products and to dispose of waste properly. Similarly, a tax based on actual measurements of motor vehicle emissions may be technologically impractical, but its effect might be closely approximated by a combination of available tax instruments such as a tax on petrol, a subsidy to new car purchases, or tax on older cars, and a tax on cars with low fuel-efficiency or high emission rates (Fullerton and West, 2002).

50. The key to achieving the potential gains from the use of taxation as an instrument of environmental policy lies in the effective targeting of incentives to the pollution or other environmental problems that policy seeks to influence. Poorly targeted environmental taxes may increase the economic costs of taxation, while offering little in the way of environmental gains.

3. Revenue and Burden Issues

Auctioning tradable emissions allowances has significant economic advantages over "grandfathering" free allowances to existing polluters (Section 3.1). The frequent auctions of government securities provide a wealth of experience on which allowance auctions can draw (3.2). To date, however, auctions of emissions allowances are rare, and grandfathering - to offset adverse effects on competitiveness - is widespread (3.3). The basis on which free allowances are allocated will have significant effects on economic efficiency. A number of options are described and compared in Section 3.4. With environmental taxes, a different route has generally been taken to neutralise effects on competitiveness - based on sectoral exemptions and tax reductions (3.5). Sectoral exemptions achieve better targeting to the most exposed sectors, with lower revenue costs than universal grandfathering. But sectoral exemptions create uneven abatement incentives across sectors, risking abatement inefficiency.

3.1 Why auction rather than grandfather?

51. The economic case for auctioning emissions trading allowances, rather than distributing them without charge to existing polluters ("grandfathering") is argued clearly by Cramton and Kerr (2002) and by Hepburn *et al.* (2006). The arguments fall into three principal groups - those concerning the auction revenues, those concerning the windfall gains that grandfathering typically confers on polluters, and those concerning the better dynamic properties of an industry where new firms and existing firms are treated on an equal basis.

3.1.1 Auction revenues

52. The principal argument for auctioning is the value of the revenues. These can be used to reduce other taxes, with consequent gains in the overall efficiency of the economy compared with "grandfathering" or other non-revenue-raising forms of allowance allocation. This efficiency argument is

the well-established and uncontroversial "weak" double dividend hypothesis as defined by Goulder (1995), which asserts that an efficiency gain is made if environmental tax revenues are used to reduce the rates of distortionary taxes in the economy, rather than being returned on a lump-sum basis. The equivalence discussed in Section 2.2 between environmental taxes and emissions trading allows this double dividend result to be interpreted in the context of emissions trading. In this context it would imply that an efficiency gain is made by auctioning and using the auction revenues to reduce the rates of distortionary taxes in the economy, rather than foregoing the revenue through free distribution (the counterpart to taxing with lump-sum return of the revenues).

53. In a number of emissions trading applications, the aggregate asset value created by the trading scheme is substantial. In the US Acid Rain Program, for example, the stock of allowances issued each year covers some 10 million US tons of sulphur with an aggregate asset value of approximately USD 7 billion. In the EU emissions trading scheme, allowances have been issued corresponding to some 2 billion tonnes of carbon, with an aggregate annual value of EUR 40 billion. The market value of these allowances should not be affected by the method of distribution - whether auctioned or grandfathered - because the price of allowances in a competitive market is determined by the marginal abatement cost at the emissions constraint set by the quantity issued. Full, competitive, auctioning of allowances in these systems would therefore generate annual revenues broadly equivalent to these asset values.

54. Equivalently, grandfathering foregoes the potential to raise these revenues. The economic value of the auction revenues - foregone if allowances are grandfathered - is broadly-speaking the reduction in marginal excess burden that could be achieved by reducing the rates of distortionary taxes in the economy. In an economy with high existing levels of taxation, the distortionary cost (marginal excess burden) of tax revenue at the margin can be substantial. Bovenberg and Goulder (2002) review a range of estimates of marginal excess burden for the US, finding values in the range 20-50 cents for each additional dollar of tax revenue. Parry presents some comparative simulations of the net benefits of policies to achieve a reduction in US greenhouse gas emissions by 150m tonnes, based on an assumption of a USD 20 per tonne environmental benefit from reducing carbon dioxide emissions. Ignoring the fiscal consequences of raising the price of carbon, such a policy would generate benefits of USD 3 billion, and net benefits, after abatement costs of USD 1.5 billion. Taking into account the fiscal interactions between policy measures that raise the price of carbon and the distortionary cost of the existing tax system, Parry calculates that the net benefit from implementing this policy using a carbon tax (or, equivalently, auctioned permits) would be USD 1.13 billion. By contrast, implementing the policy using grandfathered permits incurs a welfare loss of USD 6 billion. In other words, the choice between auctioning and grandfathering makes a difference of over USD 7 billion to the net benefit of controlling emissions, a huge figure compared with the gross environmental gain (USD 3 billion) or the abatement costs incurred by polluters (USD 1.5 billion). As Parry points out, the comparison between the benefit of auctioning and the other costs and benefits of environmental policy interventions depends on the particular policy measures being studied, and is not always as dramatic as in the calculation described. Nonetheless, the point remains that the choice of grandfathering over auctioning entails substantial economic costs in an economy where existing taxes are high.

3.1.2 Avoiding windfall gains

55. The counterpart to the foregone revenues if allowances are grandfathered rather that auctioned is that substantial and arbitrary windfall profits are conferred on polluters receiving free allowance allocations. Free allowance allocations do not simply compensate firms for the costs of an emissions trading system. Instead, an emissions trading system acts to raise the marginal costs of output, because additional output requires additional – costly - allowances, which have to be bought, or, if already held, could otherwise have been sold. The effect is to raise product prices, so that allowance costs are passed on to customers, regardless of whether allowances were auctioned or distributed free. (These product price

effects are not confined to emissions trading, or to economic instruments; they arise with many other environmental policy measures including some forms of command-and-control regulation, as noted by Fullerton and Metcalf, 2001.) The windfall gains made by polluters are essentially an arbitrary redistribution within the economy. Auctioning would avoid this redistribution, and, to the extent that firms or industries do experience adverse effects from emissions trading, the revenues gained by auctioning can be partly deployed in targeted measures to offset undesired distributional effects.

56. The windfall profits conferred by grandfathering can generate costly political lobbying and "baseline inflation" to influence the pattern of free distribution. A further advantage of auctioning is that it avoids giving rise to these potentially wasteful activities.

3.1.3 Effects on industry dynamics

57. Auctioning promotes a more efficient long-term evolution of the regulated industries, avoiding the adverse effects on new entry and exit that can arise when allowances are grandfathering to existing firms. Auctioning ensures that existing firms and new entrants are treated the same, obtaining allowances in the same way, facing the same allowance cost per unit of emissions. Regular auctioning will also tend to increase market liquidity, ensuring that potential purchasers have the opportunity to buy; new entrants cannot be excluded by the unwillingness of incumbent firms to release allowances for sale. Likewise, auctioning tends to promote efficient decisions about whether to cease production and leave the industry. Firms will choose to do this if, when the full costs of their pollution are taken into account, they cannot earn profits. Exit in these circumstances is one of the ways of achieving cost-effective pollution reductions. Allowance grandfathering can tend to inhibit exit - especially if "use it or lose it" allocation rules are applied, so that firms which leave the industry forego their allowance allocation.

58. More generally, auctioning rather than administrative allocation of allowances ensures that firms trade where this saves costs, without concern about the effect on future allowance allocations.

59. The process of auctioning may also focus management attention on allowance prices and on abatement and trading opportunities, stimulating internal reorganisation and changes in business decision-making which increase the responsiveness of firms to a given environmental incentive.

3.1.4 Other issues

60. In addition to the economic advantages of auctioning, there may also be legal advantages. Free distribution may contravene competition policy or State Aid legislation, and is inconsistent - in spirit at least - with the Polluter Pays Principle.

3.2 How to auction?

61. The reviews of allowance auctioning by Cramton and Kerr (2002) and by Hepburn *et al.* (2006) also address the auction procedures that might be used. Hepburn *et al.* (2006) point out that, while practical applications of auctions to environmental allowances are limited, there is a wide range of auction experience in other applications on which to draw in designing environmental allowance auctions. The recent large-scale auctions of radio-spectrum provide some examples of how to set up new auction arrangements, and many of the issues that had to be addressed - including information dissemination, appropriate training for participants, etc. - would also need attention in the design of environmental allowance auctions.

62. In terms of the characteristics of the market, there are close similarities between environmental allowances and the auctions used in government borrowing, in the form of the sale of government securities such as Treasury Bills and Gilts. Both involve the sale of large numbers of identical items and a

large number of potential bidders, and in both cases the items sold are subject to subsequent resale in market transactions. As with the sale of government securities, some environmental allowance auctions would have the potential to raise large revenues, and over time could be expected to attract the involvement of highly-informed and sophisticated bidders.

63. Cramton and Kerr (2002) discuss the appropriate auction design for commodities with the characteristics of environmental allowances for sulphur, carbon or other homogeneous commodities. Two types of auction format would be appropriate for such auctions. Ascending-bid auctions involve multiple rounds, conducted in real time. The auctioneer publicly announces prices and invites quantity bids, and the market clears when a price is reached at which all units are sold. Sealed-bid auctions can involve multiple rounds of undisclosed bids, but typically involve a single round, in which bidders submit confidential bids specifying various price and quantity combinations that that they would be willing to transact. The auctioneer than ranks these bids, selecting the combination of highest bids that exhausts the quantity of items for sale. Sealed bid auctions can have two pricing formats: either discriminatory ("pay-what-you-bid") or uniform-price. The choice between these involves issues of both efficiency and revenues: generally, "pay-what-you-bid" auctions are more liable to generate strategic under-bidding by participants, and will not necessarily then raise higher revenues than an auction in which all bidders pay the price of the marginal market-clearing bid.

64. Hepburn *et al.* (2006) discuss the optimal limits on participation in an environmental auction. An overriding requirement is that sufficient participants are required for the auction to be competitive. However, an efficient market need not be open to all-comers, not need the market be accessible to all polluters in an industry. There may be a case for restricting participation in the auction, especially if catering for a large fringe of small, infrequent and unsophisticated bidders adds to the running costs of the auction. Regardless of whether small firms are formally excluded from the auction, the transactions costs of entering an auction (in terms of appropriate training, information and management time) may deter small firms from bidding directly for the small quantities of allowances they need. Such small firms may choose instead to purchase small quantities of allowances in subsequent market trading, and it is likely that brokers would enter the market to supply small quantities of allowances to small firms.

65. Likewise, the frequency with which auctions are held may affect their efficiency. Frequent auctions may have higher operating costs than infrequent auctions, simply because there are likely to be some fixed costs per auction for both the authorities and for bidders. However, there is a case for a reasonably high frequency of auctions, to ensure continuing liquidity and to promote learning by participants (and hence longer-term efficiency). Frequent auctions may be of particular benefit to smaller firms facing high costs of borrowing (since they can buy allowances on a continuing basis, rather than having to buy occasional large amounts).

3.3 Why grandfather?

66. To date, the vast majority of allowances in major emissions trading schemes such as the US Acid Rain Program and the EU ETS have been allocated without charge to existing firms in the industry - generally referred to as grandfathering. This may be seen as carrying over to emissions trading policy a more general tendency to subject incumbent firms to less-demanding regulation than newer entrants.

3.3.1 Vintage-differentiated regulation

67. There is a widespread tendency in environmental policy for new plants and more-recent entrants to an industry to face more stringent regulation than older plants. Often units installed before a certain date are exempted, or face less stringent requirements than those built more recently. Stavins (2005) identifies

three main groups of reasons that may prompt this "vintage-differentiated regulation", in terms of efficiency, equity and political considerations.

- ***Efficiency.*** Vintage-differentiated regulation may be more efficient than uniform regulation, requiring a specified abatement technology or emissions limit to be observed by all firms, regardless of age. It may be more cost-effective to install pollution abatement into newer plants than to retrofit older plants, because there may be savings from integrating abatement technology decisions and other aspects of design when a plant is first constructed, and because abatement equipment installed into new plants is likely to yield environmental benefits for a longer period of time than the same equipment in older plants that are nearer the end of their economic lifespan.

- ***Equity.*** It may be argued that it would be inequitable to impose additional regulatory requirements on existing firms, once investments had been committed. "Changing the rules of the game" in this way imposes unforeseen costs, and can impose capital losses on investors.

- ***Political considerations***. Political lobbying may be stronger, and may meet more resonance among lawmakers, when it concerns adverse effects to identifiable existing incumbents than among potential - possibly hypothetical - entrants to an industry.

68. However, vintage-differentiated regulation also entails costs, of two main sorts:

- ***Dynamic inefficiency.*** Vintage-differentiated regulation will tend to inhibit the dynamic restructuring of an industry, by discouraging the entry of new, more efficient firms, at the expense of less-efficient incumbents. This effect may lead to longer-term efficiency costs, to set against the possible short-term efficiency gains from vintage-differentiated regulation.

- ***Adverse emissions impact.*** Vintage-differentiated regulation may - for a time at least - result in higher emissions, possibly even higher than in the absence of any regulation at all, if the lower regulatory burden placed on older plants (with poorer environmental performance) delays the adoption of new clean technologies.

69. Gruenspecht (1982), for example, argues that vehicle emissions standards applied to new vehicles can lead to a period when older, highly-polluting vehicles continue to be used, when they would already have been scrapped and replaced if regulation had not so increased the cost of new vehicles. Stavins (2005) also reviews the empirical evidence on the effects of "New Source Review" (NSR) in US pollution regulation. He concludes that NSR has slowed the replacement of old, dirty plants by new, cleaner, facilities, has increased the costs of environmental improvement and, in the power sector, had a counter-productive effect on emissions.

3.3.2 Grandfathering ET allowances

70. Some, but not all, of these concerns and pressures lie behind the almost-universal tendency for emissions trading systems to allocate allowances for free to existing polluters, rather than to auction. Thus, both equity concerns and political pressures point towards grandfathering allowances to existing polluters. By contrast, however, the efficiency arguments which partly motivate conventional vintage-differentiated regulation do not have any counterpart in the case of grandfathering emissions-trading allowances, because emissions trading itself permits cost-efficient reallocation of abatement between polluters. The allocation of allowances in an emissions trading system determines the distribution of gains from the distribution of a valuable, tradable, asset, but does not have any implications for the pattern of abatement actions undertaken.

71. Grubb *et al.* (2005) emphasise two main positive arguments for grandfathering emissions trading allowances, in terms of compensation and competition respectively.

- ***Compensation for unforeseen regulatory costs.*** As with vintage differentiated regulation, there is the use of grandfathering to compensate holders of existing assets for the effects of environmental regulation that was not foreseen at the time of the initial investment. This argument implies that compensation should be transitional, for the foreseeable lifetime of existing assets, and does not justify grandfathering in perpetuity. It implies that any free distribution should not apply to new entrants. And it does not necessarily entail grandfathering all allowances. As Johnston (2006) discusses, the compensation made through grandfathering needs to be proportionate to the profit foregone as a result of the unanticipated additional regulation, if grandfathering is not to be vulnerable to EU State Aids Legislation. If firms pass on part of the cost in higher prices, and if they can do substantial abatement at low cost, their additional costs may be very much lower than the benefit they would receive from a completely free distribution of allowances.

- ***Offset impact of international competition.*** Grandfathering may also be seen as a way of offsetting the impact of competition from foreign producers not subject to similar regulation. Again, the proportion of allowances that may need to be grandfathered to offset this effect may be less than 100%. Grubb and Neuhoff (2006) point out that most industries covered by the EU emissions trading system would need to make only a small rise in prices to cover their net exposure to the costs of emissions trading. In practice, many have increased prices by more than this, pricing the opportunity costs of allowances into product prices. This has allowed firms to earn higher profits than in the absence of regulation, even at the costs of, in some cases, significant reductions in international market share.

72. Palmer, Burtraw and Kahn (2006) consider the effectiveness of various different free-allocation rules as a mechanism for compensating power generators that will be affected by the nine-state Regional Greenhouse Gas Initiative (RGGI), being developed by nine Northeast and Mid-Atlantic States in the USA, and planned to begin from 2008. They distinguish between the goal of compensating the industry as a whole, and the goal of compensating individual firms within the industry. Like Grubb *et al.*, they point out that as far as the industry as a whole is concerned, there is no need for free allocation. The scheme will increase electricity output prices by more than enough to compensate for the additional costs incurred by the generators. At the level of individual firms, however, there will be a significant number for which this will not be true (and also many which will experience much higher gains than the average). If the regulator is able to target compensation based on the effects on individual firms' profit performance, the costs of compensation to ensure that no individual firm loses would amount to only about one third of the value of emissions allowances. In practice, however, the regulator has incomplete information about firm performance, and it would be necessary to base any targeted compensation on various measurable proxies for firm performance. Allocating compensation in this way, while retaining the requirement that no firms should be net losers from the scheme, would be much more expensive, consuming around three quarters of the aggregate value of allowances. Much of the benefit of this would of course go to increase the profits of firms that were not in fact losers from the scheme, due to the impracticability of distinguishing gainers and losers.

