Final

ENVIRONMENT AGENCY

ANALYSIS OF THE INTERACTIONS AND COMBINATIONS OF TAX AND PERMIT-TRADING INSTRUMENTS, WITH AN APPLICATION TO CLIMATE AND WASTE POLICY FINAL DRAFT

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Executive Summary

The literature on the choice between environmental taxation or permit trading and on possible combinations of the two instruments is founded on the efficiency losses in the case of uncertainty about the abatement costs. The key conclusion from the literature is that, when a choice is to be made between tax and permit-trading systems and there is uncertainty in costs, the hybrid systems are more efficient.

If the marginal abatement costs are steeply rising but uncertain, a tax can be shown to be less efficient than a permit-trading system. If the marginal abatement cost is estimated to be rising slowly, a tax would be more efficient than a permit-trading system. Hybrid systems, which place a tax ceiling on, and possibly a subsidy floor under, the permit price are more efficient than the pure application of either a tax or a permit-trading system. The reason is that if permits are scarce and abatement costs high, the market would only be in equilibrium if permit prices are high, and for the purpose of this example, higher than the marginal damage cost. So capping the price at a ceiling prevents prices from reaching inefficiently high levels. The ceiling should be set at a level higher than the estimated optimal tax to reflect the uncertainty around the optimal level. A sliding scale system can be used to refine this efficiency advantage by putting in additional intermediate subsidy or tax thresholds, leading to a permit price path which approximates the marginal damage curve more precisely.

Although they have the same desired substitution away from a polluting activity, tax, permit-trading or hybrid systems can have different revenue effects, depending on the allocation of permits. If all permits are auctioned, a permit-trading system might raise the same amount of revenue as a tax. If all permits are grandfathered however, no money is raised. A hybrid system could result in revenue from the tax component and, possibly, from auctioning permits. The revenue could be used to offset the income effect of the tax on vulnerable groups, or, if circumstances allow, to increase the elasticity of the response to the instrument. Such expenditure will not create efficiency gains unless it passes a cost-benefit test.

Under the assumptions of perfect competition, the allocation method has no impact on competition (ie, on entry). However, market imperfections can cause either the tax to outperform trading or vice versa. Some market imperfections can be addressed through the design of the instrument.

Administrative and transaction costs should also be considered when examining the efficiency of the possible economic instruments. Transaction costs can reduce the efficiency of a permit-trading system, creating an efficiency advantage for taxes compared to hybrid or permit-trading schemes.

An application to climate policy reveals, first, that a greenhouse gas allowance trading system capped by a ceiling would reflect both the quantitative limit on greenhouse gas emissions aspired to in international agreements and national policy, and the uncertainty about the marginal abatement costs; Second, that the simultaneous applications of tax, allowance trading and hybrid systems are mostly inefficient. Four major inefficiencies are found:

- most climate policy instruments are based on the consumption of energy in a way that does not adequately reflect the carbon content of the energy taxed;

- the UK ETS applies trading inversely (ie, trading as an exemption to taxation) and does not result in the efficiency gains achieved by a standard hybrid system under uncertainty;
- there are no links that guide the convergence of the different marginal carbon abatement costs of different sectors and fuels, so total carbon abatement costs are not minimised in the long term;
- analysis of the tax incidence reveals that some energy types face double regulation with no clear efficiency gain from the incentive being split over an upstream and a downstream instrument.

Tax and permit-trading systems are also applied in waste policy. Two inefficiencies can be detected based on the analysis:

- the landfill tax and the biodegradable municipal waste (BMW) allowance trading system give duplicate incentives as biodegradeable waste would be subject to both the landfill tax and the BMW trading system. Both instruments aim to contribute to the delivery of targets under the Landfill Directive, but bear no comparison to the actual externalities generated by landfilling. A simple tax would be an appropriate instrument in that respect;
- there is no pass-through of tax or allowance costs that would incentivise all agents of the waste supply chain (notably households and small businesses).

Contents

1. Introduction

Environmental policy has increasingly made use of economic instruments in the last decade. Among the many economic instruments available, taxes and systems of permit or allowance trading have received most policy attention. Both are central to the UK government's climate and waste policies. The use of both taxation and permit trading in the same policy area raises the questions of how they interact and how to combine them optimally.

This paper gives an overview of developments in the academic literature on the efficiency of taxation, permit trading and hybrid instruments. It analyses the efficiency of the pure tax or trading instruments under uncertainty and the hybrid options that have been suggested. It briefly reviews what the literature says about raising revenue and competition.

The second part of the paper applies the theoretical framework to the policy areas of climate change and waste. The current mix of policy instruments is discussed, using the lessons learned from the literature review, and considering implementation issues.

With regards to climate policy, the interaction of the Climate Change Levy (CCL) and Climate Change Agreements (CCA), the UK Emissions Trading Scheme (UK ETS), the Renewables Obligation (RO), the Energy Efficiency Commitment (EEC), and the EC greenhouse gas emissions trading scheme are analysed.

Concerning waste policy, the analysis examines the interaction of the landfill tax and the Biodegradable Municipal Waste (BMW) allowance trading scheme. It also discusses the pass-through of incentives to households and businesses.

2. Literature Review

2.1 Overview

The use of economic instruments such as taxes and trading schemes can deliver environmental outcomes at least cost. An environmental tax places a price on the environmental externality (eg, pollution), and the functioning of the market is left to determine the corresponding quantity produced. In contrast, a trading system fixes the quantity of the environmental good or bad, and market forces determine the corresponding price.

The advantage of such instruments over traditional command and control is that they allow the market to determine the appropriate level of the quantity each agent reduces while fixing one variable only—price or total quantity. Not allowing flexibility of the distribution of the environmental good or bad removes the role of the market and removes the attractive feature of economic instruments.

Therefore, combining taxes and trading instruments may be counter-productive when this amounts to fixing both the price and quantity of the externality. Combining taxes and permits to solve the same environmental problem may lead to welfare losses.

However, as this report shows, when specific conditions are satisfied and when the combination of tax and permit instruments is carefully designed, the resulting 'hybrid' instrument can lead to greater efficiency gains than either instrument used alone.

2.2 Optimal instrument choice under uncertainty[1]

Under the (unrealistic) assumption of perfect markets and information, it is well known that taxes and permit systems, and hence also hybrid systems, yield exactly the same outcome. As such, a comparison between taxes, permits and hybrid systems is more informative when these restrictive assumptions are relaxed.

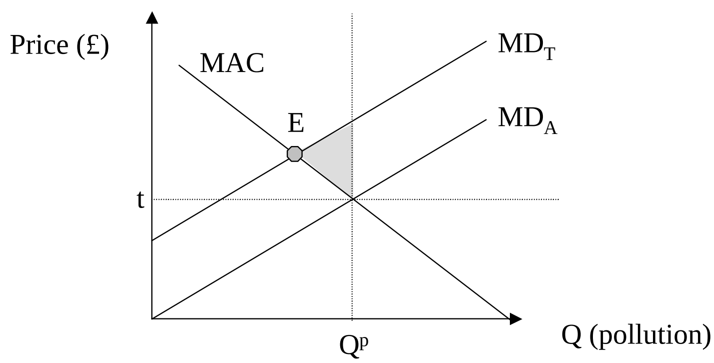
An appropriate starting point, therefore, is the different performances of permit and tax instruments under imperfect information, as developed by Weitzman (1974). Weitzman showed that when the marginal pollution abatement cost is known with certainty, taxes and permits are equivalent instruments, even if the marginal damage of pollution is uncertain.[2] Uncertainty can be characterised by supposing that the marginal damage is a function of a random variable with a known probability distribution. Figure 2.1 illustrates one possible outcome, where the policy maker implements a tax or permit instrument based upon an anticipated marginal damage curve (MD_A), which turns out to be lower than the true marginal damage curve (MD_T). Both the optimal tax (horizontal line at t) and the permit

[1] The paper exclusively deals with uniform flow pollutants. The conclusions might not necessarily apply to non-uniform pollutants and to stock pollutants.