73. The huge asset values at stake in the design of emissions trading schemes make political controversy and lobbying over the basis of allocation inevitable, and it may be difficult to see how a significant proportion of emissions trading allowances could be auctioned, without some serious attempt to address the issue of the (real and perceived) impact on industry profitability and competitiveness. Grubb *et al.* (2005) outline three possible options:

- ***International coordination of policies***. Competitiveness effects of allowance auctioning could be substantially reduced if similar measures were adopted in competitor countries. This would not require completely identical policies, nor even all competitor countries to auction emissions trading allowances. Since the effects of a system of auctioned allowances is broadly equivalent to the effect of an environmental tax at the same level, countries could adopt a range of different mechanisms, so long as these implied a broadly equivalent financial burden.

- ***Border tax adjustments.*** The competitiveness effects of auctioning emissions allowances could, in principle, be neutralised by levying a tax on competing imports and rebating allowance costs on exports. Imports would need to be charged a tax equal to the allowance costs that would be borne by an equivalent domestic producer, while refunds to exports should reflect the costs of allowances incurred during domestic manufacture. There are significant legal impediments to introducing arrangements for border tax adjustments, cf. OECD (2006). There are also difficult practical and economic issues. First, border tax adjustments may erode incentives for cost-effective pollution abatement, because of the rebating of allowance costs for exported goods. Second, a decision would have to be made whether border tax adjustments would apply to all imports and exports, or only to trade with countries that did not pursue broadly-equivalent environmental policies; the latter case raises considerable difficulties in defining policies of equivalent stringency. Third, it may be impossible to define the appropriate rate of tax adjustment, where domestic firms have a choice of production techniques involving different levels of pollution (Poterba and Rotemberg, 1995). If the border tax adjustments are calculated on the basis of average pollution characteristics then they will overcompensate some firms and provide inadequate compensation for others.

- ***Output-indexed allocation.*** A different approach to tackling the competitiveness issue would be to find a method of allocating allowances which treats existing firms and new entrants symmetrically, and which does not generate substantial polluter rents. In these circumstances the case for auctioning might then be weaker. Grubb *et al.* (2005) discuss the option of allocating allowances in proportion to current output, arguing that this would sharply reduce the impact of allowance costs on product prices, since additional output at average emission performance would no longer require the purchase of additional allowances.

3.3.3 Historic versus output-based allocation

74. If emissions trading allowances are to be allocated free of charge to existing firms, there are a range of possibilities for how this might be done. Two broad approaches may be contrasted, historic and output-based allocations.

- ***Historic allocation*** distributes allowances to firms on the basis of data relating to the characteristics of the firms prior to the emissions trading scheme. One basis would be to allocate allowances in proportion to firms' emissions in some base year. Although use of the term varies, some authors use the term "grandfathering" to refer to such an allocation rule, based on historic emissions; others use the term more widely to refer to allocation rules based on historic data, including past output or other firm characteristics. Thus, the US Acid Rain Program, which began in 1995, allocated allowances to the first power generators to enter the scheme primarily on the basis of their activity level (measured by heat input) in 1985-87, multiplied by a standard emissions rate per unit of heat input (Ellerman *et al.*, 2000). In its pure form, historic allocation rules fix the allocation across firms in perpetuity; there is no "updating" of allocations to reflect changes in output across firms or other aspects of the evolution of the industry.

- By contrast, under ***output-based or "intensity-based" allocations***, firms receive allowances in proportion to their output in the current period. The allocation basis is thus "updated" to reflect the current characteristics of the industry. Firms that grow receive a higher allocation of allowances, while those that lose market share receive fewer allowances. New entrants could be allocated allowances on the same basis as existing firms; firms that leave the industry lose their allowance allocation. Intensity-based allocation could be accompanied by an intensity-based cap on overall emissions (as discussed by Quirion, 2005), but this is essentially a separate issue from the allowance allocation. Intensity-based allocation can equally-well be used (as assumed here) to distribute a fixed total of allowances, with each firm receiving a share of the total number of allowances allocated, in proportion to its individual output.

75. It will be noted that a number of existing emissions trading systems exhibit a mixture of these two allocation bases. For example, in the first and second trading periods the EU emissions trading system is primarily a grandfathered system. Allowances are allocated under national allocation plans (NAPs) which in the first trading period (2005-7) mainly determined allocations on the basis of business-as-usual projections based on historical data, while for the next period (2008-12) verified emissions were taken into account. However, there are three respects in which allocations partly reflect aspects of the current evolution of the industry:

- Except in Sweden and the Netherlands (Åhman *et al.*, 2005), all NAPs stop allocating allowances to installations which close down, with effect from the start of the next year.

- All NAPs have provisions for the free allocation of allowances to new entrants. The rules for new entrant allocations differ across countries, and some countries treat existing plants which increase their permitted production levels on the same basis as new entrants.

- The EU ETS operates in a succession of phases, the first covering a three-year period (2005-2007), and five-year periods thereafter. Allowances are allocated for each phase according to new NAPs.

76. Some authors have argued the case for an output-based allocation in long-term emissions trading schemes, with automatic updating of allocations in line with changes in the pattern of activity in the industry. Output-based allocation is seen as having two main advantages. First, it provides a systematic treatment of new entrants, closed firms and changes in market share, and avoids a long-term outcome in which the allocation of allowances becomes increasingly out of line with the structure of the industry. Second, it can reduce the effect on product prices, and hence provides a mechanism to ameliorate impacts on international competitiveness. The primary argument against output-based allocation is that it can lead to inefficiency, both in industry structure and in pollution abatement.

77. The key to understanding the economic effects of output-based allocation is to note that, unlike a free allocation rule which assigns a fixed quantity of allowances to the firm, the firm receives allowances based on its output level.

- If the firm produces an additional unit of output under grandfathering, it must purchase additional allowances to cover the additional emissions associated with the additional production, and the cost of these additional allowances (or the opportunity cost of using allowances which otherwise would not have been needed, and could be sold) increases the marginal cost of producing additional output. It is this effect which then feeds through into higher product prices and profits), as firms raise output process to reflect their higher marginal costs.

- With output-based allocation, a firm that produces an additional unit of output receives a corresponding additional allowance allocation. As a result, the effect on marginal costs is sharply reduced (the additional allowance allocation per unit of output acts as a subsidy to output), and the effect on product prices, and hence international competitiveness, is lower.

78. In industries that are exposed to international competition, the choice between grandfathering and output-based allocation has major implications for output and profits. Demailly and Quirion (2006) simulate the effects on carbon dioxide abatement, competitiveness and "leakage" (international displacement of polluting business to less-regulated locations) in the European cement industry under different forms of allocation of ETS allowances. The cement industry is unusual in that some producers, in inland locations, are largely insulated from the effects of international competition due to the high transport costs for the product, while markets in coastal locations face intensive competition from non-EU sources, since sea transport costs are low (OECD, 2005a). Demailly and Quirion show that the effects on competitiveness and emissions are much greater under grandfathering than output based allocation. Grandfathering 50% of past emissions to cement producers is sufficient to maintain aggregate profits at business-as-usual levels, but there is a significant reduction in EU production, and significant leakage of emissions to non-EU locations. (These effects arise because of the higher product prices under grandfathering; these allow profits to be maintained, but at the cost of international market share). An output-based allocation, by contrast, has negligible effects on EU production levels and profits, but also much lower abatement in the EU, and very little international leakage.

79. Colombier and Neuhoff (2007) point out that a critical issue affecting abatement efficiency with an output-based allocation is the choice of process step to which the allocation is to be applied. Should this be the final product, or some intermediate good linked to industry output? Using the cement industry again as an example, the allocation could be based on output of the final product, cement, or of an intermediate good, clinker, produced in the course of cement manufacture. The problem is that the intermediate goods can be imported and exported as well as the final good, and that trade in these goods can lead to emissions leakage, in much the same way as when allowances are grandfathered on a basis unrelated to current output.

80. Output-based allocation will only be able to deter emissions leakage where the output indicator used for allowance allocations is tightly linked to the process step generating emissions. Thus if regulation aims to control the carbon dioxide emissions of the cement industry, the key issue is whether the carbon dioxide intensive part of the production process can be separated from other processes before the process step that is used for allowance allocations. Where the carbon-dioxide-intensive part of production can be separated from the production stage at which allowances are allocated, there is a risk of encouraging imports of untaxed intermediate goods which already embody the CO_2, but which still qualify for allowance allocation. Thus, in the cement example, if the allowances are based on cement output, but the bulk of carbon dioxide emissions are incurred in the course of clinker production, there will be an incentive to import clinker, which means that allowances are not needed to cover its manufacture, but which then generates an entitlement to an output-based allowance allocation, once further processed into cement.

81. Subject to the reservations discussed in the last paragraph, output-based allocation would reduce the risk of emissions leakage when international competitors do not apply similar environmental policies. It has this property because production of an extra unit generates an extra allowance entitlement; hence the marginal cost of producing an extra unit is not increased by the need to purchase extra allowances to cover the additional emissions. By the same token, however, it foregoes the possibility to encourage substitution of the final product to less-pollution-intensive outputs, because output-based emissions trading does not raise product prices to the same extent as with grandfathered or auctioned allowances (or taxes). It retains incentives for process improvements and low-emission process innovations, but only those which apply to stages of the production process before the allowance allocation.

Box 3.1 Auctioning versus free allocation of emissions trading allowances: a summary of the issues

Arguments for auctioning allowances

- Macroeconomic advantages - the revenues can be used to reduce other taxes, with consequent gains in the overall efficiency of the economy (compared with "grandfathering" or other non-revenue-raising forms of distribution).
- Distributional advantages: does not confer arbitrary windfall profits on polluters receiving free allowance allocations, while revenues allow more targeted measures to offset undesired distributional effects.
- Avoids costly political lobbying and "baseline inflation" to influence the pattern of free distribution.
- Effects on product prices, competitiveness and adjustment costs should not differ substantially from grandfathered permits (or most other forms of environmental regulation).
- Ensures that existing firms and new entrants are treated the same, avoiding the risk of ossifying market structure.
- Avoids the danger that "use it or lose it" allocation rules will discourage exit by inefficient firms.
- Ensures that firms trade where this saves costs, without concern about the effect on future allowance allocations.
- Increases market liquidity, ensuring that potential purchasers have the opportunity to buy.
- May focus management attention on allowance prices and on abatement and trading opportunities.
- Legal advantages: free distribution may contravene State Aid legislation, and is inconsistent with the Polluter Pays Principle.

Arguments for "grandfathering" allowances (free allocation)

- Free allocation of a proportion of allowances may compensate existing forms with sunk assets for the costs of unanticipated regulation.
- Free allocation may be used to offset the impact of international competition from companies which do not face similar regulation.
- Alternative approaches to offsetting effects from international competition (international policy coordination, border tax adjustments, output based allocation) may be impractical, and/or may have greater costs.
- An effective strategy to respond to political lobbying from firms adversely affected by regulation.

3.4 Environmentally-related taxes - revenue and tax-burden issues

82. As with emissions trading, concerns about competitiveness have been a prominent practical obstacle to greater use of environmentally-related taxes, and governments have tried to address these concerns in a number of different ways.

83. One broad group of responses has involved *revenue recycling*, either at the sectoral level or for industry more generally, in the form of measures that would reduce business tax burdens (*e.g.* reductions in payroll taxes). Some of the approaches to revenue recycling mirror very closely the effect of grandfathering free allowances to polluting firms, and raise very similar issues.

84. A second approach to neutralising effects on competitiveness has been based on *sectoral exemptions and tax reductions*, as discussed in OECD (2001). This differs quite sharply from the effect of free allowance allocations, and has no straightforward counterpart in emissions trading schemes. Sectoral exemptions and sectoral reductions in environmental tax rates achieve better targeting to the most exposed sectors, with lower revenue costs than universal grandfathering. But sectoral exemptions and tax reductions also create uneven abatement incentives across sectors, risking abatement inefficiency.

3.4.1 Revenue recycling: issues

85. One of the ways in which countries have succeeded in introducing significant new environmental taxes is through packages of explicitly revenue-neutral fiscal changes, in which the additional revenues from environmental taxes are offset by clearly-identified reductions in other taxes. Such packages may act to counter the perception that environmental taxes are simply another way for governments to extract further tax revenue from taxpayers. They may also allow two types of benefit to be perceived: not only the environmental gains from the environmental tax, but also gains from reducing revenues that have to be derived from existing taxes, that may be damaging or unpopular.

86. Explicit revenue-neutral packaging of environmental taxes together with offsetting reductions in existing taxes may also provide a way of dealing with some of the competitiveness issues arising from use of environmental taxes - either in terms of substance, or in terms of presentation:

- Recycling the revenues from an environmental tax on a particular sector back to the firms in that sector through reductions in other taxes that they pay may substantially eliminate the consequences for business costs and pricing of the additional environmental tax burden, and may largely eliminate any tendency for the sector's output to contract relative to other sectors. The principal adjustments that will remain will be asymmetric effects within the sector: some individual firms may gain, and others lose, from the changes in the pattern of taxation.

- In terms of presentation, revenue-neutral packaging may reduce business opposition to environmental tax measures. Indeed, if firms are affected differentially, it may generate support from those that anticipate gains from the revenue-neutral package.

87. The Swedish NO_x charge provides an example of an environmental tax levied on a relatively small group of firms, and accompanied by revenue-neutral return of revenues to these taxpayers as a group. Payments of tax are based on measured emissions, and the revenue collected is returned to the firms as a group, with the payments to individual firms based on output (the amount of energy each firm produces). The net effect is then very similar to that of an emissions trading system, with an output-based allocation of allowances, as discussed in Section 3.3 above. Firms with a high ratio of emissions to output are not fully compensated for the pollution tax they pay, while those with a low emissions-to-output ratio gain more from the revenue return than they pay in emissions tax. What is crucial, of course, to preserving the environmental incentive when revenues are returned to taxpayers is that the revenue return should be made on a basis that does not reflect emissions levels.

88. However, in addition to its practical and presentational attractions, revenue-recycling at the sectoral level, or to industry as a whole, involves a number of dangers.

- It may reduce the amount of pollution abatement achieved, especially in cases where there are few opportunities for pollution reduction through changes in production technology within a sector, and where the main way in which the sector can reduce pollution is by reducing output. In this case, higher output prices would be one of the main mechanisms through which an environmental tax would reduce pollution, and recycling revenue in a way that allowed the sector to maintain prices unchanged would forego a significant part of the environmental benefit.

- Contraction of a "dirty" sector may be one of the mechanisms by which environmental damage is reduced, and revenue-recycling may inhibit this. How far this is a problem will depend partly on the basis on which revenue is returned. For efficiency, firms which shut down should continue to retain their entitlement to revenue return in perpetuity, but this may frequently be difficult to sustain.

- It may require reductions to be made in taxes which are relatively-efficient revenue-raising instruments, and may therefore fail to maximise the efficiency savings from the tax reductions.

- The basis on which revenues are returned to taxpaying firms may be distortionary. As with the free allocation of emissions trading allowances, firms may change their behaviour in anticipation of the return of revenues, with the aim of maximizing their entitlement. Problems may also arise if the revenue return basis needs to be re-based periodically. Again, there are incentives for firms to behave in ways that maximise their entitlement to future receipts.

3.4.2 Sectoral exemptions and tax reductions: issues

89. With environmental taxes, a different route has generally been taken to neutralise effects on competitiveness - based on sectoral exemptions and tax reductions. This approach raises issues both of economic efficiency and of political economy.

90. Looking at the efficiency issues, sectoral exemptions or tax reductions have advantages and disadvantages compared with universal grandfathering as a way of offsetting competitiveness impacts. The principal advantage is that sectoral exemptions or tax reductions should be able to achieve better targeting to the most exposed sectors, with lower revenue costs than universal grandfathering. The drawback of this approach is that sectoral exemptions create uneven abatement incentives across sectors, risking abatement inefficiency.