[2] For refinements of this basic idea, see Ireland (1977), Laffont (1977), Yohe (1978) and Weitzman (1978). Note also that Weitzman makes the assumption that marginal costs and benefits are linear—see Malcolmson (1978) and Weitzman (1978b) for discussion of the generality of this assumption.

(vertical line at Q^p) therefore miss the true optimum (E). However, the efficiency loss from the tax and permit instrument, represented by the shaded triangle, is identical. This is because firms respond to each policy with reference to their marginal abatement cost curve (MAC). If the policy maker knows the MAC curve with certainty, the tax and permit system will result in the same reaction from firms. At least one caveat on this result is appropriate. Shrestha (1998) points out that if environmental groups can buy and retire permits, then when Q^p ends up being set too high (as in Figure 1), environmental groups would retire permits, thereby reducing Q^p and the expected efficiency loss of the permit system.[3]

Figure 2.1: Permit and tax instruments when marginal damage is uncertain

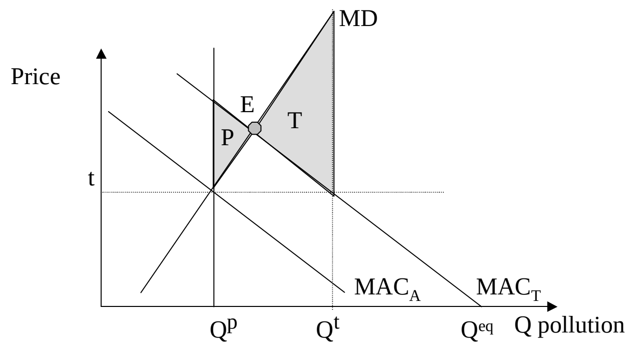


In contrast, when marginal abatement costs are uncertain, the expected welfare of taxes and permit instruments differ. Figure 2.2 shows the optimal tax (t) and permit (Q^p) given an anticipated marginal abatement cost curve (MAC_A).[4] However, in this figure, the true marginal abatement cost curve (MAC_T) is higher than anticipated, and both taxes and permits miss the optimum. The tax rate is too low, leading to too much pollution (Q^t). In contrast, the permit scheme results in too much abatement and a level of pollution that is sub-optimally low. When the marginal damage curve is relatively steep, as in Figure 2.2, the efficiency loss from a tax (shaded area T) will be greater than from a permit instrument (shaded area P).

[3] Other caveats come from considering different assumptions. In Figure 1.1, the price instrument affects firms' decisions of optimal abatement. In contrast, Laffont (1977) considers the type of situation where a group, aware of the true MD curve (perhaps ecologists), can dictate firm production, using the level of the tax. In this unusual case, price and quantity instruments lead to different results.

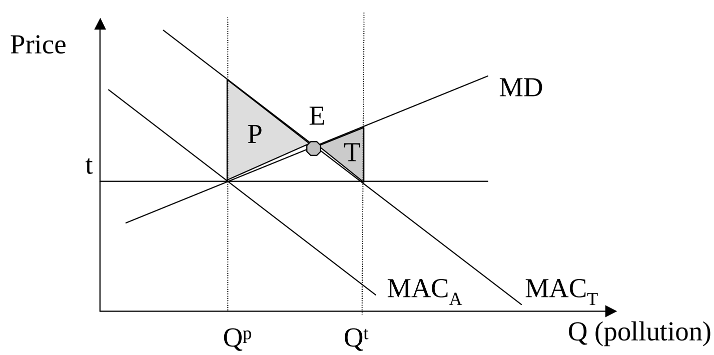
[4] Note that the MAC curves reflect the horizontal sum of the marginal abatement cost curves of many individual firms.

Figure 2.2: Permit and tax instruments with uncertain abatement costs and steep marginal damage



On the other hand, when the marginal damage curve is relatively flat, the expected efficiency loss from a tax is lower than from a permit, as shown in Figure 2.3. The intuition is straightforward. The objective of both instruments is to internalise the marginal damage from pollution. In other words, the ideal instrument is one that mimics the marginal damage curve.[5] When the marginal damage curve is relatively flat, a (horizontal) tax instrument is the better approximation. When the marginal damage curve is relatively steep, a (vertical) quantity instrument is preferable.

Figure 2.3: Permit and tax instruments with uncertain abatement costs and flat marginal damage



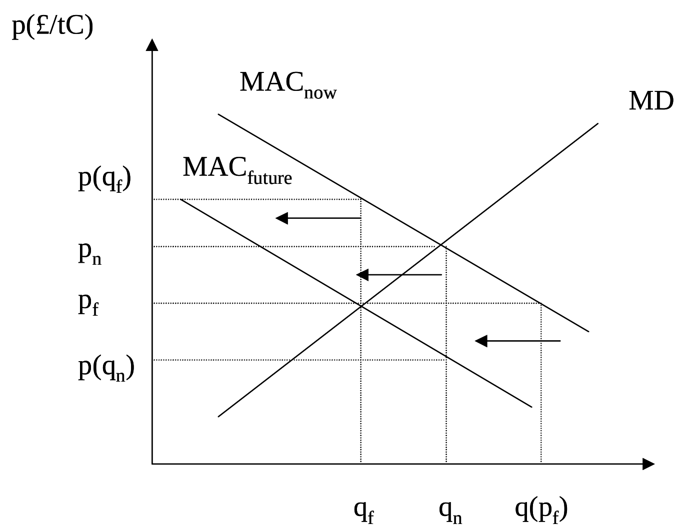
2.3 Optimal instrument choice in dynamic models

The above analysis is simple and instructive because it is static, not dynamic. It is static in the sense that the policy maker selects a tax rate or quantity of permits and implements it once, and costs do not change over time. Extending the static model to dynamic situations, where the policy maker and firms learn and interact over time, and technology and environmental factors lead to changing costs over time, provides additional insights.

[5] To be precise, the ideal instrument is one which, after aggregating firm behaviour, results in an implicit penalty function that mimics the marginal damage curve. This distinction is important to keep in mind in sections 2.3 and 2.5.

A simple dynamic analysis (considering effects over time) of a tax and a permit-trading system is shown in Figure 2.4. If marginal abatement costs decrease over time—for example, because innovation or commercialisation results in lower abatement costs—the optimal level of emissions would become q_f. The corresponding appropriate future tax is then p_f. If the appropriate future tax, p_f, were to be introduced now, when marginal abatement costs are higher, resulting emissions would amount to $q(p_f)$. A permit-trading system based on an emissions constraint at the future optimal level would result in a high permit price $p(q_f)$. Such a high permit price would give a strong incentive to commercialise low carbon technologies, bringing down their costs. The tax would not have this effect.

Figure 2.4: Tax and trading instruments under falling marginal abatement costs



However, if policy is based upon the current marginal abatement cost curve, the opposite conclusion results. Based upon MAC_{now}, the appropriate tax would be set at p_n. Permit trading based upon an emissions constraint at the current optimal level, q_n, would correspond to a permit price at the same level as the optimal tax, p_n. However, as innovation occurs and costs fall, the equilibrium permit price will also fall, to $p(q_n)$, while the tax remains constant, implying that the tax provides stronger and more optimal incentives to innovate in this case. The solution would be to reduce over time the number of permits in circulation.

A similar result is found by Denicolo (1999) who considers pollution-reducing innovation in a perfect competition model. He finds that if the government commits to a particular tax or permit system,[6] taxes provide a stronger incentive for firms to innovate than permits.[7]

[6] That is, the government does not adjust its policy after the innovation. Naturally, taxes and permits are equivalent in his model if the government can adjust them at all stages to ensure optimality.