91. The political economy issues raised by sectoral tax exemptions or reductions arise because of the advantages that are conferred on the sectors benefiting from these measures, as compared with sectors that do not qualify. As with the free allocation of emissions trading allowances, significant resources are likely to be consumed in socially-unproductive, but privately-profitable, lobbying to influence the scope of the tax exemptions or reductions. Costs will be incurred by business in trying to influence the form of the arrangements, and by government in resisting self-interested lobbying. Once sectoral tax exemptions or reductions are in place, moreover, their value to the beneficiaries is likely to make it very difficult to reverse or change the arrangements. Trade policy in general shows many examples of the extraordinary durability of sectoral trade protection measures, even whether they were originally introduced on a temporary basis.

92. Against the backdrop of these economic efficiency and political economy considerations, the following four questions address some principal issues in the design of arrangements to offset international competitive pressures through sectoral exemptions or tax reduction.

1. Which sectors should the arrangements cover?

93. In principle, if the aim of sectoral tax exemptions/reductions is to minimise adverse effects arising from international competition from sources not subject to equivalent environmental taxes, then the sectors to which these exemptions apply should be those most exposed to this international competition. This will depend on the extent of actual and potential trade (imposts and/or exports) and on the nature of the market (competitive pressures will be stronger in markets for price-sensitive homogeneous commodities than for differentiated goods where price is only one of many attributes affecting sales). It will also depend on the significance of the environmental tax as a cost element. This will typically mean that exemptions will be given to the most pollution-intensive sectors, either reducing the effectiveness of the environmental tax and/or requiring large increases in the rates of tax applying emissions by to non-exempt sectors in order to meet overall environmental goals.

94. The choice of sectors will raise difficult practical issues about where to draw the boundary between sectors. Defining a defensible boundary between tax categories is a familiar problem in sales taxation (*e.g.* between goods subject to VAT at different rates), and can lead to protracted and costly litigation by individual firms. In the arrangements for reduced rates of the UK Climate Change Levy, the sectors chosen were selected on the basis of an existing regulatory definition, primarily because using an existing definition was easier and less-vulnerable to lobbying than a new, purpose-built definition.

95. Further difficult practical issues arise about how to handle firms with multiple outputs, some of which are in exempt sectors and others which should bear the full rate of tax. It may not always be possible, either in practice or in principle, to divide the costs of a firm between different output categories.

2. Should the chosen sectors be exempt from the environmental tax, or pay a lower rate?

96. Either choice involves inefficient abatement incentives compared with the first-best policy (and compared with the effect of regulating through emissions trading). Levying the tax at a non-zero lower rate, rather than exempting sectors completely, has the merit that it raises some revenue, and retains some incentive for abatement (albeit weak). It is unlikely that competitive pressures would be so severe that exemption is essential, and, indeed, the exchange rate adjustments that would follow the introduction of an environmental tax would partly offset competitive pressures on all sectors. On the other hand, the higher administrative costs of levying the tax at a low rate rather that exempting sectors entirely may outweigh the modest revenue and environmental benefits of levying the environmental tax at a low rate. Exemption may preferred because it is cheaper to run.

3. Should any exemptions be formally time-limited?

97. The case for sectoral tax exemptions or reductions is primarily an adjustment case, and the argument for indefinite protection of firms in exposed sectors is weaker. Formally time-limiting any sectoral tax exemptions or reductions could reduce the risk that they last beyond the point that adjustment assistance is needed, and that they encourage continued or new investment in the protected sectors.

4. How – if at all – should exempt sectors be regulated?

98. Alternative regulation, not involving tax payments, might be applied to sectors benefiting from sectoral tax exemptions or reductions. This would help to reduce the abatement inefficiency that would result if abatement is confined to non-exempt sectors.

99. An example where explicit alternative regulation is applied to sectors paying an environmental tax at a lower rate can be seen in the discussion of the UK Climate Change Programme in Section 5.1. This requires sectors to make quantitative commitments to emissions reductions in the form of sectoral Climate Change Agreements (Voluntary Agreements), in order to qualify for an 80 per cent reduction in the applicable rate of energy tax (Climate Change Levy).

4. Instruments in Combination

There is a widespread tendency in environmental policy to employ market mechanisms as part of a mix of instruments, and rarely - if ever - for market mechanisms to constitute the sole regulatory approach. There a number of reasons for this, including the environmental complexity of problems, the better targeting that can be achieved using multiple instruments (e.g. to get closer to optimal outcomes under conditions of uncertainty, to reduce risks of geographical "hot spots", etc), and the reduction in cost that can be achieved by limiting the most sophisticated regulation to a small number of large polluters. A range of non-environmental reasons (income distribution, stakeholder pressure, etc) may also limit the use of instruments such as taxes, and may motivate policy packages combining different forms of regulation (Section 4.1). Because of their economic similarity it is perhaps surprising that taxes and emissions trading have sometimes been used together to address the same problem. However, there could be reasons for this. One well-known reason is to provide economic and environmental "safety valves" in the operation of a trading regime (4.2). Apart from this, however, the economic interactions of taxes and trading need to be considered carefully; a tax may simply affect allowance prices, without having any effect on emissions if these are already capped (4.3). Examples where taxes and emissions trading are combined include the two UK case studies discussed in Section 5.

4.1 Combined use of TPs and other instruments

100. Much of the theory of environmental policy considers policy instruments as alternatives, rather than complements. There is good reason for this. Parallel operation of multiple instruments might be undesirable for a number of possible reasons. It may, for example, be:

- wasteful (if employing two instruments doubles the administrative and compliance costs borne by government and regulated firms), or
- inefficient (if other instruments inhibit the efficient reallocation of pollution abatement that tradable permits should encourage), or
- unnecessary (if only one instrument actually "bites").

101. In practice, however, combinations of instruments are frequently employed (OECD, 2007), with new instruments supplementing - rather than replacing - the existing mechanisms of regulation. There are a number of reasons for this.

102. Some of these reasons reflect real-world complications not present in the theory - for example, the multi-dimensional nature of many pollution problems, which means that the availability of multiple instruments can allow more precisely-targeted and effective regulation (OECD, 2007).

103. Other reasons reflect powerful forces shaping the policy process, which have the effect that the accretion of additional instruments occurs more readily than abolition-and-replacement (Smith, 1999).

- There may be uncertainty about the outcome of new approaches to regulation. It may be less risky to proceed incrementally, adding new instruments to an existing portfolio. In this approach, the combination of instruments may be temporary rather than permanent. Once the new policy instrument has confirmed its effectiveness, the instrument portfolio can be rationalised, weeding out those instruments which are less effective, in favour of concentration on those which have the greatest advantages. It is possible that this sequence could, and should, be followed in the case of tradable permit applications. Once sceptical public opinion has been reassured that tradable permits can indeed ensure adequate pollution control, it may be possible to remove remaining command-and-control legislation, and it may also be very desirable to do so if this earlier legislation prevents the full benefits of the tradable permit system being realised.

- A role may also be played by "stakeholders" in the existing regulatory process who have an interest in the retention of existing forms of regulation, and who can lobby to prevent rationalisation taking place. Much of what "command-and-control" regulators have to do, in the way of negotiating the emission limits or technology requirements with individual firms, is unnecessary when pollution control is based on tradable permits, and much of the power they possess is undermined when market forces, rather than officials, determine the pattern of pollution abatement. It would be unrealistic to think that the people involved in these aspects of the existing system would be happy to see their influence diminished, and that they would not seek reasons to prevent the rationalisation of pollution control policy based on the retention of only the most effective instruments.

104. These "policy process" arguments probably have most force as an explanation of the tendency for some of the forms of traditional "command and control" regulation in parallel with new market mechanisms such as environmental taxes or emissions trading. There are less likely to explain the reason that on occasion environmental taxes and emissions trading regimes are encountered in parallel, addressing

the same, or closely-similar problems. As with other instrument combinations, parallel use of taxes and emissions trading carries the risk of excess cost for all concerned (administration costs for government, compliance costs for regulated firms). It risks inefficiency, if the instruments conflict in their operation. And there is a significant risk of redundancy with combinations of taxes and emissions trading. As discussed below, in Section 4.3, the effect of a tax which exactly overlaps an emissions trading scheme will simply be to reduce the allowance price, leaving the incentive for pollution abatement - and hence the environmental impact – unchanged.

105. Nevertheless, it is possible to identify circumstances in which the permanent joint use of two or more policy instruments might be preferable to the selection of the single, most effective, instrument (Smith, 1999). Most of these in principle could apply to combinations of environmental taxes and emissions trading.

4.1.1 To provide a "safety valve" in conditions of uncertainty

106. One widely-discussed argument for using tradable permits in combination with another pollution control instrument is the "safety-valve" argument advanced by Roberts and Spence (1976). In their scheme, tradable permits would be supplemented with elements of price-based regulation, in effect taking the form of supplementary emissions charges for "excess" pollution, and pollution-reduction subsidies for "super-abatement". This mechanism is discussed further in Section 4.2 below.

4.1.2 To spread enforcement risk across multiple, separately-enforced, instruments

107. Parallel operation of two different policy instruments directed at the same problem will not always incur unnecessary costs of administration, enforcement and compliance. Certainly, it is possible that there will be wasteful duplication, and the use of two instruments will mean that these dead-weight costs of policy are unnecessarily magnified. However, this will not always be so, and will depend on how the various costs of administration and enforcement relate to the "stringency" of policy.

108. The costs of administration and enforcement of any policy instrument would be expected to be higher, the more demanding the standard of environmental protection which the policy aims to achieve. Compliance is likely with little effort, and at little administrative and enforcement cost, if the policy tries to achieve only a very small change in polluter behaviour. Compliance will be much harder to achieve, and the costs of administration and enforcement correspondingly higher, if the policy aims to require major modifications in polluter behaviour, involving large abatement costs. In this situation, some polluters may be inclined to try to evade the requirements of policy, and to conceal their non-compliance, since the potential penalties from being caught and fined may be much less than the saving in abatement costs through non-compliance.

109. It is conceivable that the costs of administration and enforcement could rise more than in proportion to the "stringency" of policy. Instruments which are "under pressure" from polluters who would stand to make large savings from non-compliance, may be much more costly than the same instruments aiming at a lower level of abatement. If this non-linearity in administration and enforcement costs is sufficiently severe, it may be less costly to achieve a given abatement level by spreading the burden of policy across two instruments than by loading the policy entirely onto a single instrument.

110. A critical consideration here will be the informational independence of the two instruments: is their enforcement dependent on the same monitoring information? If so, polluters may be able to avoid compliance with both instruments through (costly or risky) efforts to "fiddle the figures" in relation to this required information. Only if the operation of the two instruments is dependent on different information

(*e.g.* on compliance with required technologies, and on emissions levels), is it likely that there would be benefits to spreading a policy intervention across multiple instruments.

4.1.3 To limit geographical "hot spots"

111. Joint use of more than one instrument may be appropriate where unrestricted use of a market-based approach might lead to undesirable geographical redistribution through trading, creating "hot spots" with very high levels of pollution damage. This may be undesirable from the perspective of equity, and uneven pollution may also generate even greater unevenness in environmental damage if pollution damage is non-linear in emissions (so that a tonne of emissions causes greater additional damage in an already-polluted area, than in an area where pollution is lower. Combining a general system of emissions trading, with additional taxes (or some types of regulation) in locations where emissions are most damaging, may provide a way to limit geographical concentration of pollution while allowing many of the efficiency gains from market mechanisms to be achieved.

4.1.4 Where neither instrument can be perfectly targeted

112. Use of more than one instrument may also be desirable where none of the available instruments can be precisely targeted to the exact environmental externality. An example drawn from urban traffic policy may illustrate the point.

113. For various political or technical reasons the ideal instrument to deal with urban road congestion, the introduction of exact time-of-day congestion pricing, may not be feasible. None of the available alternatives, however, provides a very close substitute in discouraging urban congestion, if used on its own. Discouraging urban congestion by increasing petrol taxes, for example, hits rural road use too, and urban road use at less-congested times of day, as much as it affects peak-hour urban traffic. Using petrol taxes alone to discourage urban congestion would be inefficient, but they may have a role to play as part of a package using multiple instruments. If the ideal instrument, time-of-day congestion pricing, cannot be used, the next-best approach may be to combine a petrol tax with other instruments, which could include various forms of tradable permit (e.g. to regulate on-street or workplace parking). Taken together these may perform better than either instrument alone.

4.1.5 Where the responsiveness of polluters varies

114. A further argument for operating multiple instruments in parallel may be that the effects of different instruments may vary across polluters. Some polluters may be relatively-insensitive to financial incentive mechanisms (if, for example, their internal organisation separates tax payment functions from technology decisions). Such organisational separation may be rational, and efficient from the point of view of the enterprise as a whole, since it may lead to an efficient division of labour with respect to the most important decisions facing the firm. However, it does have the drawback that such a firm may be insensitive to the financial incentives created by environmental taxes and charges that are small relative to other business costs. Whilst other firms may respond efficiently to such incentives, the pollution decisions of a firm organised in this way may be more efficiently controlled through direct quantitative controls, but for efficiency reasons there is no reason to prevent these being tradable. The internal decision-making structure of a firm may well respond very differently to taxes and to tradable emissions permits.

Box 4.1 Instrument combinations as a solution to the cost of regulating small firms: three examples.

International practice includes a number of examples where firms of different sizes are regulated using instruments of different types.

The NO_x charge in Sweden

The nitrogen oxides charge in Sweden, introduced in 1992, was confined to a relatively small number of large emissions sources, where the high costs of emissions measurement costs could conceivably be justified by abatement cost savings. The tax is based on measured NOx emissions by large industrial combustion plants and boilers; the cheaper option of taxing input fuel use would have been inefficient because there is no stable relationship between input characteristics or activity levels and the amount of NOx emitted. The costs of emissions measurement per source include one-off equipment costs of approx SKr 250,000 – 300,000 (Euro 30,000 – 36,000), and annual costs of measurement and inspection of some SKr 100,000 (Euro 12,000) per plant (SEPA, 2000). Around 250 plants are covered by the charge, accounting for some 40 per cent of energy sector NOx emissions in Sweden. Smaller firms are subject to non-incentive regulation.

To avoid distorting competition between the large plants within the scheme and smaller plants below the 25 GWh per year charging threshold, the revenues raised from the charge are returned to the participating firms, in proportion to their final energy output. Overall scheme thus has a revenue-neutral impact, on average, on the firms within the system. Sources with high emissions relative to their energy output are net payers to the scheme, while sources with low emissions relative to energy output are net recipients. Despite this revenue-neutrality, there is some evidence of tax-induced distortions in activity close to the qualifying output threshold for the system; a significant "cluster" of plants appear to be maintaining output just below the level at which they would have to participate in the scheme (SMENR, 1994).

Water pollution charges in the Netherlands

In the Netherlands the 1969 Act on Pollution of Surface Water (Wet verontreiniging oppervlaktewater, WVO) established a regulatory system of discharge licences, and a system of water charges paid by both households and firms to finance the costs of water treatment. For firms, the system is applied on a different basis to three categories. Small companies pay a fixed rate. The largest firms pay charges which are based on measurements of the quantity and concentration of emissions. Companies of intermediate size normally pay the levy according to a schedule which takes into account the number of employees, the type of activity, and consumption of water and raw materials, but have the option to choose direct measurement in place of the schedule-based charge.

The high initial fixed cost of continuous emissions measurement (approx € 100 000), explains the limited scope of direct measurement. As a result, the incentive effect of the charge is limited to the large firms, where the potential efficiency savings from the use of a market mechanism might be enough to warrant the costs of measurement. The charges levied on small firms may reduce the risk of competitive distortion between firms of different sizes, but provide no emissions-reduction incentive (since abatement does not reduce the firm's charge liability). Emissions reductions by these firms are promoted using other forms of regulation.

Phase 1 of the US Acid Rain Program

The US Acid Rain Program, a "cap-and-trade" system, was set up under Title IV of the 1990 amendments to the Clean Air Act. It is directed at emissions of SO_2 from coal- and oil-fired electricity generation plants, and was implemented in two phases. Phase I, covering the period 1995-1999, required aggregate emissions reductions of around 3.5 million tons per year from the 263 generating units with the greatest emissions (the so-called "Table A" units), while Phase II, starting in 2000, extended the scope of the aggregate cap on SO_2 emissions to all coal-fired and oil-fired electric power plants above 25 MW capacity. The detailed evaluation of the scheme by Ellerman et al. (2000) notes its success in facilitating sharp emission reductions, and at providing operators with extensive cost-reducing flexibility. An efficient and active competitive market for allowances developed quickly, and proved robust to quite significant unanticipated developments in abatement costs and market conditions.

During Phase 1, when the system applied only to the largest emissions sources, "substitution" provisions allowed operators to substitute other generating units in place of the designated Table A units. Ellerman et al. are critical of these provisions, pointing out that a major driver of the decision to substitute appears to have been the basis on which allowances were to be allocated to the substitute units. The units chosen for substitution tended to be those which would benefit from overgenerous allowance allocations, rather than those with the most scope for reducing abatement costs, and units may have been selected for "voluntary" inclusion which were due to make emissions reductions anyway. The net effect of these substitution provisions was to weaken the incentives for abatement, and the authors argue that this experience suggests that such "opt-in" provisions should therefore be considered very carefully before being imitated in other applications.

4.1.6 To regulate firms of different sizes

115. An important group of circumstances in which it may be appropriate for environmental policy instruments of different types to be operated in parallel is where the optimal instrument choice varies for firms of different sizes. For example, if there are large fixed costs of emissions measurement and compliance monitoring at the level of the individual firm, then it may be most efficient to regulate small and large firms using different instruments. For large firms, the potential efficiency gains from precise targeting of abatement incentives may be large relative to the costs of firm-level emissions measurement. It may therefore be cost-effective to employ emissions trading, based on direct emissions measurement, to regulate these firms. For smaller firms, however, the efficiency savings from regulatory flexibility may be too small to warrant the cost of firm-level emissions monitoring, and it may be more efficient to employ methods of regulation which have lower administrative and enforcement costs, such as for example, an environmental tax on inputs or outputs associated with pollution. Three examples of actual policy are described in Box 4.1.

4.1.7 To offset distributional or competitiveness problems

116. The extent to which environmental policy can operate solely through the use of environmental taxes, charges or tradable permits may in practice be limited by the (actual or perceived) distributional or competitiveness effects of these instruments. This is most likely to be a problem with revenue-raising instruments, such as taxes, charges and auctioned permits, because the pattern of tax, charge or permit payments on residual units of pollution may be a significant additional cost for some polluters, over and above the abatement costs involved in reducing emissions. The use of revenue-raising market mechanisms in the energy sector, for example, is likely to lead to large additional costs for both businesses and households, reflecting the importance of energy as a business input and in household consumption, and reflecting the low price elasticities of energy demand. Concerns about the possible effects of carbon tax payments on the competitive position of energy-intensive sectors of industry, and on the welfare of poorer households, have been prominent in the policy debate in a number of countries. In some cases these concerns have prevented such measures being adopted. But in other cases, they have limited the politically-feasible carbon tax to a low level, requiring a major part of total abatement required to be pursued using other instruments alongside the carbon tax. (These issues are discussed further in OECD, 2006.)

4.2 Combined use of taxes and TPs to deal with uncertainty

117. As noted in Section 2.2 above, where abatement costs are uncertain, an instrument such as emissions trading that directly regulates the overall quantity of emissions may have a different outcome from that achieved by an instrument that regulates emissions through imposition of a price signal such as a charge per unit of emissions. Emissions trading can guarantee that polluting emissions will not exceed a certain level (given by the number of permits issued), while by contrast, the environmental impact of an emissions charge set at a particular level depends on the responsiveness of polluters. If abatement costs are higher than anticipated, some polluters will choose to pay the charge if regulated by an emissions charge, while with emissions trading, the effect of higher abatement costs will be felt in the allowance price rather than in the quantity of abatement.

118. It is important to recognise that in this situation, neither instrument achieves the efficient level of abatement, viewed in the light of the actual costs of abatement. Both instruments have disadvantages, one in terms of excessively-costly pollution abatement which cannot be justified by the pollution damage avoided, the other in the form of inadequate pollution control, leading to excessive pollution damage that could have been avoided cost-effectively through greater abatement. Emissions charges place an upper limit on the abatement costs per unit of pollution that will be incurred, but have an uncertain outcome in terms of pollution quantities. Tradable permits, on the other hand, achieve a guaranteed effect on

emissions, but at the price of correspondingly greater uncertainty about the abatement costs that will have to be incurred.

119. If a choice has to be made between the two instruments, then the instrument that is preferable will depend on the characteristics of both abatement costs and pollution damage in the particular application. Cases where abatement costs are sharply rising with additional pollution control will tend to favour "price-based" regulation such as an emissions charge, which will prevent firms finding themselves facing the risk of undertaking unexpectedly-costly abatement measures. Cases where pollution damage rises sharply with additional pollution will, by contrast, tend to favour the employment of "quantity-based" regulation such as tradable permits.

120. However, it may be that in these conditions of uncertainty about polluters' abatement costs a better outcome can be achieved by using both instruments together than by reliance on tradable permits or an emissions charge alone. The Roberts and Spence scheme combines tradable permits with provisions for repurchase of permits if their price falls below a certain floor, or additional supply of permits if the price of the initial quantity offered exceeds a certain upper threshold. The effect of this is to limit the feasible range of permit prices that would be experienced, and hence to limit the exposure of polluters either to excessively high abatement costs, in excess of the environmental benefits, or the exposure of the environment to an inflexible pollution target, when it becomes clear that further abatement could in fact be achieved very cheaply. Within a "central" range, therefore, the scheme guarantees that a particular pollution abatement quantity will be achieved, but it allows for some relaxation of this guarantee where circumstances are such that achieving this quantity would either impose excessive burdens on polluters, or where sticking to the initial abatement target would forego opportunities for further cheap and cost-effective abatement.

121. The "safety valves" discussed by Roberts and Spence could be implemented within the context of an emissions trading scheme as upper and lower price thresholds, at which the regulatory authority would be willing to supply additional allowances, or to repurchase surplus allowances, if asked to do so. Alternatively other instruments, implemented in parallel with emissions trading, could be used to supply the element of price-based regulation which allows polluters to escape from the otherwise rigid quantity constraint of the emissions cap.

122. An emissions tax, set at a low-ish level, might act as a floor to price incentive for abatement. Since the allowance price cannot fall below zero, the emissions tax will then provide a constant marginal abatement incentive, placing what a positive floor to the marginal abatement incentive. (If the emissions tax applies to all firms in the emissions trading system, it will reduce the allowance price by the amount of the tax; the lower threshold thus comes into play when the allowance price reaches zero).

123. Likewise it is sometimes suggested that appropriate design of non-compliance penalties could act as an upper "safety valve", akin to that proposed by Roberts and Spence. If the allowance price rises above the penalty per unit of excess abatement, polluters could opt to pay the penalty instead. Clearly, for this to function as the kind of safety valve envisaged by Roberts and Spence, the penalty must not be a function of the allowance price. In some actual applications, the penalty for non-compliance is implicitly related to the allowance price, for example by requiring non-compliant firms to surrender additional allowances in subsequent periods in addition to a fixed fine.

4.3 Combined use of taxes and TPs: effects on allowance prices

124. Given the close similarity between emissions taxes and emissions trading discussed in Section 2.2, it should be expected that the market prices of emissions allowances will be directly affected by environmental taxes applied to the same emissions or to closely-related transactions. Typically, where

environmentally-related taxes apply to the same emissions that are the subject of an emissions trading scheme, or to a transaction base closely-related to these emissions, this will have the effect of reducing the allowance price.

4.3.1 Co-extensive tax and trading

125. The most clear-cut case to consider is where all emissions regulated by a cap-and-trade emissions trading system are also subject to an emissions tax. The two systems, in other words, are "co-extensive".

- If the tax is low relative to the permit price that would rule in the absence of the tax, the allowance price would be reduced dollar-for-dollar by the amount of the tax. The reason for this can be seen by considering that the allowance price is determined by the value of the marginal allowance (*i.e.* the last allowance before the constraint set by the emissions cap). In the absence of any emissions tax, holding this allowance has a value given by the marginal abatement cost that would otherwise have to be incurred. With an emissions tax, however, the saving that can be made by holding the allowance is lower; while the firm avoids the marginal abatement cost for that unit of emissions, it is required to pay the emissions tax on any residual units of emissions. hence the saving that can be made by holding an allowance is now the difference between the marginal abatement cost at the constrain set by the cap and the tax per unit of emissions.

- If the tax rate is higher than the allowance price that would be observed in the absence of the tax, emissions will fall below the cap, and the permit price will fall to zero. In effect, the emissions cap no longer binds, and allowances have no value. What determines the level of emissions is simply polluter responses to the tax, and the emissions trading scheme is superfluous.

126. An example of an environmental tax and a system of tradable allowances applying to emissions also subject to the tax is the UK landfill tax and the parallel LATS scheme of tradable landfill allowances for biodegradable waste. The landfill use regulated by LATS is also subject to the tax, and the value of landfill allowances in LATS (currently some GBP 20) is lower than it would be if there were no landfill tax, by the amount of the landfill tax per tonne (which will average some GBP 30 per tonne over the period covered by the trading scheme). The effect of the tax is not to add to the abatement incentive given by the LATS allowance price, and much the same average incentive for reduced landfill use as LATS provides could instead have been achieved by increasing the landfill tax by GBP 20 per tonne. The key difference, which explains the introduction of LATS in parallel to the existing landfill tax is that LATS has greater prospect of achieving quantity certainty in landfill use, a key policy goal for the UK, given the landfill quantity targets set in the EU Landfill Directive.

4.3.2 Taxing some, but not all, emissions within a cap and trade system

127. Less clear-cut relationships between taxes and emissions trading arise where some, but not all, of the emissions covered by a trading scheme are also subject to an environmental tax. A practical example would be the case of national carbon taxes and EU emissions trading. The national carbon tax would apply only to the emissions of one country, and not to other emissions elsewhere in the EU.

128. If the tax rate is low, and the proportion of the capped emissions covered by the tax is small, the tax will have a negligible effect on permit prices. With a higher tax rate, or a higher proportion of emissions covered by the tax, the tax may partly reduce the allowance price, by reducing emissions from sources subject to the tax, and hence increasing the availability of allowances for other sources. As the proportion of emissions covered by the tax increases, this case tends towards case (i) above, where the tax and trading are co-extensive, and hence tends towards the limiting case where the market price of allowances is exactly reduced by the amount of the tax.

129. Another set of circumstances where this logic would apply is where the definitions of the tax base and quota cap differ. This would generally be the case where environmentally-related taxes are based on transactions rather than directly-measured emissions, if measured emissions are used as the basis for trading (although efficient, well-linked environmentally-related taxes on goods and services will be levied on a base which is a reasonably close proxy for actual emissions. In this situation the combined system would depart from case (i) to the extent that it is possible to reduce abatement without incurring additional tax liability.

4.4 Use of taxes to recover excess profits under grandfathered TPs

130. As discussed above, one of the effects of grandfathering emissions trading allowances is to confer windfall profits on the firms to which allowances are allocated, to the extent that they are able to cut emissions at lower abatement cost that the allowance price, and/or to the extent to which their selling prices rise to reflect the impact of allowances on the marginal cost of production.

131. The results discussed in Section 4.3 suggest that it would be possible to recover some of the excess profits given to firms through allowance grandfathering by introducing an emissions tax on a base which closely proxies the use of allowances. Then the value of allowances will fall by the amount of the tax, as in case (i) in Section 4.3, and consequently this part of the value of allowances will be recovered by the authorities. (A similar effect could be achieved by auctioning some proportion of the allowances.)

5. Case Studies

132. Since the 1980s, UK environmental policy has, at least in principle, been favourably disposed towards the case for employing market mechanisms. A clear statement of the potential contribution that could be made by "market mechanisms" in environmental policy was included in the 1990 environment White Paper, "This Common Inheritance" (Department of the Environment, 1990) and subsequently reiterated in other DoE and Treasury documents (Jordan *et al.*, 2003).

133. From the mid-1990s onwards, both Conservative and Labour Chancellors of the Exchequer have included environmental tax measures within annual budget proposals (Leicester, 2006). New environmental taxes introduced in the UK have included three new national environmental taxes, on landfill (Davies and Doble, 2004), industrial energy use (the Climate Change Levy[3]) and the extraction of aggregates. The transport authority in London has introduced a congestion charge for vehicle use in the central area (Santos and Fraser, 2006; Leape, 2006). Taxes on motor fuels and the annual vehicle excise duty have both been restructured, with differential rates reflecting the different environmental attributes of fuels and vehicles. In addition to these explicitly environmental tax measures, a wider range of areas of tax policy-making routinely include some discussion of environmental issues.

134. The UK has also introduced a number of "tradable permit" instruments. The most high-profile of these has been the UK Emissions Trading Scheme for carbon (discussed in Section 5.1 below). Two other tradable-permit-type mechanisms in the energy sector are tradable compliance certificates ("ROCs") under the Renewables Obligation, which aims to stimulate electricity generation from renewable sources, and Energy Efficiency Certificates (EECs) which fulfill a similar function in stimulating demand-side management measures by power companies (Sorrell, 2003). The UK also has two waste management applications of tradable permits (Salmons, 2002), tradable "Packaging Recovery Notes" (PRNs) for compliance with packaging waste recovery obligations, and the Landfill Allowance Trading Scheme (LATS) discussed further in Section 5.2 below, to regulate the use of landfill disposal for biodegradable municipal waste.

---

3 OECD (2005b).

135. This section looks at two areas where the UK has employed emissions trading and an environmentally-related tax in combination. Section 5.1 considers the relationship between the UK emissions trading scheme for greenhouse gas emissions and the Climate Change Levy, an environmental tax on industrial energy use. Here the tax and trading form part of a complex and interlocking instrument combination (also including sectoral voluntary agreements), in which it is difficult to assess the impact of any single component in isolation from the others. Section 5.2 considers the parallel use of both a landfill tax and a system of tradable landfill allowances. Both regulate very similar aspects of the same environmental problem, the use of landfill for waste disposal. The reason for the introduction of landfill allowance trading, when the UK already had a long-standing landfill tax at a significant level, has to do with the overriding priority that has had to be given to meeting quantitative targets for reducing landfill use, set out in the EU Landfill Directive.

5.1 Instrument mix in the UK Climate Change Programme

136. Under the Kyoto Protocol the EU has accepted a commitment to reduce greenhouse gas emissions by 8 per cent by 2008-2012, as measured against a baseline of the 1990 emissions level. Within this overall 8 per cent EU abatement target, the United Kingdom is required to achieve a 12.5 per cent emissions reduction. In addition, however, the UK has unilaterally stated a policy goal of reducing CO_2 emissions to 20% below 1990 levels by 2010.

137. In late 1998 a government study on the scope for using economic instruments to reduce energy use and emissions of greenhouse gases by the industrial and commercial sectors recommended a "mixed approach", combining existing forms of regulation with economic instruments to provide clear signals for longer-term emissions reductions (Marshall Report, 1998). The subsequent policy development process, in which industry stakeholders played a major role, resulted in the UK's Climate Change Programme (DETR, 2000). This implements a package of measures designed to achieve the UK's Kyoto commitments, and the subsequent tougher unilateral UK abatement target. The programme makes use of three different economic instruments, which have interlocking functions:

- the Climate Change Levy (CCL), an environmental tax
- negotiated sectoral Climate Change Agreements
- the UK Emissions Trading Scheme

5.1.1 The Climate Change Levy

138. The Climate Change Levy was announced in the 1999 Budget, and took effect from April 2001. It is a single-stage excise, imposed at the time of supply to energy users in industry, the public sector and agriculture, at varying tax rates per unit of energy, depending on the fuel type. Fuels supplied for transport, for non-fuel uses, for electricity generation and to the household sector are exempted from the tax. The tax is applied to gas, coal, non-transport LPG and electricity, at the rates per unit of energy shown in Table 5.1; these rates remained unchanged from the introduction of the tax until 2007. There are exemptions from the tax for energy generated in "good quality" CHP (combined heat and power) plants, for fuels derived from waste, and for renewable energy sources such as wind and solar power.

Table 5.1 UK Climate Change Levy: tax rates for different fuels, and rates of "implicit" carbon tax

	Tax rate (pence per kWh)	Implicit tax rate per tonne of carbon content	
Gas	0.15	£30	$52
Coal	0.15	£16	$28
Liquid Petroleum Gas (LPG)	0.07	£11	$19
Electricity	0.43	£31	$54

Note: Tax rate for LPG is defined as 0.96 pence per kg.
Source: OECD (2005b).

139. An 80% discount from the Climate Change Levy is awarded to energy-intensive sectors which have negotiated "Climate Change Agreements" with the environment department (DEFRA), under which they have taken on collective quantitative targets for improvements in energy-efficiency or carbon emissions. Initially, the energy-intensive sectors qualifying for climate change agreements, and hence for this discount, were defined on the basis of the Integrated Pollution Prevention and Control (IPPC) Directive, but eligibility has since been extended.