A comprehensive study of the innovation effects of taxes and permits in a multi-firm setting is by Milliman and Prince (1989). They find that when taxes and emissions constraints are fixed at 'Pigouvian' levels—ie, in line with marginal damage costs, or at a level of quantity where marginal abatement costs and marginal damage costs are equal—incentives for innovation are greater under an emissions tax than under free (eg, grandfathered) emissions permits, and higher still under auctioned emissions permits. These results are driven by two primary effects.

First, as innovation reduces marginal abatement costs, this induces more emissions abatement under a tax. In contrast, under permit-trading the industry-level amount of emissions will remain constant (by design). Since firms reduce emissions by a larger amount under the tax, they will pay for innovations that reduce abatement costs.

Second, innovation will reduce the equilibrium permit price. If firms have to purchase permits, for example, in an auction, they benefit from lower permit prices. Falling permit prices will lessen the incentive to reduce emissions. This effect does not operate under a (fixed) emissions tax or with grandfathered permits. According to Milliman and Prince (1989), this second effect is generally sufficient to raise the overall incentives for innovation under auctioned permits above those under the emissions tax.

If firms act strategically against the government, Moledina et al (2003) suggests that with permits, firms have an incentive to under-abate, leading to a high permit price. This is to encourage the regulator to believe that firms have high abatement costs, such that it is then optimal to issue more permits in the next period. This is a simple example of the well-known 'ratchet effect'.[8]

Moledina et al (2003) also suggests that with an emissions tax, firms have an incentive to over-abate, thereby signalling that their costs are low, and prompting the regulator to implement a lower tax in subsequent periods. However, over-abatement is expensive, so firms collude in order to balance the desire to appear to have low abatement costs, with the desire to minimise actual abatement expenditure.

2.4 The economics of hybrid tax and trading schemes

Once Weitzman (1974) had shown that the expected efficiency of tax and permit schemes differs when the marginal abatement cost is uncertain, it was a small step to propose that a hybrid scheme would provide a closer approximation to the marginal damage curve than either a tax or permit scheme alone. This step was first taken by Roberts and Spence (1976), who investigated 'mixed systems' such as:

- a mixed permit and tax scheme;

[7] Just as efficiency is not the only relevant criterion for the ranking of taxes, trading and hybrid systems in different situations, so too with the incentives provided for innovation. Indeed, Denicolo (1999) notes that the welfare ranking of taxes and permits does not necessarily coincide with the ranking according to the incentive to innovate.

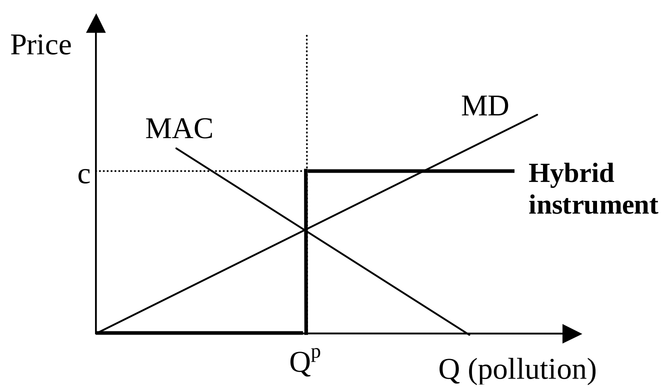
[8] See, eg, Weitzman (1980).

- a mixed permit, tax and subsidy scheme; and
- a scheme of charges on a sliding scale (modelled by the use of multiple licences).

Figure 2.5 illustrates the simplest hybrid scheme, where a tax and a trading instrument are combined. The trading scheme is designed so that the number of permits corresponds to the anticipated 'optimal' level of pollution.[9] The tax essentially operates as a pressure-relief valve. If abatement costs are higher than anticipated, and the price of permits rises above the tax rate, firms will prefer to pay the tax rather than to purchase permits from the market. The tax therefore caps compliance costs and places an upper bound on the permit price. Note that the appropriate price ceiling in a hybrid scheme, denoted by 'c' in Figure 2.5, is higher than the estimated optimal tax rate if an environmental tax were employed alone. The optimal level of the price ceiling in a hybrid scheme can be determined for a specified degree of uncertainty in the marginal abatement cost function. Yohe (2000) points out that the flatter the marginal damage function, the lower the optimal permit price ceiling (and, therefore, the closer the price ceiling is to the estimated optimal tax rate).

The effect of the incentives generated by a hybrid system can be described by an implicit 'penalty function', shown as the heavy step function in Figure 2.5. The penalty function does *not* represent the incentives faced by individual firms. The penalty function shows incentives *as if* the firms were merged and made decisions centrally.[10] As noted above, the policy maker's aim is to design a scheme so that the implicit penalty function is as close as possible to the marginal damage function, so that firms correctly internalise the environmental externality. It should be clear from Figure 2.5 that the hybrid penalty function is a better approximation of the marginal damage function than either a simple tax or simple trading system.

Figure 2.5: Economics of hybrid tax and trading scheme

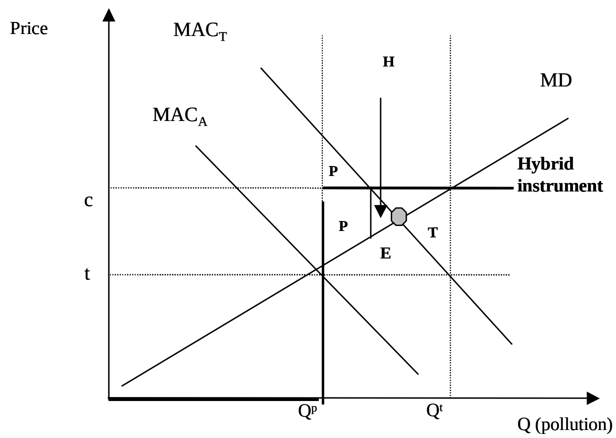


[9] In the real world of policy-making, the number of permits may correspond to an allocation based more on political factors than scientific and economic optimality. The allocation of greenhouse gas emissions between EU Member States provides one example.

[10] Similarly, Figure 2.1 shows the total number of permits (Q^p), not the number of permits available for each individual firm. In other words, it represents incentives as if there were only one (merged) firm in the industry.

As noted, a major advantage of hybrid systems—especially in terms of political palatability—is that they cap the costs of compliance with environmental regulation. In economic terms, hybrid instruments lower the expected efficiency loss of regulation under uncertainty. The analogue to Figure 2.3 for a hybrid instrument is presented in Figure 2.6. If true abatement costs (MAC_T) turn out to be higher than anticipated (MAC_A), efficiency losses result from the tax, trading and hybrid schemes. As can be seen, as the marginal damage curve is relatively flat, the tax efficiency loss (T) is less than the permit loss (P), corresponding to the situation in Figure 2.3. However, the loss from the hybrid scheme (H) is smaller than both the tax and trading losses. This is because the hybrid penalty function is closer to the marginal damage function at the true optimum than the tax or permit penalty functions.

Figure 2.6: Hybrid tax-trading scheme with uncertain abatement costs



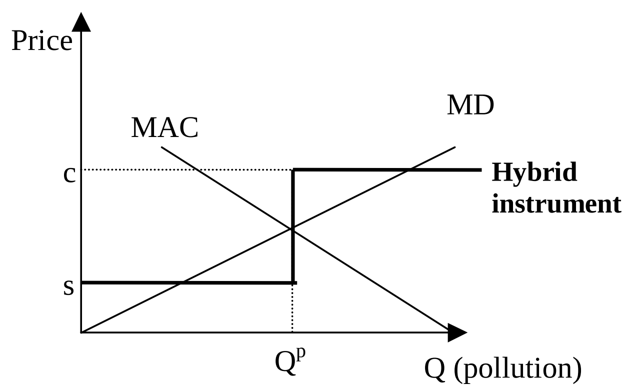
It is worth stressing that these efficiency gains result from the careful construction of hybrid system so that tax and trading instruments complement one another. Such efficiency gains are highly unlikely to be achieved by merely introducing separate tax and trading schemes with no coordination.