140. The Climate Change Levy was introduced as part of a package of measures intended to be broadly revenue-neutral, contributing no additional net revenues. Nearly all of the revenue expected to be raised from the tax (approximately GBP 1 billion in a full year) was offset by a reduction of 0.3 percentage points in the rate of employers' National Insurance Contributions. A small part of the revenues (less than 5 per cent) was initially assigned to the Carbon Trust, an organisation established to stimulate the development and adoption of low-carbon technology.

141. The evolution of this tax has shown the political difficulties of immediate introduction of large-scale environmental taxes on energy (Pearce, 2001). The political legacy of the previous government's attempt to impose standard-rate VAT on domestic energy has been that the Climate Change Levy excludes the domestic sector. This obviously foregoes the possibility of equal energy-saving incentives in the domestic and business sectors, but, less obviously, has led to some messy compromises in the design of the tax, requiring it to be imposed nearer the point at which energy is sold to final users, so that the domestic sector can be exempted. Fear of the impact that a tax on carbon content might have on the coal industry has led the government to choose energy content, rather than carbon content as the base for the tax, thus foregoing the possibility that carbon emissions could be reduced through fuel-switching incentives. Concern about the impact of the tax on the competitiveness of energy-intensive sectors led to arrangements that give these sectors a large reduction in the levy, in return for sectoral negotiated agreements to achieve equivalent improvements in energy efficiency. This again complicates the design of the levy and reduces further the proportion of the economy experiencing the incentive effects of the tax.

5.1.2 Climate Change Agreements

142. "Climate Change Agreements" are negotiated agreements between sectoral industry organisations and the Government. More than 40 industry associations, representing some 6000 companies, have negotiated CCAs with the environment department (DEFRA), under which they have taken on collective quantitative targets for improvements in energy-efficiency or carbon emissions, in return for an 80% discount from the Climate Change Levy.

143. The agreements can, in principle, take a number of different forms. They can relate either to carbon emissions, or to energy use. In addition, they may be specified in either absolute or relative terms, in other words, as a reduction of energy use or emissions in tonnes, or as a reduction in the rate of energy use or emissions per unit of output. In practice, the overwhelming majority (39 of the original

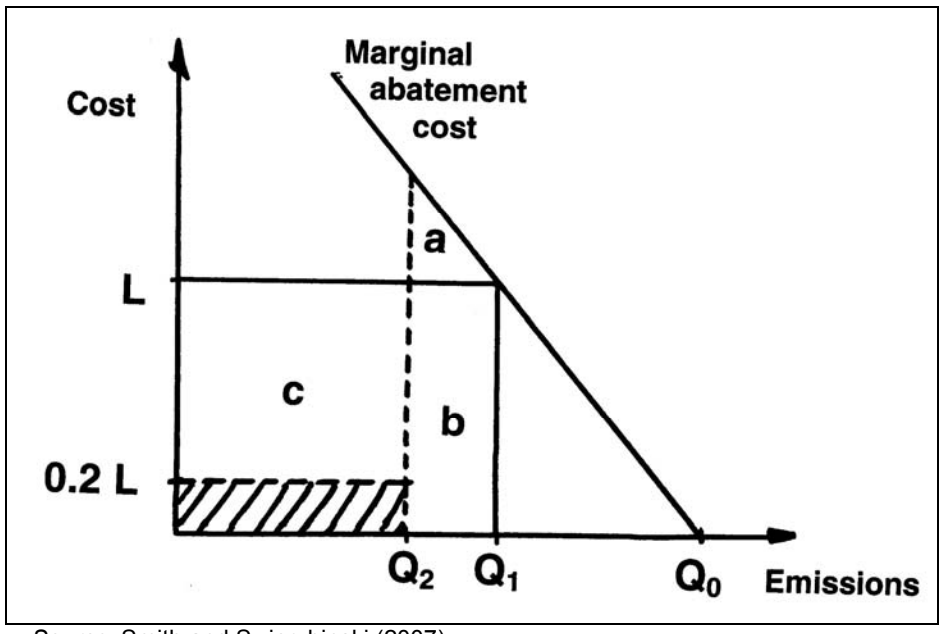
44 agreements) have set targets for energy use relative to output, in other words, have been agreements for improvements in energy efficiency. Four agreements have specified absolute targets for reduced energy use – those concerning aerospace, steel, supermarkets and wall coverings. One agreement, for the aluminium industry, set a target for emissions per unit of output. (Pearce, 2005)

144. The agreements all have a two-tier structure, specifying obligations for the sector as a whole, and translating these obligations into targets for each individual firm. Each CCA sets a final target for 2010, and interim targets for alternate years (2002, 2004, 2006 and 2008). Enforcement procedures pay attention both to the sectoral outcome, and to individual firms' responsibility for the sectoral outcome. No enforcement action is taken if the sector as a whole meets its obligations, but where the sector falls short of its target, non-compliant firms are identified and are liable to a penalty in the form of the loss of the 80 per cent Climate Change Levy discount for the subsequent two years (Dijkstra and Rübbelke, 2007).

145. What incentives were there for industrial sectors, and the firms within them, to offer additional abatement, in order to conclude a Climate Change Agreement? The benefit to the firm of such an agreement is the 80% reduction in the rates of Climate Change Levy that would otherwise be payable. The cost is the abatement required in return. In theory, the government would have considerable potential bargaining power in negotiating a deal of this sort, as Figure 5.1 shows.

146. Figure 5.1 illustrates the costs and benefits of concluding a climate change agreement from the firm's perspective. The figure represents the costs of reducing emissions or energy use by a marginal abatement cost schedule. Q0 is the level of emissions that the firm would choose in the absence of any emissions-reduction incentive, and Q1 is the emissions level that the firm would choose if subject to the Climate Change Levy at the full rate L. Emission reduction from Q0 to Q1 is worthwhile if the firm has to pay the full levy on each unit of energy used, since the marginal costs of reducing energy use and related emissions are lower than the tax rate up to Q1. Q1 should then be thought of as the baseline in negotiating a climate change agreement, because if no agreement is reached the firm will be subject to the Climate Change Levy at the full rate L, and will therefore choose point Q1. Negotiation of a climate change agreement could then ask firms to undertake additional abatement (*i.e.* move to the left of Q1) in exchange for the 80% reduction in the rate of the Climate Change Levy. From the firm's point of view a deal which required the firm to reduce emissions from Q1 to Q2 would be worthwhile so long as the additional abatement costs incurred (areas a plus b) are less than the reduction in Climate Change levy payments (areas b plus c). Area a increases with increasing emissions reductions, while area c decreases, and the net benefits of joining a climate change levy are positive up to the point where area a equals area c. In other words, although the firm would naturally prefer to receive the 80% levy discount while making no commitments to additional abatement beyond Q1, a deal which offers the firm the discount in exchange for additional abatement will be preferable to no agreement (and paying the full levy rate), so long as the additional abatement costs do not exceed the benefit from the levy discount.

Figure 5.1 The firm's incentive to reach a Climate Change Agreement



Source: Smith and Swierzbinski (2007).

147. How much additional abatement could in principle be demanded from firms in exchange for the 80% Levy discount will depend on the slope of the marginal abatement cost schedule and the level of CCL payments in the absence of any agreement. Some level of additional abatement would always be a worthwhile price for obtaining the benefit of the CCL discount, and with a linear marginal abatement cost schedule (as drawn) it would be possible to demand a substantial level of additional abatement before the gains from the CCL discount were exhausted.

148. Whether, in practice, the government has sought, or been able to achieve, anything like this level of additional abatement in exchange for the negotiated Climate Change Agreements is, however, a different matter. To begin with, there are good reasons to doubt that any government would be in a strong position to negotiate tough abatement targets with industry, given the relatively weak informational position of the government compared to the firms on the other side of the negotiation. Generally the government may be able to do little more than project past trends, as a business-as-usual baseline for the negotiations, while the industry side of the negotiation may be in a position to reveal considerably more information, if it helps their case to do so. Likewise, any empirical analysis of this question is complicated by the difficulty of defining and measuring genuinely-additional energy efficiency improvements or carbon abatement by CCA participants, in the sense of changes that would not have occurred in the absence of the agreement. There has been controversy over the extent to which targets set in climate change agreements have in practice required any significant additional action by industry (de Muizon and Glachant, 2004), although a review by the National Audit Office of the CCL and CCAs concluded that both had led to emissions savings. Not all CCAs had set demanding targets, but despite this there was evidence of genuine and significant improvements in energy efficiency in sectors covered by CCAs (National Audit Office, 2007).

149. In any event, it is clear that the rationale for the levy discount was not primarily the bargaining power that it gave government in negotiating tough climate change agreements, but a concern to avoid the substantial tax burdens on energy-intensive sectors that would have arisen if they had been subject to the full climate change levy. From this perspective the goal of the climate change agreement negotiations may have been more modest: achieving point Q1 while imposing the levy at only 20% of the full rate. This goal

would, moreover, be consistent with overall abatement efficiency. Although the CCL discount could have been used to drive a harder bargain, demanding emission reductions well below Q1 would entail a higher marginal abatement cost for firms in the CCA than in sectors subject to the full CCL, an outcome inconsistent with overall abatement cost minimisation.

5.1.3 Emissions trading

150. The third element in the Climate Change Programme was an emissions trading scheme for greenhouse gases, which was launched in April 2002. The scheme aimed to provide flexibility for individual firms in their compliance with greenhouse gas abatement obligations, so as to reduce the economic cost of achieving a given abatement total. A second, overt, objective of the emissions trading scheme was to establish the London financial markets as the global location for environmental permit trading. The scheme regulates overall emissions of the six groups of greenhouse gases covered by the Kyoto Protocol, weighted according to global warming potential. Individual emission limits defined under the scheme, and the unit used for trading, are defined in terms of tonnes of carbon dioxide equivalent (tCO_2-e).

151. There are two principal groups of potential participants in emissions trading, referred to as "direct participants" and "agreement participants".

152. Direct participants (DPs) are the 32 firms who entered the scheme as a result of an auction of subsidy payments conducted by the government in March 2002. This auction allowed any organisation to offer abatement of its UK emissions over the period 2002-6, as against baseline emissions in 1998-2000, in exchange for a subsidy per tonne. Firms entering the auction were required to commit to a specified level of abatement in 2006, and to make phased progress towards it in the intermediate years 2002-5, with the 2002 target being 20% of the 2006 target, rising to 40%, 60% and 80% in each of the subsequent years. As a result, a direct participant making a commitment to abate by 1 tonne in 2006 would be committed to a total abatement of 3 tonnes over the period 2002-6 as a whole.

153. The auction aimed to "buy" as much abatement as possible, using a fixed budget of GBP 215m. The auction was conducted using a descending clock format, with a starting price per tonne of abatement in 2006 of GBP 100. After nine auction rounds, a market-clearing price was established of GBP 53.37 per tonne of CO_2-equivalent. In exchange for a subsidy payment at this level, the DPs were assigned abatement commitments totalling 3.96 million tonnes of CO_2e (1.1 million tonnes C) in 2006, and the corresponding phased abatement obligations for the intermediate years. Once the intermediate-year commitments implied by the 2006 target are taken into account, the auction closing price of GBP 53.37 per tonne of CO_2e abatement in 2006 is equivalent to a subsidy payment of GBP 17.79 per tonne of CO_2e abatement in a single year.

154. The direct participants are subject to a cap-and-trade system of emissions trading, being allocated allowances equal to their baseline emissions, minus the contracted abatement commitment for each year. They may use trading to meet their abatement commitments, and can sell allowances in the UK ETS if their abatement exceeds the contracted level.

155. Agreement participants are the 6000 firms covered by Climate Change Agreements (CCAs). These firms can generate and sell allowances by exceeding their negotiated emission-reduction targets, or alternatively, can achieve compliance with their obligations under the agreement by purchasing permits in place of some or all of their abatement obligations. For these firms, emissions trading is effectively a baseline-and-credit system of emissions trading, and participation in trading by individual firms is wholly voluntary. In practice, about a quarter of the 6000 firms covered by CCAs have participated in emissions trading.

156. An interlocking relationship between the three market-based components of the Climate Change Programme underpins the involvement of agreement participants in the UK ETS. These firms may choose to participate in the ETS to meet compliance obligations which result from their participation in sectoral Climate Change Agreements. In turn, the primary financial motivation for industrial sectors to conclude CCAs with the government was the substantial (80%) reduction to which they were then entitled in the energy tax, the Climate Change Levy.

157. A complication to the trading scheme arises because most of the sectoral Climate Change Agreements have been defined in relative terms, in other words as targets for energy use per unit of output, while other parts of the scheme are specified in absolute terms. Trading between the absolute and relative sectors could potentially erode the effectiveness of the overall scheme in terms of control of overall emissions. Firms in the relative sector can comply with their obligation even if their emissions increase, so long as they are experiencing a sufficiently large growth in output. If such firms exceed their targets, and then sell permits to firms in the absolute sector, emissions in both sectors could potentially rise. To prevent this outcome, the scheme includes a mechanism, the "Gateway", to restrict the flow of allowances from the relative to the absolute sector. Individual sales of allowances by firms in the relative sector to firms in the absolute sector are permitted only if there is no net aggregate flow of allowances out of the relative sector into the absolute sector. In practice, the Gateway controlling the flow of allowances from the relative sector to the absolute sector has been open continuously since the scheme began, reflecting the large generation of surplus allowances through over-compliance by the direct participants.

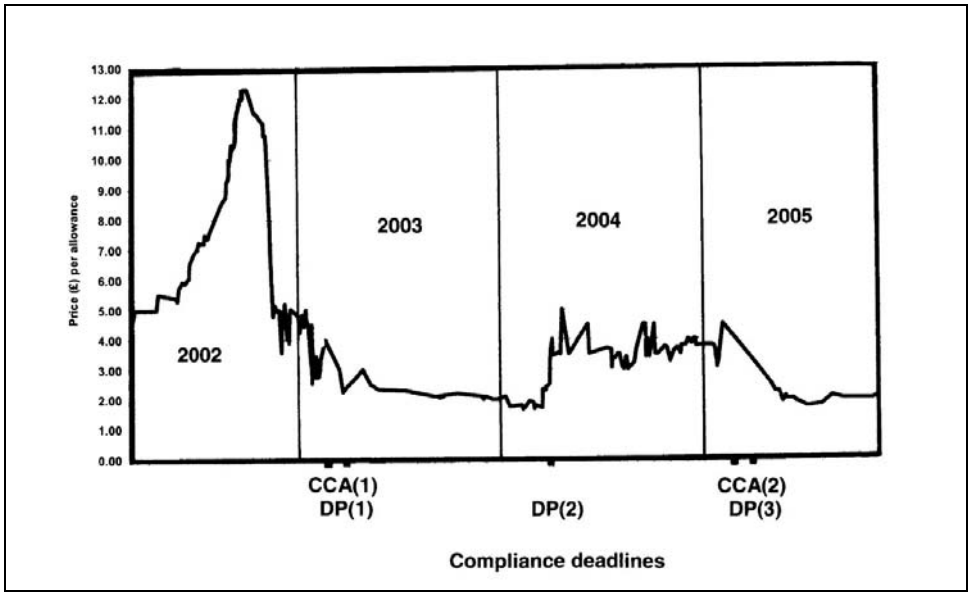
5.1.4 Trading activity and allowance prices

158. In an analysis of the publicly-available register of transactions for the first three years of the scheme, Smith and Swierzbinski (2007) find that the market has been both active and liquid. In total, there were 2420 transactions between separate firms ("external trades") between April 2002 and the end of March 2005, with a total traded volume of some 6.3 million allowances. Monthly trading volumes averaged some 176,000 per month across the three years, and exceeded 100,000 allowances in 23 of the 36 months. The number of individual transactions showed two clear peaks, with 60 per cent of all trades taking place in early 2003 and early 2005, at the end of the first and second CCA Milestone periods respectively. Most of these trades were for comparatively small numbers of allowances, as agreement participants purchased the small amounts of allowances they needed to meet their abatement shortfalls relative to their CCA targets.

159. In total, 1397 firms have participated at least once in trading (out of the 6000 or so potential traders - the 32 Direct Participants awarded allowances in the incentive auction, plus firms subject to Climate Change Agreements). The majority have been buyers of allowances, while the number of firms selling allowances is relatively small. In the first three years of the scheme, 1348 firms bought permits, while only 171 firms were recorded as making permit sales. 123 firms were active as both buyer and seller; this group includes a number of firms acting as brokers and intermediaries, typically buying large quantities, and then "retailing" smaller quantities to firms with compliance obligations.

160. From the start of trading, allowance prices were much lower than the closing price of GBP 17.79 per tonne of abatement in the March 2002 ETS auction (Figure 5.2). Market trading appears to have begun at a price of about GBP 5 per tonne in April – June 2002, about one third of the level of the GBP 17.79 auction price, rising to a peak of about GBP 12 per tonne in October 2002, and then declining sharply in November and December 2002 to about GBP 5 per tonne of CO_2e. Allowance prices then drifted downwards during the course of 2003, to about GBP 2 per tCO_2e by the end of the year, rose to around GBP 4 per tCO_2e for most of 2004, and have since fallen back to around GBP 2 per tCO_2e.

Figure 5.2 UK ETS: Evolution of spot prices for current-vintage allowances



Source: Price series provided by Natsource Europe Ltd.

161. What lies behind the price movements for UK ETS allowances? It has been argued (*e.g.* NAO, 2004) that the initial price peak reflected a shortage of allowances in the run-up to the first CCA Milestone period, because of the relatively slow pace at which allowance allocations were made to direct participants. The subsequent decline in allowance prices, to a level which probably only compensates sellers for the costs of selling, seems likely to have reflected the growing realisation among market participants that there was substantial and growing excess supply in the allowance market, as a result of over-generous allocation of allowances, coupled with much higher-than-expected abatement outturns.

5.1.5 Abatement

162. The official evaluation of the first year of ETS (DEFRA, 2003) reported that in aggregate the direct participants substantially exceeded, by a factor of almost 5, their abatement targets for the first year (set at 20% of the abatement required in 2006), achieving aggregate abatement of 4.62 $mtCO_2$-e compared with a target of 0.79 $mtCO_2$-e. Only two of the 32 direct participants fell significantly short of their 2002 target, and about a dozen exceeded their target by significant amounts. Two firms in particular accounted for a large part of the total abatement, each achieving more than one million tonnes of carbon-dioxide equivalent abatement in excess of their 2002 target. Despite the rising time profile of direct participants' abatement targets (from 20% of the 2006 target in year 1, to 40% in year 2, 60% in year 3, etc) direct participants as a group exceeded the abatement targets by a similar amount in the second and third years of the scheme.

163. In a critical report published in 2004, the National Audit Office argued that the ease with which some direct participants achieved their targets was partly due to failings in the way that baseline emissions levels (against which additional abatement is measured) were assigned to participants. The emissions of a number of DPs were already well below their baseline at the start of the scheme, and as a result they may have been able to achieve compliance without further abatement action. It was suggested that this over-generosity in the allocation of baseline emission levels may partly reflect the short timescale in which the allocations had to be made, and also may reflect the difficulty experienced in finding enough firms willing to participate in the auction.

164. Most of the additional abatement by direct participants was banked, and only a relatively small proportion was sold to CCA agreement participants for compliance purposes. The accumulated allowance bank was projected to be well over 10 $mtCO_2e$ by the end of the third year of the scheme, and much of this was likely to remain after 2006, beyond the end of the direct participants' role in the ETS. The effect of the large bank of unused allowances would be to undermine abatement incentives for CCA participants, who could continue to use ETS allowances to meet their obligations until 2010.

165. In August 2004 Defra sent a consultation document to DPs, outlining various options for reducing the size of the bank by some 15 $mtCO_2e$. Most of the options outlined included some retrospective element, such as cancelling part of the existing allowance bank; other options included limiting the tradability of some allowances, and, most dramatically, re-running the incentive auction. In response, six of the largest participants in the scheme made a counter-proposal of voluntary additional emission reductions totalling 8.9 $mtCO_2e$. This ended the threat of compulsory, and possibly retrospective, changes. However, it did not lead to any recovery in allowance prices, and this suggests that it may not have completely eliminated the excess supply of allowances. On this interpretation, the GBP 2 – GBP 4 price at which allowances trade is presumably a payment by the buyer to cover the trading costs of sellers.

5.1.6 Conclusions

166. To some extent, the complex institutional context within which the UK ETS is embedded makes it difficult to draw lessons of wholly general applicability about the economic efficiency and environmental effectiveness of emissions trading. The participants are drawn from two very distinct groups. Most of the major players in the market are the 32 firms which entered the scheme as Direct Participants as a result of the 2002 abatement subsidy auction. But the bulk of the participants entered the scheme as a way of achieving compliance with quantitative commitments for energy efficiency improvements which they had been allocated in sectorally-negotiated "Climate Change Agreements". The reason to negotiate such agreements ultimately derives from the 80% discount on the Climate Change Levy, an energy tax introduced in parallel with the ETS. The impact of the ETS on abatement incentives and overall emissions is a joint result of this set of interlocking mechanisms, and identifying the separate contribution of the ETS is not always practical or straightforward.

167. Smith and Swierzbinski (2007) argue that the experience of the UK ETS highlights the need to pay attention to issues of market concentration and potential market power in analyzing emissions trading and in market design. In the UK ETS market, despite the large number of potential participants, sales are very concentrated. The four-firm concentration ratio (*i.e.* the fraction of total sales accounted for by the four largest sellers, a common measure of market concentration) is 65.7%, a value generally regarded as high in analyses of market power. The four largest sellers in this market are all Direct Participants that entered the ETS through the auction, and this high degree of concentration is partly a result of the auction outcome, which was already highly concentrated, but also because these four firms achieved very substantial levels of abatement.

168. It is clear from the UK ETS experience that the overall constraint on emissions is critical to the success of a trading scheme. In the UK system, the cap on emissions is derived implicitly from decisions about the targets for abatement which participants are given and the emissions baseline against which these targets are defined. The authorities are at an informational disadvantage in negotiating baselines with individual firms or sectors, but the aggregate effect of setting baselines too high for individual sources can undermine allowance prices, and hence the effectiveness of the system in encouraging abatement.

169. Given the difficulty of defining appropriate baselines, because of the natural information asymmetry at the government's expense, emissions trading policies need to take account of the risk of initial error, and the need for subsequent adjustment. However, such adjustment is both difficult and

potentially costly, and it may be more costly to undo "mistakes" with emissions trading than with alternative market instruments such as emissions taxes. Efficient functioning of the market requires stability, and confidence about current and future property rights in quantities traded. Retrospective adjustment of targets or other parameters of the scheme undermines this stability, and the alternative of repurchasing rights once allocated can be costly.

5.2 Landfill Tax and Landfill Trading in the UK

170. The UK employs a number of economic instruments bearing on aspects of waste management, especially landfill disposal, which is extensively used in the UK, accounting for around 90% of all municipal waste in the UK in the early 1990s, and still some 62% today. The UK's first explicit environmentally-related tax, introduced in 1996, was a tax on waste delivered to landfill sites, set at a level based on an assessment of the external costs of landfill use (Davies and Doble, 2004). Other economic instruments introduced in the UK, including the aggregates levy, and packaging waste recovery notes are used in the management of specific elements of the waste stream. Then, in 2005, the UK introduced a Landfill Allowance Trading Scheme (LATS), as part of its strategy to achieve compliance with the targets for reduced landfilling of biodegradable waste set in the EU Landfill Directive. This trading scheme operates in parallel with the landfill tax. This section describes these instruments and their performance, and considers the reasons for employing both a tax and emissions trading in the regulation of landfill.

5.2.1 Landfill tax

171. The UK's Landfill Tax is charged per tonne of commercial, industrial and municipal (household) waste delivered to landfill sites. Two different components of the waste stream are taxed at different rates. The standard rate applies to active (biodegradable) waste, and a reduced rate applies to "inert" waste, such as building rubble, etc. When first introduced, in 1996, the rates applied were GBP 7 per tonne for standard waste, and a lower rate of GBP 2 per tonne for inert waste.

172. Prior to its introduction, there was some consideration of the relative merits of weight or volume-related taxes on the one hand, and *ad valorem* taxes in the form of a percentage of the charges levied by landfill operators on the other. The initial proposal, announced in the 1995 Budget, had been for an *ad valorem* tax, and this attracted considerable criticism. One relevant consideration was the documentation needed to levy taxes on the different possible bases; typically, *ad valorem* taxes, based on the value of transactions, would be likely to be more straightforward to operate than taxes based on physical attributes requiring measurement. The choice of a weight-related tax required records to be kept for tax purposes of the weight of deliveries to landfill sites, but the additional costs of this documentation were in most cases believed to be small as most landfill operators were charging waste disposal authorities by weight, and had suitable weighbridges already in place at many sites. A second consideration in the choice between possible bases was how well each related to the various external costs generated by landfill use - including transport-related externalities, local disamenity through noise, dust and smell, the leaching of dumped materials into groundwater and rivers, etc. While some of these external costs may be broadly proportional to the weight of materials dumped, an ad valorem tariff would charge more for wastes that required more costly management, and this could be a better proxy than weight for some of the leaching externalities. However, a strong argument against ad valorem taxation was that this would tend to penalise the operators of higher-quality facilities, operating to more stringent – and more costly – environmental standards. The choice of a weight-related tariff with two charging categories was seen as a reasonable compromise between differentiation to reflect the external costs of different components of the waste stream, and administrative practicality and cost.

173. The initial rate of the landfill tax was set with reference to estimates of the external costs of landfill which had been produced in consultancy studies commissioned by the Department of the

Environment.[4] This work estimated the externalities from various different types of landfill (differentiating between the use of landfill in urban and rural locations, and landfill with and without energy recovery), and from incineration (with energy recovery), the most likely long-term possibility for diversion of landfilled wastes. The external costs of landfill were estimated to lie in the range between GBP -1 and GBP 9 per tonne of waste, depending on the type of landfill, while incineration with energy recovery had a net external benefit of GBP 2-GBP 4 per tonne of waste, reflecting the greenhouse gas and other emissions of the power generation that would be displaced (CSERGE, 1993). The largest external cost element of landfill disposal was the climate change externality from methane emissions from landfill sites, valued at between GBP 0.86 and GBP 5.40 per tonne; in addition, the climate change impact of carbon dioxide emissions was valued at some GBP 0.08-GBP 1.27 per tonne[5]. The external costs of leaching accidents were estimated at some GBP 0.9 per tonne from exiting landfill sites (while the regulatory conditions attached to new sites were assumed to fully internalise the cost of leaching risks). Transport externalities were estimated to be less that GBP 1 per tonne, and disamenity costs (inferred mainly from US evidence) approximately GBP 2 per tonne. Averaged across the whole waste stream, and the various different types of landfill, the average externality was assessed at about GBP 5 per tonne, or approximately GBP 7 for active and GBP 2 for inactive waste, the rates at which the landfill tax was initially set.

174. On introduction, the projected revenues were used to finance a cut of 0.2% in the rate of employers' National Insurance Contributions (a payroll tax), with the declared aim of ensuring that the tax would not lead to a net increase in overall business costs. It was possible for landfill operators to make contributions to registered environmental trusts in lieu of paying the tax (the "Landfill Tax Credit Scheme"). Overall revenues from the tax, net of voluntary contributions to the trusts, were GBP 360 million in the first full year of operation (1997-98), roughly corresponding to the revenue cost of the payroll tax reduction.

175. A 1998 review of the tax by the government department responsible for its operation, HM Customs and Excise, observed that the tax had led to a significant reduction in the volume of inactive waste sent to landfill (paradoxically the least-taxed component), but to have had negligible impact on landfilling of other wastes, and this trend has continued. Davies and Doble (2004) show that landfilling of inactive waste fell from 35.4m tonnes in 1997-98 to 15.7m tonnes in 2001-02, a 56% reduction, while landfilling of waste subject to the standard rate of tax remained static at some 50m tonnes over the same period.

176. The Aggregates Levy, introduced in April 2002, further reinforced incentives to avoid landfilling of inert waste, by stimulating demand for recycled materials to replace virgin aggregates in road-building and other applications. The Aggregates Levy was intended to reflect the environmental costs associated with quarrying sand, gravel and rock. The levy is charged at GBP 1.60 per tonne, normally payable by the quarry operator. Full-year revenues are of the order of GBP 300 million, part of which is used to finance a Sustainability Fund (to promote local environmental benefits in areas affected by quarrying), and the remainder to finance a 0.1 percentage point cut in employer NICs.

177. The standard rate of the landfill tax remained unchanged until 1999, when it was raised to GBP 10 per tonne, and a commitment made to an annual GBP 1 in the rate over the five years 2000-2004, so that the rate reached GBP 15 per tonne in 2004. Noting that the tax had, so far, been ineffective in reducing the amount of non-inert waste landfilled, a Cabinet Office Strategy Unit paper in 2002 concluded that "a rise to GBP 35 a tonne is required over the medium term". Accordingly, the annual escalator was then raised to GBP 3 per tonne, with the aim of raising the rate eventually to the GBP 35 per tonne level.

4 Davies and Doble (2004) provide details.

5 The estimates were based on Fankhauser's (1992) estimates of the external costs of greenhouse gas emissions.

By April 2007 the rate had reached GBP 24 per tonne, and rises to GBP 32 per tonne from April 2008 and GBP 40 per tonne from April 2009 have been announced. In contrast to this succession of increases in the standard rate, the lower rate of landfill tax for inert waste has so far remained unchanged from the start of the system, but is scheduled to rise to GBP 2.50 per tonne from April 2008.

178. The steady acceleration in the standard rate of the landfill tax reflects increasing concern about the inability of the UK to reduce its use of landfill as the predominant means of waste disposal. Under the EU Landfill Directive (1999/31/EC), the UK is required to meet quantitative targets for reductions in the quantity of biodegradable municipal waste sent to landfill. Judged against the levels in 1995, the UK must reduce its landfill use by 25% by 2010, 50% by 2013 and 65% by 2020. Failure to meet these mandatory EU targets will make the UK liable to substantial penalties for non-compliance. It is clear that what has driven the acceleration in UK landfill tax rates is not an upward revision in the estimates of landfill externalities, but the overriding priority that has been given to attainment of the EU landfill targets. (The setting of these targets appears to have been based on no quantitative assessment of landfill externalities, or the relative external costs of different disposal options, and measures to achieve these targets therefore imply tax rates well in excess of marginal external costs). Even raising the landfill tax to very high levels cannot however guarantee compliance with the quantity targets set by the Landfill Directive. The UK therefore has turned to a tradable permit system, to operate in parallel with the existing landfill tax, as a mechanism intended to achieve a predictable quantity outcome in the target years specified in the Landfill Directive.

5.2.2 Landfill Allowance Trading Scheme (LATS)

179. The Landfill Allowance Trading Scheme (LATS) is a system of tradable permits designed to restrict landfill disposal of biodegradable municipal waste (BMW), in order to ensure UK compliance with the targets set under the EU Landfill Directive (Salmons, 2002; Barrow, 2003). The scheme started on 1 April 2005. Permits were allocated without charge to Waste Disposal Authorities (local governments) according to a formula based on current landfilling and total current waste quantities, and relate to a particular target year. The first allocation was for the period up to 2010, by which date the UK must have reduced its landfilling of BMW to 75% of the 1995 level. (OECD, 2005c)

180. Unsurprisingly, given the purpose of the scheme, the compliance obligations for local waste disposal authorities have a structure that mirrors the timing of the UK's targets under the EU landfill directive. The target years for the Landfill Directive are 2009-10, 2012-13 and 2019-20, and waste disposal authorities are required to meet targets in those years, without recourse to borrowing or banking, that sum to the relevant global target (75% of 1995 levels in 2010, 50% in 2012-13 and 35% in 2019-20). For the intervening years, local waste disposal authorities are also assigned targets, implying a broadly linear adjustment to each successive EU target year. Rather greater inter-temporal flexibility is allowed in compliance with these intermediate targets: during the period between each EU target year, waste disposal authorities can bank allowances, and can also anticipate ("borrow") a small percentage of future allowance allocations (currently limited to 5% of the next year's allocation). This inter-temporal flexibility does not apply into the target years, or across target years, meaning that the trading system consists of, in effect, six separate sub-periods (the three target years, and the intermediate years before each target).

181. Penalties for non-compliance (*i.e.* for failing to deliver allowances to cover the amount landfilled) are set at GBP 150 per tonne, a level higher than the marginal cost of non-landfill disposal for most authorities, and considerably higher than the current landfill allowance price (which appears to be of the order of GBP 20 per tonne). These penalties are not a function of the allowance price, and do not require that the "missing" allowances are also supplied. As a result, they can play the "ceiling price" role envisaged by Roberts and Spence, and discussed in Section 4.2 above. Higher penalties apply for non-compliance in the target years, in that any penalties imposed by the EU (up to approx GBP 0.5 million per

day) could be passed on to those authorities responsible for the non-compliance, in proportion to the extent of their non-compliance (*i.e.* the landfill use in excess of allowances held). Barrow (2006) notes that these penalties are draconian, especially if only a small number of authorities are responsible for the UK's non-compliance, and may be an empty threat. (The authorities which would be penalised would be those which had been unfortunate enough not to be able to buy allowances in the market to cover their use of landfill, and not necessarily those which had made the least progress towards reducing landfill use.)