Yohe (2000) makes the point that hybrid instruments confer even larger efficiency gains if the initial permit allocation has been set in too restrictive a manner. He argues that if the greenhouse gas emissions reductions agreed at Kyoto (and beyond) are potentially too severe, the pressure-relief value inherent in a hybrid scheme will prevent enormous efficiency losses. On the other hand, if the initial permit allocation turns out to be too large, the efficiency loss—excluding the costs of providing for the unused pressure-relief value—will be identical to that of a pure trading scheme.

2.5 Hybrid tax, trading and subsidy schemes

Roberts and Spence (1976) show that subsidies can also be integrated usefully with tax and trading schemes.[11] In a hybrid tax, trading and subsidy scheme, the regulator issues a finite number of tradeable licences. Firms are paid a subsidy if their licence holdings exceed their emissions. Firms with emissions exceeding licence holdings must pay a tax. The result is essentially a system of marketable permits where the realised permit price is constrained between an upper limit c (given by the tax) and a lower limit s (given by the subsidy). The implicit penalty function is shown in Figure 2.7, where Q^p licences are issued, c is the tax rate and s is the subsidy rate. The addition of the subsidy instrument enables the hybrid instrument to approximate the marginal damage function more closely than in Figure 2.5 above, where no subsidy was employed.

Figure 2.7: Economics of a hybrid tax-permit-subsidy scheme



A feature that emerges from Roberts and Spence (1976) is that hybrid schemes are only useful for policy making when the marginal damage of pollution is an increasing function, because a tax can kick in after a subsidy but not vice versa. This limitation should be borne in mind when designing hybrid schemes. It would seem, however, unlikely to be especially restrictive.

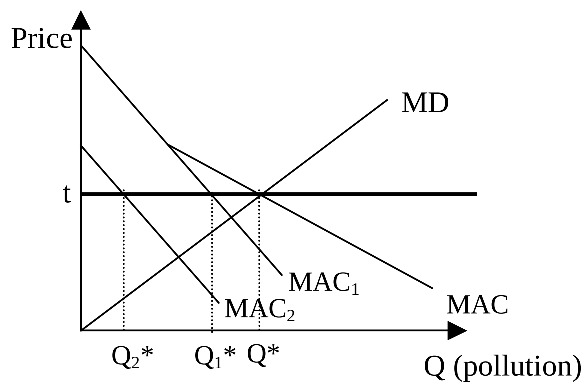
[11] Indeed, the model in their paper considers a regulator using a hybrid permit, tax and subsidy scheme to approximate the damage function.

2.6 Sliding scales

We have seen that a major advantage of hybrid schemes is that the resulting implicit penalty function approximates more accurately the marginal damage function. It is therefore natural to ask why regulators do not merely employ a (variable) tax so that the implicit penalty function equals the marginal damage function. Indeed, as Roberts and Spence (1976) note, when there is a single polluter, the best regulatory system is to employ a tax equal to the marginal damage curve.[12] However, when there is more than one polluter, a variable tax generally does not achieve an efficient allocation of abatement between firms.

An efficient allocation between firms requires that pollution be abated to the point that firms' marginal costs of abatement are equal. For the simplest case of two firms, Figure 2.8 shows that this is achieved by a constant tax.

Figure 2.8: Optimality of a constant tax with two polluters

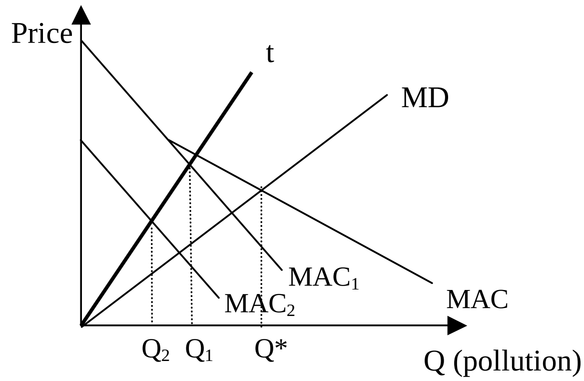


With a variable tax imposed upon many firms, equalisation of marginal abatement costs is unlikely. For instance, Figure 2.9 shows a variable tax imposed upon two firms so that total pollution $\Sigma Q = Q_1 + Q_2$ is equal to the optimal level of pollution Q*. However, the allocation of abatement between the firms is sub-optimal because their marginal abatement costs are different. A Pareto improvement is possible if firm 2, with lower abatement costs, polluted less and firm 1 polluted more, as in Figure 2.8.[13]

[12] In fact, the 'ideal prices' refinement of the Weitzman (1976) idea by Ireland (1977) amounts to employing a variable tax equal to the marginal benefit schedule: see Karp and Yohe (1979). This is optimal for one firm but the extension to the multifirm case causes difficulties.

[13] This is simply because the marginal damage function appropriate for each individual firm is not the aggregate marginal damage function. For instance, if firm 1 has already emitted Q_1 units of pollution, the marginal damage of firm two emitting its first unit of pollution is not zero.

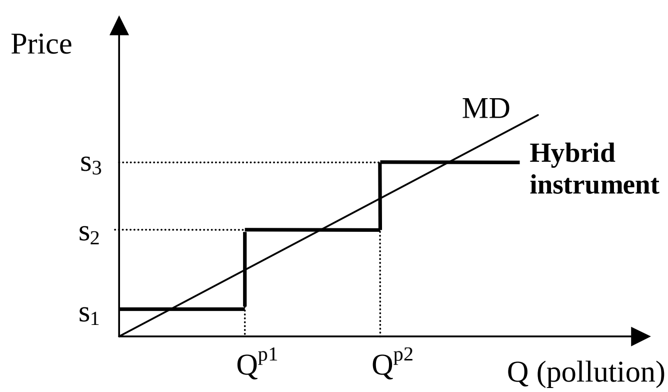
Figure 2.9: A linear tax with two polluters



With more than one firm, the challenge is to design a system so that the implicit penalty function is as close as possible to the marginal damage function, while ensuring that the allocation of pollution between firms remains efficient.

Roberts and Spence (1976) show that hybrid systems can achieve these two goals. They demonstrate that, if the regulator employs a hybrid system with many different tradeable licences, the implicit penalty function can provide an arbitrarily close approximation to the marginal damage function. The more types of licence employed, the closer the approximation to the marginal damage curve and the smaller the efficiency losses due to uncertainty. One type of licence differs from another in two ways. First, each type of licence carries a right to a different rebate. Second, there are different numbers of licences of each type available. Figure 2.10 shows the situation where two tradeable licences are employed (p1 and p2), resulting in an implicit penalty function that more closely approximates the marginal damage curve.

Figure 2.10: Economics of a hybrid sliding scheme (two licences)



In Figure 2.10, there are fewer of the first type of licence available than the second type ($Q^{p1} < Q^{p2}$). Also, firms receive a smaller rebate for first type of licences (s_1) than for the second type ($s_2 > s_1$). A consequence of the differential rebate is that the market price of the second type of licence will not be less than the price of the first type.

In this manner, the implicit penalty function is a series of steps, with each step corresponding to a type of licence. With many steps, the hybrid instrument can approximate the marginal damage function. Moreover, as Roberts and Spence (1976) show, such a hybrid system results in a (decentralised) efficient allocation of pollution between firms.

Various papers, including Karp and Yohe (1979) and Yohe (1981) have extended this idea to include cases where firms' costs are correlated. In particular, Yohe (1981) shows that, with negative cost correlation, the appropriate penalty function becomes flatter (more like a tax) as the number of firms increases. With positive cost correlation, the optimal penalty function is steeper (more like a trading scheme) as the number of firms increases.

While in theory the use of multiple licences and sliding scales reduces expected efficiency losses under uncertainty, such schemes can be incredibly complex, and incorporate significant transaction and administrative costs. They are more difficult to design than simple single instrument or hybrid schemes, and their complexity implies that more effort is required by regulators to ensure that they function correctly. Moreover, sliding scales would impose a greater intellectual burden on firms, which would need to devote more resources to understand the incentives they face.

2.7 Revenue implications

Taxes, trading and hybrid schemes are generally aimed at internalising an environmental externality, and thus ensuring that firms pay the full social costs of their actions. To achieve this, any of these policy instruments will lead to a change in the price of the environmental good (or bad). It can be useful to decompose the impact of such a price change into an income and a substitution effect.

The imposition of a tax on pollution, for instance, represents a change in the price of pollution. The increased price of pollution has two effects:

- firms will move away from polluting process and towards cleaner process;
- firms will have less income after paying the tax for the pollution they continue to produce and after paying the cost of the substitute (if it is more expensive).

The use of a trading system to control pollution similarly increases the price of pollution and therefore will potentially have income and substitution effects.

In general, the focus of environmental policy is upon the substitution effect. The aim of policy instruments such as taxes and trading schemes is to correct *relative* prices so that they reflect full social costs. The revenue implications of environmental policy are generally of secondary concern to the desired substitution effect. The efficient, ie, welfare-improving, or equitable, ie, income effect smoothing, expenditure of tax revenue is a matter for fiscal policy. The revenue might be used to subsidise measures which improve the responsiveness to the tax or trading system, or to reduce the incidence of the instrument on vulnerable groups. However, each such measure would need to be weighed on the balance of its costs and benefits. Generally, unless other market failures, eg informational failures, can be identified, it should be assumed that the tax or the allowance price gives an efficient incentive.

Nevertheless, it is often asserted that differences in the aggregate revenue implications of taxes and trading schemes justify employing one instrument instead of the other.[14] Trading schemes, it is sometimes argued, are revenue neutral, while taxes provide government with the ‘double dividend’ of additional revenue.[15] As a result, there is frequently opposition from industry to environmental taxes, and a general preference for trading schemes.

Tax and trading schemes can be designed so that their overall revenue effect is equivalent. For instance, an environmental taxation scheme where revenue is returned to the agents taxed is revenue neutral, as is a trading scheme where permits are grandfathered for free. In order to maintain the incentive, a rule must be devised which re-allocates revenue without distorting the incentive. This means that revenue-neutrality is not an aim for every single agent, but rather for all agents combined. Hence some agents will be better off relative to others once the instrument has been introduced, and the distribution of wealth could either be progressive (ie, the poor benefit more than the rich) or regressive (the reverse).

Equally, a trading scheme where permits are auctioned will, under (restrictive) assumptions of perfect markets and complete information, raise the same revenue as the corresponding tax. This equivalence is presented in Table 2.1. Equally, the revenue implications from a hybrid scheme can be adjusted to suit the specific policy situation.

Table 2.1: Revenue equivalence of tax and trading instruments

	Tax/subsidy	**Trading scheme**
Revenue raising	Tax revenue retained by government	Permits sold to polluting firms (eg, by auction)
Revenue neutral	Taxation with revenue returned to industry as a lump sum or output subsidy	Allocate permits for free (eg, grandfathering)
Revenue losing	Subsidies provided for reduced pollution	Firms bid for payments for emissions reduction credits (eg, UK emissions trading)

However, as a matter of practical policy-making, there are important differences. It is not always possible to return taxes to industry so that the tax is revenue-neutral. McKibbin and Wilcoxen (2002), for instance, tacitly assume that returning taxation revenue to firms is impossible in the process of arguing for a hybrid policy for climate change:

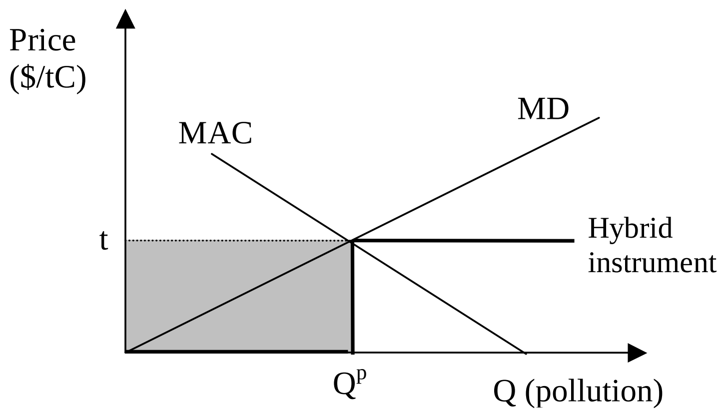
> Although a tax would be more efficiency than a permit system for controlling greenhouse gas emissions (given flat marginal benefits, rising marginal costs and high levels of uncertainty), a tax has a major political liability: it would induce large transfers of income from firms to the government.

[14] It is self-evident that the impacts upon individual firms of an economic instrument will differ. Hence a policy which is revenue-neutral overall will clearly have positive and negative revenue effects for individual firms.

[15] Of course, there is only a ‘double dividend’ to the extent that the shadow value of revenue raising by environmental taxation is lower than that of general taxation. This depends on the price elasticity of the environmental good relative to labour (and other sources of public revenue).

Even if the possibility of returning tax revenue to industry is accepted, the promise to do so may not be perceived as credible. For these reasons, an advantage of hybrid schemes is that, assuming permits are allocated at no cost to firms, they can be designed to provide similar overall incentives to a tax with a smaller revenue transfer than the tax. An example is presented in Figure 2.11 where the permit price ceiling is set (inefficiently) at the level of the optimal tax. Effectively, the hybrid instrument operates much like a tax but avoids the shaded revenue transfer. The only difference arises if marginal abatement costs are lower than anticipated. With a simple tax, firms will reduce emissions below Q^p until abatement costs exceed the tax. With the hybrid instrument, however, if abatement costs are lower than anticipated, the permit price falls and firms have no incentive to reduce emissions below Q^p.

Figure 2.11: Revenue implications of hybrid schemes



2.8 Impact on competition

In a market that is already perfectly competitive, the impact of taxes, trading and hybrid schemes upon the degree of competition would be expected to be minimal. In particular, with perfect competition in the output market, the tradeable-permits market is also likely to be competitive.

However, if a trading (or hybrid) scheme allocates all perpetual permits to incumbents, new entrants must purchase permits from incumbents in order to commence operation. Permits therefore represent a fixed cost, and thus a barrier to entry. However, in an otherwise competitive market with many small firms, this should not be a significant problem: permits are unlikely to represent a large proportion of total operating costs, and with a liquid and competitive market, new entrants would simply purchase permits at the market price.

Moreover, it is relatively straightforward to design the trading scheme to reduce or eliminate and adverse impacts upon competition. First, temporary permits which expire at regular intervals (eg, annually) may be employed so that expenditure on permits by incumbents and new entrants is a variable rather than a fixed cost. Second, if perpetual permits are considered desirable, at the time of allocation a proportion of these permits might be put aside for new entrants. Third, new entrants can be provided for by retiring a small proportion of permits each year, and putting these up for auction, as is the practice in the US sulphur trading system.

If the market under regulation is imperfectly competitive to begin with, then there are multiple market failures—a pollution externality and market power—and Laffont (1994) shows that three instruments are required to achieve the first best:

- a tax, trading or hybrid scheme;
- an output subsidy to correct for underproduction;
- a lump-sum tax to extract the oligopoly rents.