182. Permits are tradable between local waste disposal authorities, and individual trades are recorded on the central LATS database. Local authorities may engage a (registered) broker to trade on their behalf, but otherwise access to the market is limited to waste disposal authorities. It is not possible, for example, for environmental groups to buy up allowances and retire them, to tighten the landfill targets, and the market organisation also precludes the kind of active market participation by intermediaries and speculators that has developed in the EU ETS, and was also evident, although to a more limited extent, in the UK ETS. The absence of specialist market operators and traders without compliance obligations carries some risks, in that it may reduce liquidity in the market. The absence of active dealing and speculation may also significantly reduce the resources devoted to market analysis and price forecasting, with the result that processes of price determination in the market may be slower and less-informed, and the market may not be as effective in promoting cost-effective reallocations of abatement. Nevertheless, these concerns may be lessened in the case of the UK LATS by the limited amount of inter-temporal flexibility that the rules of the scheme allow. Sophisticated price forecasting and active dealing by professional market operators may be of greatest value in shaping price expectations, rather than in disseminating information about the current willingness to trade of market participants. The latter is probably the most important information process in the UK LATS market, given the succession of short periods into which it is segmented.

183. The first year of the LATS scheme, 2005-06, achieved a substantial 18.5 per cent reduction in landfilling of biodegradable municipal waste below the total allowance allocation, and a modest amount of trading. Ten waste disposal authorities met their compliance obligations by buying additional allowances from other authorities, or by drawing on part of their allowance allocation for future years. One authority, Hampshire, has been the supplier of most of the allowances sold in the market, having taken the decision to invest in substantial new incinerator capacity in the mid-1990s (Barrow, 2006). It is too early to judge whether this authority holds appreciable market power in the LATS market because of its multi-year nature. Nevertheless this situation does highlight the difficulty noted in Section 2.5 of ensuring a fully-competitive market where most abatement opportunities arise through costly large-scale one-off investments.

184. Since the biodegradable municipal waste which is regulated by LATS is all also covered by the landfill tax, the value of allowances will be given by the marginal cost of diverting biodegradable municipal waste from landfill, at the quantity constraint given by LATS, minus the landfill tax paid on each tonne of waste. If LATS allowances are trading at approximately GBP 20 per tonne, this would imply that the marginal cost of achieving the constraint on landfilling set by the first period of LATS is of the order of GBP 20 + GBP 32 = GBP 52 (where GBP 32 per tonne is taken as the average landfill tax rate that will be applicable over the LATS period prior to 2010. Future movements in the LATS allowance price should then reflect changing expectations about the marginal cost of diverting sufficient waste to achieve the aggregate quantity cap set by LATS, and changes in the rate at which the Landfill Tax is charged. The multi-period structure of the LATS regime creates some complications in price determination, if reductions in landfill use are largely achieved by one-off investments in large-scale incineration facilities. Given the severity of the penalties for non-compliance in the target years, where the LATS regime covers a single year with no scope for borrowing or banking, it is likely that local authorities' investment decisions will be designed to achieve compliance in these years. If some facilities come on stream before the target year at which they are directed, it is entirely conceivable that, despite the stringency of the overall cap, allowance prices for the prior trading period could fall to zero. The overall cost of achieving the landfill targets cannot

therefore be read off from the price of allowances in a single trading period, but needs to be judged across the multiple trading periods that LATS has established.

185. As far as municipal waste is concerned, establishing LATS has substantially reduced the significance of the Landfill Tax, in the sense that it is the quantity constraint under LATS that will, in the main, determine the use made of landfill for biodegradable municipal waste, and not the rate at which the Landfill Tax is charged. The higher rates of Landfill Tax planned for future years mainly have the effect of depressing the landfill allowance price, pound for pound with the Landfill Tax rate. Two roles remain for the landfill tax, however. First, the tax acts as, in effect, a floor price, in the event that the LATS targets prove so easy to achieve that the value of LATS allowances falls. Second, the tax continues to play a role in relation to regulate those components of the waste stream not covered by LATS (which only regulates landfilling of biodegradable municipal waste). Commercial and industrial waste, which falls outside the scope of LATS, constitutes about half the active waste sent to landfill in the UK, and the tax will continue to provide an incentive - and, with the planned rise in rates, a steadily increasing incentive - for diversion of this component of the waste stream from landfilling.

5.3 Discussion: the relative merits of taxes and trading in the case studies

186. Both case studies discussed above include a tax and an emissions trading system regulating the same subjects. In both cases, which has been the more successful instrument?

5.3.1 Climate Change Levy and UK ETS

187. The two instruments cannot be entirely separated, as they form part of an interlocking trio of instruments, along with the Climate Change Agreements (sectoral negotiated agreements), and their effects are the outcome of this joint system. One feature of the particular way in which the instruments are combined is that the combination of tax and emission trading instruments in practice involves relatively little redundancy: both instruments play a role. The tax provides a direct abatement incentive for sectors which are not covered by voluntary agreements, and played a key, indirect, role in encouraging sectors to conclude Climate Change Agreements.

188. Both tax and trading have functioned as the basic theory predicts. The Climate Change Levy has led to behavioural responses by polluters, and the trading system has led to trades which appear to be cost-reducing. Taken as a whole, there has been very substantial abatement against the "business-as-usual" baselines used in the negotiation of the climate change agreements. Only part of this can be accounted for by unintended generosity in the negotiation of these baselines.

189. Both instruments have features which reflect the influence of political economy factors discussed in this paper.

- The Climate Change Levy involved major exemptions, including road transport fuels (already heavily taxed) and domestic energy (too politically-sensitive to tax); political considerations relating to the impact on the coal industry also led to the tax being based on energy rather than carbon. In addition to these primary exemptions, the 80% reduction in the rate of tax for sectors concluding Climate Change Agreements allowed the tax to be levied at a much reduced rate on energy-intensive sectors (although the conditional nature of this exemption may have ensured that there was less unevenness in abatement incentives than without the requirement to conclude CCAs).

- In the UK Emissions Trading System, the allocation of allowances was entirely free of charge, and all potential auction revenues were foregone. The allowance auction which did take place

was a mechanism for the distribution of an abatement subsidy budget, not a revenue-raising auction.

190. Allowance prices within the UK ETS have declined to a level where it no longer provides a significant incentive for abatement by firms within Climate Change Agreements. Because some large firms achieved substantial abatement beyond their commitments in the early years of the scheme, a bank of surplus allowances has accumulated, which the remaining firms can buy at low cost. In one sense this reflects efficient working of the instrument – reallocating abatement between those with different opportunities for compliance. However, it is likely that abatement costs have been lower than anticipated when the scheme was initiated and commitments negotiated. This abatement cost "surprise" should, ideally, call for some adjustment in goals, but this is difficult (or costly) to achieve once allowances have been grandfathered.

191. Even though the UK ETS allowance price has fallen to low levels, the CCL remains as a small residual "safety valve" incentive for abatement for firms within CCAs.

5.3.2 UK Landfill tax and LATS

192. This case study shows a greater risk of redundancy in the combination of tax and trading instruments. The scheduled rise in Landfill Tax rates will have negligible effect on the incentives to reduce landfilling of biodegradable municipal waste, the waste stream also being regulated by the LATS quantity cap. Since all landfill use covered by LATS is also subject to the Landfill Tax, the Landfill Tax will be offset pound-for-pound in the equilibrium allowance price in LATS, so that the Landfill Tax contributes no additional marginal incentive (unless the LATS allowance price falls to very low levels). One effect of the Landfill Tax is then to claw back revenues that were foregone by free allocation of LATS allowances. In addition, of course, there are significant elements of the waste stream that are not covered by LATS, and are subject to the Landfill Tax, and for these – industrial and commercial wastes – the tax remains a relevant determinant of landfill costs.

193. These two instruments are more conventionally separate in their design and application than are the inter-locking climate change instruments discussed above. The choice of instruments exemplifies issues at stake in the choice between "price" and "quantity" regulation. The recent introduction of the LATS trading regime, in a context where there was already a well-established and efficiently-designed Landfill tax reflects the overriding policy priority that has had to be given to the achievement of quantity outcomes, as a result of the rigid quantity targets for landfill use set in the EU Landfill Directive. Given that constraint, LATS is clearly more fit for purpose than the tax incentive, although, as with any quantity instrument, there are risks that achieving the target will incur unexpectedly high abatement cost.

194. It is hard to make a definitive assessment at this stage of the comparative performance of the two instruments. The Landfill tax is longstanding, but only two years of LATS trading have so far taken place, and there have been only a modest number of trades. As noted above, the pattern of trades involves a very small number of significant sellers – illustrating the difficulty of ensuring a fully-competitive market in an emissions trading system where abatement is the outcome of large-scale investments by a small number of participants.

195. In contrast to the climate change instruments, "political economy" factors appear to have had little impact on the design of the Landfill tax. The Landfill tax is uniform across sectors (except where a tax differential can be justified by the different external cost characteristics of inactive wastes). LATS allowances have been grandfathered (although the landfill tax recovers much of the foregone revenues from free allowance allocation). The relatively muted impact of political economy factors on instrument design in this case is perhaps unsurprising, since the sectors covered are not industrial sectors exposed to

international product market competition, but local authorities, and a largely domestic waste disposal industry experiencing negligible international competitive pressure.

6. Conclusions

196. The focus of this paper has been on environmentally related taxes and emissions trading in practice. In the growing number of real-world applications in OECD countries, both of these instruments have tended to exhibit features that differ from the straightforward instrument specification that might be chosen in a first-best setting, and that reflect real-world constraints and concerns. Some of these constraints are practical – concerning the costs and feasibility of administration and enforcement. Others respond to the concerns of stakeholders – about perceived impacts on competitiveness or income distribution, for example – and may have a sharp political focus. The key question for this paper is how, if at all, these various features of real-world environmentally related taxes and emissions trading systems affect their functioning and effectiveness. In particular, once these constraints are recognised, how does this alter the policy comparison between environmentally related taxes and emissions trading?

197. This concluding section summarises some of the key points from the paper about what has been learned from practical experience with environmentally related taxes and emissions trading (Section 6.1). Section 6.2 then proposes a framework for assessing the relative merits of taxes and trading in a context where their design and implementation has to reflect a range of frequently-encountered real-world constraints. In particular, this section focuses on the trade-off between inefficiency with imperfect taxes (*e.g.* with sectoral exemptions) and inefficiency with grandfathered allowances.

6.1 What has been learned from experience?

198. Three broad aspects of experience with environmentally related taxes and emissions trading have been discussed in this paper – the effectiveness in practice of these market mechanisms, the role of political and other constraints in modifying the structure of these instruments, and the parallel employment of these and other instruments.

199. Past OECD work has documented the wide range of practical applications of environmentally related taxes and emissions trading, and has contributed to a substantial body of evidence on their performance in practice. In broad terms, this *experience has demonstrated that these environmental market mechanisms work, and work broadly as predicted.* The experience of the NO_x tax in Sweden, emissions trading under the US acid rain programme and a number of other policy applications provides *ex post* evidence that environmentally related taxes and emissions trading systems are both capable of delivering substantial environmental improvements combined with cost-reducing flexibility – possibly well beyond what could be achieved with conventional instruments.

200. *In principle, taxes and emissions trading have very similar properties.* Indeed, under certainty and with a competitive allowance market, the economic and environmental effects of emissions taxes and auctioned tradable permits would be identical. There are likely to be significant differences in their performance in circumstances where policy has to be implemented with relatively poor information about polluters' abatement costs, and it is well-recognised that this will point towards one or the other approach depending on nature of the environmental problem and the abatement possibilities. A further way in which the effects of environmentally related taxes and emissions trading may differ arises because of the *various ways in which these instruments in practice depart from the straightforward first-best specification*. Most environmentally related taxes, for example, are levied on bases which are linked more or less closely to emissions, but very rarely directly related to actual emissions. Considerations of administrative cost sometimes limit the application of environmentally related taxes, or emissions trading in various ways.

Likewise, the need to ensure a competitive and relatively low-cost allowance market may act as a constraint on the design and scope of emissions trading.

201. An important set of constraints on the design of environmentally related taxes and emissions trading systems arises where *the political process and stakeholder influence leads to measures to moderate the "fiscal" burden* of these instruments. While governments have little difficulty raising tax revenue from other, non-environmental, fiscal instruments, the tax burden imposed by environmentally related taxes, or the equivalent burden involved in selling pollution permits, frequently attracts much attention, and leads to policies in which some or all of the revenue potential of the instrument is foregone, or dissipated in compensating measures. Emissions trading allowances are frequently "grandfathered" to existing firms, rather than auctioned. Environmentally related taxes are often rebated or charged at lower rates to some sectors, especially to those which are most exposed to international competition. In both cases, these modifications alter the properties of the instrument, and may have a significant bearing on whether one or other approach is ultimately more efficient and effective. (These issues are discussed further in Section 6.2 below.)

202. A third feature of actual practice which departs from the "textbook" instrument comparison is that market mechanisms such as environmentally related taxes and emissions trading are *frequently adopted as complements to, rather than substitutes for, other forms of regulation*. There seem to be a variety of reasons for this. Some reflect real-world complications not present in the theory. Other reasons reflect powerful forces shaping the policy process, which have the effect that the accretion of additional instruments occurs more readily than abolition-and-replacement. Again, however, the properties of instruments employed in this way may not coincide with those in more straightforward applications. Indeed, while there may be good reasons for combining instruments in some situations, there is also a danger of excessive cost and regulatory burden, and a risk of redundancy. As discussed in Section 5, the potential interaction between tax policies and allowance prices needs to be carefully considered, and may significantly alter the properties and effectiveness of each instrument.

6.2 Summary: Imperfect tax versus grandfathered TPs

203. As discussed above, a common feature of both environmentally related taxes and emissions trading in practice is that the instruments are frequently implemented in ways that aim to reduce the tax burden or allowance payment expenditures incurrent by participants, especially those exposed to international competition. How far would the comparative properties of the instruments when implemented in this way differ from the "first-best" uniform taxes and emissions trading with auctioned allowances?

204. The policy choice may be represented as a comparison between two forms of "imperfect" economic instrument:

- emissions trading with less-than-100% auctioning, which foregoes some of the potential revenues,

- an environmental tax with reduced tax rates or tax exemptions for some sectors, which foregoes part of the potential revenue, and which incurs inefficiency because different sources face different marginal incentives.

205. Among the differences between the two instruments, the following economic considerations may be highlighted:

206. The two approaches differ in terms of the coverage of the environmental incentive; this is more broadly-spread with emissions trading than with the tax. With emissions trading, *all sectors within the*

scheme face the same marginal incentive to reduce emissions, and free distribution of allowances does not affect this, if carried out in a manner which does not in itself distort business decisions. By contrast, exempting some sectors from the environmental tax reduces the coverage of the instrument; only those sectors subject to the tax face any incentive to reduce emissions. A similar effect arises where compensation takes the form of reduced tax rates for some sectors. In this case, these sectors do not face the same incentive to reduce emissions as other sectors subject to the full rate of tax, and there will be inefficiency in the pattern of abatement. So from the point of view of abatement efficiency, emissions trading is preferable to the environmental tax with sectoral differences in tax rates.

207. Second, the underlying objective of compensation needs to be considered. The underlying reason for not auctioning allowances or for sectoral tax exemptions or reduced tax rates might be seen in two different ways.

- First, the aim might be to reduce the financial burden of the tax payments or allowance costs on firms; in other words, by distributing free allowances or reducing tax rates to transfer, in effect, a certain financial sum to firms. Much discussion of market mechanisms in environmental policy seems to assume that the impact on the competitiveness of sectors exposed to international competition can be offset in this way. If this is the goal, either instrument would seem capable of achieving the intended outcome.

- Alternatively – and with a stronger economic rationale – it could be argued that the purpose of compensation is to reduce the economic impact of emissions trading or environmental taxes on product prices and business activity in sectors exposed to international competition. If firms set prices in relation to their *marginal costs*, then the key issue will be how different forms of compensation affect marginal costs. Here there is a clear advantage to sectoral tax reductions, rather than free allowance allocations. Even if distributed free, the use of tradable allowances by firms has an opportunity cost (in terms of the money that could be made by selling the allowance). Grandfathering allowances will increase profits, if this opportunity cost can be passed through to customers in higher selling prices. Where businesses are exposed to strong international competition, they may have less scope to pass through opportunity costs in higher prices, but nonetheless experience higher marginal costs. Business responses to these higher marginal costs might include reductions in output and sales and consequent loss of market share. As a result, free allocation of allowances may be less effective than sectoral tax exemptions or reduced rates in ameliorating the impact on businesses exposed to international competition.