Although environmental regulators never have a mandate to correct imperfectly competitive markets, this does not mean that it can be ignored: implementing a tax, trading or hybrid scheme without taking account of market power can reduce welfare.[16]

Requate (1993) compares tax and trading (but not hybrid) schemes in a Cournot duopoly. Based upon his model, although neither approach is unambiguously preferable, trading schemes resulted in higher welfare more frequently than taxes.[17] Nevertheless, with imperfect competition in the output market, the danger of an imperfectly functioning permits market is much greater. Hahn (1984) and Misolck and Elder (1989) show that concentration (market power) in the permit market adversely affects the performance of trading schemes, reducing their relative attractiveness.

Concentration problems occur when one or more firm is able to act as a price setter. Hahn (1989) notes that this is a particular problem for water pollution, where a trading scheme must be developed for each individual basin, reducing liquidity and the number of participants in each permit market. Joskow and Schmalensee (1998) note that evidence from the USA suggests some concentration problems in SO_2 markets.

Trading or hybrid schemes can also increase barriers to entry if the market is already imperfectly competitive. Incumbent firms may behave collusively in the permits market to extract rents from new entrants as they acquire the permits necessary to commence operation. However, the suggestions noted above (eg, use of temporary permits) should mitigate these problems.

2.9 Transactions and administrative costs

The transactions costs involved with a tax may be significantly lower than with trading or hybrid schemes. Following Stavins (1995), transactions costs may be usefully divided into three categories:

- search and information;
- bargaining and decision;

[16] Buchanan (1969) showed that using a Pigouvian tax to regulate a monopolist polluter will generate welfare losses by further reducing output when output is already sub-optimally low. Misiolek (1980) and Oates and Strassman (1984) make a similar point. Malueg (1990) argues that a trading scheme may reduce welfare when the product market is imperfectly competitive.

[17] In essence, this is because the less efficient firm closes down under a permits system (regardless of the initial allocation), which does not always occur when the optimal tax is imposed.

- monitoring and enforcement.

The third category—monitoring and enforcement costs—is relevant to tax, trading and hybrid systems. For a tax to be appropriately designed (and modified as time passes), accurate information about aggregate emissions is also required. Monitoring of individual firm emissions is required to determine the correct total tax payment. Similarly, for trading and hybrid systems, individual firm emissions must be monitored. In addition, monitoring of trades is necessary to ensure compliance. Hence transaction costs under this third category are likely to be relatively similar across tax, trading and hybrid systems.

In contrast, transactions costs in the first two categories are applicable primarily to trading and hybrid systems. Every trade will involve costs under these categories, and several authors, particularly Stavins (1995), have argued that these transactions costs may be very significant. In a relatively illiquid market, firms must incur the costs of identifying exchange partners. They also incur the cost of deciding upon and communicating their willingness to pay and to accept. In a more liquid market with a broker or 'market maker', the broker reduces these transaction costs but firms are charged brokerage fees and incur costs equal to the spread between the permit bidding and asking prices. Brokerage fees of 5% for SO_2 allowance trades in the USA are cited Klaassen and Nentjes (1997). Furthermore, when the permit price fluctuates, as it will on most markets, firms are exposed to risk and incur risk-related transaction costs, as noted by Baldursson and von der Fehr (2002).

Stavins (1995) argues that transactions costs of trading systems may be significant, which implies a reduced incentive to trade and thus increased abatement costs. Moreover, transaction costs imply that the efficient outcome may not be attainable, and hence that the initial distribution of permits alters the efficiency of the trading system.[18] Indeed, Hahn and Hester (1989) assert that one trading programme—the Fox River water pollution scheme—failed because high transaction costs eliminated the potential gains from trade. Further evidence of high transactions costs is the bias towards 'internal trading' within firms, as compared with 'external trading' between firms. Hahn and Hester (1989b) propose that differential transaction costs are the cause.

Of course, in addition to transaction costs, once the market has been created, the establishment of a trading or hybrid schemes requires the creation of a market *de novo*, which can itself be a relatively costly. Additional costs arise when, as would be the case in the EU Emissions Trading Scheme, several markets must function in parallel and where Member States would ideally allocate their tradeable instruments simultaneously.

Overall, it appears that transaction costs imply that taxes have a significant advantage over trading and hybrid schemes, which makes taxation more optimal for small and diffuse sources. Also, as the price ceiling in a hybrid system involves additional administrative and

[18] For instance, auctioning the permits will result in the efficient outcome in the presence of transaction costs, whereas a free allocation may not.

decision costs, hybrid systems would appear to be have higher transaction costs than simple tax or trading schemes.

3. Policy Applications

The insights gained from the literature review are used in this section to illuminate the application of tax and trading instruments in two major environmental policy areas—climate and waste policy. This section examines how hybrid systems are applied in both policy domains, and discusses their design. Apart from efficiency considerations, other policy criteria, such as administrative feasibility and equity will also be analysed. The following implementation issues will be examined in the context of both climate and waste policy.

- *Uncertainty of impact and/or cost*—what are the main uncertainties in the policy area, and how are these reflected in instrument choice?
- *Sources under the schemes*—are the tax, trading and/or hybrid systems imposed on the same or different polluters, diffuse and/or point sources, downstream and/or upstream players?
- *Incidence of the tax, trading and/or hybrid system*—after costs have been passed on via the pricing of intermediate and final goods, on whom does the additional cost fall? Are some goods or services burdened twice or omitted?
- *Design*—could a (partly) revenue-raising instrument address equity issues? Is administration of hybrid designs feasible? In the case of permit trading, does the market structure deliver low transaction costs? How will the scheme perform over time? How large are the administrative costs?

3.1 Climate policy

3.1.1 Current tax and trading instruments

Current climate policy displays a mix of tax and allowance trading instruments. The main taxes are the Climate Change Levy (CCL) and excise duty. Permit trading is applied in the Renewables Obligation (RO), the UK Emissions Trading System (UK ETS), the EU missions trading scheme (EU ETS) and the Energy Efficiency Commitment (EEC).

The CCL is a tax on the consumption of electricity, gas and coal by industrial, commercial and public consumers (see Defra, 2001, and Defra, 2002) The tax does not apply to the domestic, the transport or the horticultural sectors, to energy used in the generation of electricity and to small businesses which use a household amount of electricity. Electricity from renewable sources or Good Quality CHP is exempted, as is electricity used in electrolysis processes. Exemptions of up to 80% of the CCL liability can be obtained by signing a CCA which sets targets for the decrease in energy intensity in a particular sector. The revenue from the CCL is partly offset by a commensurate reduction in employer's National Insurance Contributions and part of it is used for subsidising the take-up of renewable energy.

Road fuels used in cars, and oils used for heating in households are subject to excise duty (see Customs and Excise reference). The excise duty collection is imposed on the suppliers, in a similar way to value added tax.

The RO is an obligation on electricity suppliers to buy a certain percentage of electricity from renewable sources.[19] The target increases annually from 4.6% in 2003 to 10.4% in 2010. Compliance involves the surrender of Renewables Obligation Certificates (ROCs), which are tradeable. The price at which ROCs trade indicates the marginal cost of achieving the target for the whole of England and Wales. If the price exceeds £30/MWh, suppliers can decide to pay £30/MWh into a buy-out fund as an alternative means of compliance. The monies in the fund are recycled to the suppliers in proportion to the share of total ROCs they submitted.

In the UK ETS, participants can trade allowances in order to comply with the targets they have taken on (see Defra 2002b). Thirty-four direct participants took on absolute emissions reduction target in exchange for a payment in an incentive auction. Several thousand other participants can sell certified emission reductions in excess of their CCA obligations or buy allowances to comply with their CCA target. Project participants can sell allowances from emission reductions projects into the ETS. Trade between the participants with an absolute target and those with a relative target is restricted by a 'gateway', which ensures that there is no net transfer of allowances from the relative to the absolute sector. The first compliance period of the UK ETS is 2005–07.