208. A third issue is how effectively the two approaches can target the compensation. If the problem which compensation aims to address can be specified in terms of particular exposed sectors, then compensation through the allowance allocation could take the form of sectoral differences in the proportion of allowances grandfathered, and this could be targeted to exactly the same firms as sectoral tax exemptions. The two approaches (tax and TPs) would be equally effective in targeting the "compensation" to affected firms and sectors. On the other hand, it is possible to think of reasons why the targeting of allowance allocations might be better or worse than equivalent tax reductions. In principle, allowance allocations could be extremely flexible, targeting the benefit to particular firms rather than uniformly to whole sectors, and it may be difficult to think of tax exemptions or rate reductions being targeted in this way. Alternatively, it is possible that the discretionary targeting that might be possible with allowance allocations could actually lead to a poorer outcome, if, for example, allowance allocations between firms were influenced more by lobbying or political factors than by genuine need. It is possible, therefore, that one or other instrument may be better in terms of targeting efficiency, but hard to say which way this points.

209. Fourthly, there are "double dividend" considerations. In each case, the revenues collected fall short of what would be collected with the "first best" instrument. Emissions trading foregoes some revenue through grandfathering, while sectoral exemptions or reduced rates collect less revenue than uniform application of the tax at its full rate. However, the way in which the revenue is foregone differs, and this may have significant fiscal implications. Free allocation of some allowances in an emissions trading scheme delivers the compensation in a "lump sum" form, and product prices will remain as high as if allowances were fully auctioned. Sectoral reductions in tax rates, by contrast, are likely to feed through into reduced product prices for the exempted sectors. To the extent that higher product prices exacerbate the distortions of the existing fiscal system (for example by increasing the distortionary impact of labour taxes), this argument would tend to favour compensation through sectoral rate reductions rather than free allowance allocations.

210. In sum, the relative merits of free allocation of allowances and sectoral exemptions as responses to problems of internationally-exposed and emissions-intensive sectors depend on a number of factors. Crucial to the judgement will be the underlying reason for seeking to reduce the burden on these sectors. If this is seen in terms of reducing the impact of regulation on product prices, then environmentally related taxes coupled with sectoral reduced rates or exemptions would seem to have the edge, because grandfathering is incapable of achieving this effect on product prices. If, on the other hand, the goal is to reduce the financial burden on exposed sectors (without any concern for the price effect), then grandfathering and tax reductions/exemptions may be able to achieve this outcome to a similar extent. In this case, an attraction of emissions trading with grandfathering is that it maintains a uniform abatement incentive across all sectors, and hence achieves the required abatement at least aggregate abatement cost.

REFERENCES

Åhman, Markus, Dallas Burtraw, Joseph A Kruger and Lars Zetterberg (2005), "The Ten-Year Rule. Allocation of Emission Allowances in the EU Emission Trading System". Resources for the Future Discussion paper 05-30.

Barrow, Michael (2003), "An economic analysis of the UK landfill permits scheme", *Fiscal Studies*, vol. 24, no. 3, pp. 361-381.

Barrow, Michael (2006), "Initial effects of the Landfill Allowance Trading Scheme", University of Sussex, mimeo.

Bennear, Lori S and Robert N Stavins (2007), "Second-best theory and the use of multiple policy instruments", *Environmental and Resource Economics*, 37(1), pp. 111-129.

Bernard, Alain L, Carolyn Fischer and Alan K Fox (2007), "Is there a rationale for output-based rebating of environmental levies?", *Resource and Energy Economics*, 29, pp. 83-101.

Bohm, Peter, and Clifford F. Russell (1985), "Comparative Analysis of Alternative Policy Instruments", In Handbook of Natural Resource and Energy Economics, Vol. 1, edited by A.V. Kneese and J.L. Sweeney. New York: Elsevier, pp. 395-460.

Bressers Hans TA and Kris RD Lulofs (2004), "Industrial water pollution in the Netherlands: a fee-based approach", in *Choosing Environmental Policy. Comparing Instruments and Outcomes in the United States and Europe*, Washington, D.C.: Resources for the Future.

Burtraw, Dallas, Danny Kahn and Karen Palmer (2005), "CO_2 allowance allocation in the Regional Greenhouse gas Initiative and the Effect on Electricity Investors", Resources for the Future Discussion paper 05-55.

Colombier, Michel, and Karsten Neuhoff (2007), "Can sectoral agreements and output-based allocation address leakage?", Climate Strategies working paper, July 2007.

Cornwell, A. and J. Creedy (1996), "Carbon taxation, prices and inequality in Australia", *Fiscal Studies*, 17(3), pp. 21-38.

Cramton, Peter and Suzi Kerr (2002), "Tradable carbon permit auctions. How and Why to auction not grandfather". *Energy Policy*, 30, pp. 333-345.

CSERGE (Centre for Social and Economic Research on the Global Environment) (1993), *Externalities from Landfill and Incineration*, Department of the Environment, HMSO, London.

Davies, Bob, and Doble, M (2004), "The development and implementation of a landfill tax in the UK", in OECD (2004) *Addressing the Economics of Waste*, OECD, Paris.

Demailly, Damien and Philippe Quirion (2006), "CO_2 abatement, competitiveness and leakage in the European cement industry under the EU ETS: grandfathering versus output-based allocation", *Climate Policy*, 6 (1), pp. 93-113.

de Muizon, G and M Glachant. (2004), "The UK Climate Change Levy Agreements: Combining Negotiated Agreements with Tax and Emissions Trading" in A Baranzini and P Talman (eds.) *Voluntary Approaches in Climate Policy: An economic assessment of public-private partnership*. Cheltenham: Edward Elgar.

DEFRA (Department for Environment, Food and Rural Affairs) (2002), The UK Emissions Trading Scheme. Auction Analysis and Progress Report. October 2002. Online at http://www.defra.gov.uk/environment/climatechange/trading/uk/pdf/trading-progress.pdf

Department of Environment, Transport and the Regions (2000), Climate Change: The UK Programme. London: DETR. Cm 4913.

Department of the Environment (1990), This Common Inheritance. Britain's Environmental Strategy. (White paper). Cm 1200. London: HMSO.

Diamond, Peter A. (1973), "Consumption externalities and imperfect corrective pricing", *Bell Journal of Economics and Management Science*, pp. 526-538.

Dijkstra, Bouwe R and Dirk T G Rübbelke (2007), "Group rewards and individual sanctions in environmental policy", University of Nottingham, mimeo.

Ellerman, A. Denny, Richard Schmalensee, Elizabeth M Bailey, Paul L Joskow, and Juan-Pablo Montero (2000), *Markets for Clean Air. The US Acid Rain Program*. Cambridge University Press.

Eskeland, G. (1994). "A Presumptive Pigovian Tax: Complementing Regulation to Mimic an Emissions Fee". *The World Bank Economic Review*. Washington, DC: World Bank.

European Environment Agency (2006), *Using the market for cost-effective environmental policy. Market-based instruments in Europe*. EEA report No. 1/2006. Copenhagen: EEA.

Fullerton, Don, and Gilbert E. Metcalf (2001), "Environmental Controls, Scarcity Rents, and Pre-Existing Distortions", *Journal of Public Economics* 80, pp. 249-267.

Goulder, Lawrence H. (1995), "Environmental Taxation and the Double Dividend: A Reader's Guide", *International Tax and Public Finance*, 2(2) August, pp. 157-83.

Goulder, Lawrence H., Ian W. H. Parry, and Dallas Burtraw (1997), "Revenue-Raising versus Other Approaches to Environmental Protection: The Critical Significance of Pre-existing Tax Distortions", *RAND Journal of Economics*, 28(4), Winter, pp. 708-31.

Gruenspecht, Howard K (1982), "Differentiated regulation: the case of auto emissions standards", *American Economic Review*, 72(2), Papers and Proceedings, pp. 328-31.

Hahn, R. (1984), "Market Power and Transferable Property Rights", *Quarterly Journal of Economics*, 99(4), pp. 753-765.

Hammar, Henrik and Åsa Löfgren (2004), "Leaded gasoline in Europe: differences in timing and taxes", in *Choosing Environmental Policy. Comparing Instruments and Outcomes in the United States and Europe*, Washington, D.C.: Resources for the Future.

Hepburn, Cameron, Michael Grubb, Karsten Neuhoff, Felix Matthes and Maximilien Tse (2006), "Auctioning of EU ETS Phase II Allowances: how and why?" *Climate Policy* 6(1), pp. 137-160.

Johnston, Angus (2006) "Free allocation of allowances under the EU emissions trading scheme: legal issues", *Climate Policy*, 6 (1), pp. 115-136.

Jensen, Jesper and Tobias N Rasmussen (2000), "Allocation of CO_2 emissions permits: a general equilibrium analysis of policy instruments", *Journal of Environmental Economics and Management*, 40, pp. 111-136.

Johnstone, Nick (ed.) (2007), *Environmental Policy and Corporate Behaviour*, Cheltenham: Edward Elgar.

Jordan, Andrew, R.K.W. Wurzel, A. R. Zito and L. Brückner (2003), "Policy Innovation or 'Muddling Through'? 'New' Environmental Policy Instruments in the United Kingdom" in Andrew Jordan, Rüdiger Wurzel and Anthony Zito (eds) *'New' Instruments of Environmental Governance? National Experience and Prospects*, London: Frank Cass Publishers.

Kerr, Suzi, and David Maré (1998), *Transaction Costs and Tradable Permits. The United States Lead Phasedown*, mimeo, Motu Research Trust, NZ. http://www.motu.org.nz/pdf/transaction_costs.pdf.

Leape, Jonathan (2006), "The London Congestion Charge", *Journal of Economic Perspectives* 20(4), pp. 157-176.

Leicester, Andrew (2006), "The UK Tax System and the Environment", *IFS Report Series* 68, London: Institute for Fiscal Studies.

Mæstad, Ottar (2007), "Allocation of emission permits with leakage through capital markets", *Resource and Energy Economics*, 29, pp. 40-57.

Marshall Report (1998), *Economic Instruments and the Business Use of Energy*, a report by Lord Marshall, November, HM Treasury.

Millock, Katrin and Thomas Sterner (2004), "NO_x emissions in France and Sweden: Advanced Fee Schemes versus Regulation", in *Choosing Environmental Policy. Comparing Instruments and Outcomes in the United States and Europe*, Washington, D.C.: Resources for the Future.

Misiolek, W. and Elder, H. (1989), "Exclusionary Manipulation of Markets for Pollution Rights," *Journal of Environmental Economics and Management* 16(2), pp. 156-166.

National Audit Office (2004), *The UK Emissions Trading Scheme. A New way to Combat Climate Change.* Report by the Comptroller and Auditor General. HC 517 Session 2003-2004: 21 April 2004.

National Audit Office (2007), *The Climate Change Levy and Climate Change Agreements.* August 2007. Online at http://www.nao.org.uk/publications/nao_reports/06-07/climate_change_review.pdf

NERA (2004), *Review of the First and Second Years of the UK Emissions Trading Scheme*. NERA Economic Consulting. Online at www.defra.gov.uk/environment/climatechange/trading/uk/pdf/nera-commissionreport.pdf

Newbery, David M. (2005), "Why Tax Energy? Towards a More Rational Policy", *The Energy Journal* 26(3), pp. 1-39.

Newell, Richard G. and Robert N. Stavins (2003), "Cost Heterogeneity and the Potential Savings from Market-Based Policies", *Journal of Regulatory Economics* 23(1), January, pp. 43-59.

OECD (Organisation for Economic Co-operation and Development) (1993), *Taxation and the Environment. Complementary Policies*, OECD, Paris.

OECD (1996), *Implementation Strategies for Environmental Taxes*. OECD, Paris.

OECD (2005a), *The Competitiveness Impact of CO_2 Emissions Reductions in the Cement Sector*. OECD, Paris. Online at http://appli1.oecd.org/olis/2004doc.nsf/linkto/com-env-epoc-ctpa-cfa(2004)68-final.

OECD (2005b), *The United Kingdom Climate Change Levy. A Study in Political Economy.* OECD, Paris. Downloadable from www.oecd.org/env/taxes.

OECD (2005c), *Instrument Mixes Addressing Household Waste*, OECD, ENV/EPOC/WGWPR(2005)4/FINAL.

OECD (2006), *The Political Economy of Environmentally Related Taxes,* OECD, Paris.

OECD (2007), *Instrument Mixes for Environmental Policy,* OECD, Paris.

O'Neil, William, Martin David, Christina Moore and Erhard Joeres, (1982), "Transferable Discharge Permits and Economic Efficiency: The Fox River", *Journal of Environmental Economics and Management*, 10, pp. 346-355.

Palmer, Karen, Dallas Burtraw and Danny Kahn (2006), "Simple Rules for Targeting CO_2 Allowance Allocations to Compensate Firms", Resources for the Future Discussion paper 06-28.

Parry, Ian (1995), "Pollution Taxes and Revenue Recycling", *Journal of Environmental Economics and Management*, 29(3), Part 2, November, S64-S77.

Pearce, David W. (1991), "The role of carbon taxes in adjusting to global warming", *The Economic Journal*, 101(407), pp. 938-48.

Persson, Åsa (2006), "Characterizing the policy instrument mixes for municipal waste in Sweden and England", *European Environment*, 16(4), pp. 213-231.

Poterba, James M. (1991), "Tax Policy to Combat Global Warming: On Designing a Carbon Tax", in R. Dornbusch and J. M. Poterba (eds.), *Global Warming: Economic Policy Reponses*, Cambridge, MA.: The MIT Press.

Salmons (2002), "New Areas for Application of Tradeable Permits – Solid Waste Management", in OECD (2002) *Implementing Domestic Tradeable Permits. Recent Developments and Future Challenges*, pp. 187-226. OECD, Paris.

Sandmo, Agnar (1976), "Direct versus indirect Pigouvian taxation", *European Economic Review*, 7, pp. 337-49.

Santos, Georgina, and Gordon Fraser (2006), "Road pricing: lessons from London", *Economic Policy* 21 (46), pp. 263-310.

Schöb, Ronnie (2003), "The Double Dividend Hypothesis of Environmental Taxes: A Survey". FEEM Nota di Lavoro 60.2003. Milan: FEEM.

SEPA (2000), *The Swedish charge on nitrogen oxides – Cost-effective emission reduction,* Swedish Environmental Protection Agency, Stockholm.

Sinclair, Peter JN (1992), "High Does Nothing and Rising Is Worse: Carbon Taxes Should Keep Declining to Cut Harmful Emissions", *The Manchester School of Economic & Social Studies*, 60(1), pp. 41-52.

Sinn, Hans-Werner (2007), *Public policies against global warming*, CESifo Working Paper 2087. Munch: CESifo.

SMENR (1994), *The Swedish Experience. Taxes and Charges in Environmental Policy*, Stockholm, Ministry of the Environment and Natural Resources.

Smith, Stephen (1992), "The Distributional Consequences of Taxes on Energy and the Carbon Content of Fuels", *European Economy*, Special Edition No 1/1992: "The economics of limiting CO_2 emissions", pp. 241-268.

Smith, Stephen (1994), "Who Pays for Climate Change Policies? Distributional Side Effects and Policy Responses", in OECD (1994) *The Economics of Climate Change. Proceedings of an OECD/IEA Conference*, pp. 277-291.

Smith, Stephen (1999), "The compatibility of tradable permits with other environmental policy instruments", in OECD (1999), *Implementing Domestic Tradable Permits for Environmental Protection*, pp. 199-219. ISBN 92-64-17022-7. OECD, Paris.

Smith, Stephen and Joseph Swierzbinski (2007), "Assessing the performance of the UK Emissions Trading Scheme", *Environmental and Resource Economics*, 37(1), pp. 131-158.

Sorrell, S (2003), "Who owns the carbon? Interactions between the EU Emissions Trading Scheme and the UK Renewables Obligation and Energy Efficiency Commitment". *Energy and Environment*, 14(5), pp. 677-703.

Stavins, Robert N (1995), "Transaction costs and tradeable permits", *Journal of Environmental Economics and Management*, 29, pp. 133-148.

Stavins, Robert N (2005), "Vintage-differentiated environmental regulation", Resources for the Future Discussion paper 05-59.

Tietenberg, Tom H (1991), "Economic Instruments for Environmental Regulation" in Dieter Helm (ed) *Economic Policy Towards the Environment*, pp. 86-111.