Under the EU ETS, energy-intensive installations used for some industrial activities (eg, combustion, metal and steel, glass, ceramics and pulp) have mandatory, absolute greenhouse gas emission reduction targets for the compliance years in two periods, 2005–2007 and 2008–2012 (see European Commission, 2001) An initial allocation of allowances is grandfathered to the installations in national allocation plans. In the second period, up to 10% of the allowances could be auctioned. Installations can opt out in the first period if they are subject to alternative measures of equivalent effect. Allowances can be traded across the installations in countries participating in the EU ETS (ie, the enlarged EU plus Norway and Iceland). In the case of non-compliance, allowances must be deposited in addition to a penalty of €40/tCO_2e in the first period and €80/tCO_2e in the second.

The EEC imposes an obligation on energy suppliers to achieve energy savings by their customers.[20] Energy savings can be realised in electricity, gas, oil, coal and LPG and should total 62TWh in the period 2002–05. The commitment is based on a target spend of £3.6 per fuel per customer but suppliers can achieve reductions at lower cost. The EEC can be traded between obligated suppliers.

[19] Statutory Instrument 2002, No. 914, The Renewables Obligation Order 2002. Note that the RO is analysed solely from the perspective of climate policy. Other externalities the RO might seek to address (eg, the risk of insecurity of supply) are not taken into account.

[20] Statutory Instrument 2001 No. 4011, Electricity and Gas (Energy Efficiency Obligations) Order 2001 and background information on www.defra.gov.uk/environment/energy/eec/index.htm.

3.1.2 Uncertainty considerations in UK climate policies

Climate change and climate policy are areas of major uncertainty. The uncertainties are large and the potential for learning is high. Among those who are convinced of the problem posed by climate change and who accept the need for intervention, the uncertainties are about the optimality of the response—ie, the marginal damage and the marginal abatement cost functions.

Uncertainties concerning marginal damage and marginal abatement costs

The uncertainties surrounding the damage estimation are adequately captured in studies on the social cost of carbon. Published estimates range from £2.4–£15/tC (Pearce, 2002) to £70/tC (Clarkson and Deyes, 2002). Differences between estimates originate mainly from the assumption on the level of adaptation of economics to climate change, and, to a lesser extent, from the choice of discount rate and the equity weighting put on damages to poorer countries. The future inclusion of amenity benefits, low probability catastrophic events and new climate model results will cause these estimates to change.

The abatement cost is also a major area of disagreement among academics. Most studies model the cost of achieving the short-term goals posed by the Kyoto Protocol (see Ellerman and Decaux, 1998, and den Elzen and Both, 2002) Carbon costs can be derived for the UK policy measures. The CCL caps the abatement cost at £37/tC for electricity and £29/tC for gas.[21] The RO buy-out price of £30/MWh translates into £250/tC.[22] The EEC's target spend of £3.6 per household results in an carbon value of around £24–£55/tC.[23] The UK incentive auction sold emission allowances at £46–65/tC.[24]

Tax, trading and hybrid systems

Given the above uncertainties about the marginal abatement costs and the shape of the marginal damages curve, the question is whether a tax, a greenhouse gas emissions trading system or a hybrid system would be the best instrument. As concluded above:

- if the marginal damage curve is relatively steep (flat), uncertainty about the marginal abatement costs lead to greater (less) efficiency loss under a tax than under a permit-trading system;
- a hybrid system, ie, a permit-trading system with a tax as ceiling and, possibly, a subsidy as floor, can be more efficient than the application of a pure tax or trading system.

So the choice of instrument is influenced most by the gradients of the marginal damage and the marginal cost curve. If the marginal damage curve of carbon emissions would be relatively flat, a carbon tax would be a more optimal instrument for small emissions

[21] Based on CCL rates of £4.3/MWh for electricity and £1.5/MWh for gas, and carbon factors of 0.12tC/MWh and 0.05tC/MWh respectively.

[22] Based on a carbon factor of 0.12tC/MWh.

[23] Based on a target spend of £3.6 per fuel per customer, 49m customers (cumulatively), 63TWh energy savings, resulting in 3–7MtC.

[24] Based on an auction clearing price of £18/tC, see Defra (2002), 'The UK Emissions Trading Scheme: Auction Analysis and Progress Report', October.

reductions than a permit trading system. On the other hand, if climate change were to cause sudden changes in ecosystems (ie, a steep increase in marginal damage, triggered by an excess of a certain level of the stock pollutant), it would be important to achieve 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system',[25] and so a permit trading system would to be more optimal.

The Kyoto Protocol does not constrain the world's carbon emissions to a level that would achieve the United Nations Framework Convention on Climate Change (UNFCCC) goal of stabilisation and neither do the national climate programmes based on it (eg, the UK Climate Change Programme or the European Climate Change Programme (ECCP)). The Climate Change Programme aims to 'make sure that the UK delivers its legally binding Kyoto target and moves towards its domestic goal' and 'to prepare the UK for the fundamental changes that will be needed in the longer term to meet the challenge of climate change' (Defra, 2002). Similarly, 'the goal of the ECCP is to identify and develop all the necessary elements of an EU strategy to implement the Kyoto Protocol' (Communication from the European Commission).

The Kyoto Protocol, the UK Climate Change Programme and the European ECCP all have fixed the quantity of emissions, and not the price, and opted, among other instruments, for emissions trading to reduce emissions efficiently. Yet the carbon constraint has been made without particular reference to a particular level of damage. If the goal was to make a small, contained effort, it might have been more efficient to fix the marginal abatement cost than the amount of emissions.

A possible explanation for this choice of permit trading without reference to a particular amount of damage is that the Kyoto Protocol Parties the UK and the EU aim to make greater emission reductions to achieve the long-term goal of the UNFCCC of stabilisation. The UNFCCC aim is rather based on the belief that the marginal damage curve is relatively steep, so emissions trading is the more efficient instrument. From that perspective, the advantage of allowance trading becomes greater because of the institutional learning that might enable more drastic emission reductions, which might achieve the UNFCCC stabilisation goal in the future.

The dynamics (effect over time) of a tax and a permit-trading system have been discussed in section 2.3. If marginal abatement costs decrease over time—for example, because the commercialisation of low carbon technologies result in lower costs—the optimal level of emissions would decrease. The conclusion from the literature is that a tax gives more incentives for innovation when set at the current optimal level, whereas an emissions trading system gives more incentives when set at the future level. In the case of the emissions trading introduced at the UN, EU and UK levels, the dynamic effects would be greatest when future targets are set at a level achievable after introduction of low carbon technologies. However, the uncertainties about the marginal abatement cost remain and

[25] United Nations Framework Convention on Climate Change, Article 3.

thus, a hybrid system, which puts a ceiling on the allowance price, could still be more efficient than the application of either a tax or a trading system. None of the emissions trading systems at the international, EU and UK level is designed as a pure hybrid system, however.

In conclusion, the long-term goal of the UNFCCC embodies the belief that the marginal damage curve is relatively steep and so an emissions trading system would probably be more efficient under uncertainty about the marginal abatement cost. In order to have sufficient incentive for innovation, targets should be set at future optimal levels of emissions, not at levels that are currently optimal. The emissions reductions agreed to in the Kyoto Protocol and implemented in the UK and European climate change programmes rather reflect the belief that the marginal damage curve is relatively flat; therefore, a tax might be more efficient under uncertainty about the abatement costs. As uncertainties are great, a hybrid system is probably the best choice as a long-term climate policy instrument. In the following paragraphs the actual UK policy mix is examined in more detail.

3.1.3 Complementarity of UK climate tax, trading and hybrid schemes

When combining tax and trading systems, as in the UK climate policy, it must be checked whether the coverage of emitters is complementary. This section analyses some of the efficiency features of the UK climate policy.

Tax and trading in UK climate policy

UK climate policy is made on three levels, international, EU and national. All three levels incorporate some kind of greenhouse gas emissions trading, but taxes only feature at the national level.

The three emissions trading systems are fundamentally different with respect to the agents they cover.

- Emissions trading under Article 6 of the Kyoto Protocol is emissions trading on a Party level. Parties to the Kyoto Protocol, (ie, countries and the EU) can exchange Assigned Amount Units (AAUs) to cover the country's greenhouse gas emissions as limited by the Protocol. Although Parties can decide to devolve the emissions trading system, the relevant scope of emissions trading under Kyoto is nationwide. The AAUs reside with the government.

- The EU ETS is allowance trading on an installation level. The greenhouse gas emissions from installations used for electricity generation, and for the making of steel, iron, glass, ceramics, paper and pulp have a mandatory target and are eligible for trading.

- The UK ETS is a voluntary emissions trading scheme based on companies and sectors. Direct participants can trade on the basis of their absolute emission reduction commitment via the incentive auction and other participants can trade on the basis of verified reductions from their CCAs on energy efficiency. The trading systems under the RO and the EEC cover electricity supply from renewable sources and energy savings from all energy sources respectively.

- The UK's CCL covers all industrial, commercial and public consumption of electricity, gas, coal and LPG, except where it is used in transport.

Table 3.1 summarises the coverage of the schemes. They are further analysed below.

Table 3.1: Comparison of international, EC and UK tax and trading systems

	Type of instrument	Type of fuel	Type of activity	Downstream/ upstream	Diffuse/point sources
Kyoto trading	Allowance trading	All	All	Country level	Both
EU ETS	Allowance trading	All fossil fuels	Energy-intensive industries (not chemicals and waste incineration)	Downstream for fossil fuels (upstream for electricity)	Point sources
UK ETS	Allowance trading	Fossil fuels and electricity	Industry, commerce and public institutions (not electricity generation and supply)	Downstream	Point sources
RO	Certificate trading	Electricity from renewable sources	Energy suppliers	Upstream (incentivised via suppliers)	Point sources
EEC	Certificate trading	Electricity, gas, coal and petrol	Energy suppliers	Downstream (incentivised via suppliers)	Diffuse sources
CCL	Energy tax	Electricity, gas, coal and LPG	Industry, commerce and public institutions (not electricity generation and supply)	Downstream	Point sources

Source: OXERA.

Emissions trading under the Kyoto Protocol is an exchange mechanism between governments. The relevant compliance measure is total emissions of the country. The fact that Kyoto trading is trading between governments has two consequences. First, Kyoto emissions trading is, of itself, unlikely to have the efficiency characteristics of a normal liquid market. It is more likely to involve a series of bilateral and multilateral deals in which AAUs are exchanged for funding programmes. The system’s safety valve is not a tax, as in the hybrid system, but rather exercise of a country’s sovereignty to renegotiate or withdraw from the Protocol when costs are too high. Second, the efficiency of emissions trading under the Kyoto Protocol depends on the instruments the governments use to reduce emissions. As the marginal abatement cost of a country is an aggregate of the marginal abatement costs of all greenhouse gas emitting installations and activities or entities, efficient Kyoto trading would imply that the AAU price is also the marginal abatement cost of the domestic measures. So to assess the efficiency of the Kyoto trading system, the efficiency of the tax and trading systems on the EU and the UK level which target those installations is most important.

The EU ETS is a pure emissions trading system based on mandatory targets for energy-intensive industries. The EU ETS has no safety valve, at least not in the form of a tax. The total penalty for non-compliance consists of the cost of the allowances which had not been surrendered, plus the penalty for each tonne of the CO_2 emissions for which no allowance was surrendered. As the cost of the allowances depends on the market allowance price, the total penalty for non-compliance varies with the allowance price and does not establish a ceiling to that allowance price. However, there is a legal safety valve foreseen in the EU ETS. A Member State can invoke force majeure when emissions targets cannot be met because of some unexpected event.

The UK climate policy targets downstream consumers of energy directly or via the energy suppliers, with the exception of the RO, which targets upstream electricity generation. The CCL and UK ETS involve all industrial, commercial and public consumers of energy. The EEC targets domestic energy consumption, as the obligation on suppliers is to carry out investments at the household level. Transport fuel consumption is taxed via excise duties. Together, the CCL, the UK ETS, the EEC and excise duties cover all energy consumption in the British economy, though not necessarily in an efficient way (see next sub-section).

UK climate policy contains a confusing mix of tax and trading systems. The RO, as source-specific trading system, acts as a tax on the consumption of electricity which is itself subject to a tax, and offers the option of tax exemption in exchange for a target in an allowance trading system. So there are two hybrid systems in the UK system which are partly overlapping, but neither of which directly involves greenhouse gases. The RO is a classic hybrid system applied to a technology commitment (not an emissions commitment). Electricity suppliers must supply a share of electricity from a particular type of source, but if the ROC price exceeds a certain ceiling, a tax can be paid instead. The cost of the RO is integrated in the price of electricity which is already taxed through the CCL. As the UK ETS allowance trading is voluntary but partly incentivised by the CCL through the CCAs, the UK ETS has the features of a hybrid system. First the CCL is set, but companies that think they can reduce energy consumption at lower cost can opt for the trading system.

The UK ETS is also partly incentivised through a subsidy in the form of the incentive auction. The subsidy is paid in return for emissions reduction commitments but companies that do better can sell into the ETS.

Efficiency of the UK policy instrument mix

The UK combination of tax and trading systems creates some inefficiencies. Three are discussed here. One more is presented in the next section.

A first inefficiency is that the UK ETS does not offer greater efficiency than a pure tax. Under uncertainty, the inefficiency of a tax consists of keeping the price fixed at a level which might not be optimal so too few or too much emissions reductions are made. A hybrid system can improve on that by letting the price vary in a permit trading system but providing a ceiling in case the allowance price rises inefficiently high. The CCA companies also have a ‘safety valve’ which is the cost of losing the exemption from the CCL. Unless the CCA company miscalculated its commitment under the CCA, the cost of allowances will always be less costly than losing the exemption.[26] So the allowance price can rise much higher than the CCL without any constraint. Alternatively, when the UK ETS allowance price is lower than the CCL, this is an indication of the fact that the marginal abatement cost is lower than the CCL. Thus, assuming an increasing marginal damage curve, more emissions would have been reduced under the CCL without CCAs and trading. In conclusion, the efficiency offered by a hybrid system is turned on its head in the case of the UK ETS: the price is uncapped when the cost is actually higher than expected, and when the cost is lower, the total emissions are capped at a total level lower than the CCL would have achieved. Hence, this inverse hybrid system does not offer an efficiency improvement in the face of uncertainty. On the contrary, it makes it worse.

Second, neither the CCL, the RO nor the EEC directly target greenhouse gases. The CCL taxes electricity without differentiating between the carbon content of the electricity generation (apart from the exemption for renewables). The EEC obliges investment in domestic energy savings without differentiating between the actual carbon emissions saved. So the CCL and the EEC target greenhouse gas reductions in an indirect way, failing to differentiate adequately between the carbon content of various fuels. The RO does target development of zero-carbon electricity generation but it is selective. Thus the RO, too, is inconsistent in its choice of low-carbon electricity generation.

Third, the separate trading systems involve an efficiency loss by the lack of convergence to a common carbon price. The implied carbon value of the EEC, the ROCs and the UK ETS allowance price are quite disparate and there is no opportunity for arbitrage.

The EU ETS scores better on all three points. Although it is not a hybrid system, it still has the efficiency features of a standard emissions trading scheme, unlike the inverse hybrid characteristics of the UK ETS system. Second, it measures performance on the basis of carbon content of emissions. And finally, it is more likely to develop a unified carbon price which reflects both the cost of the obligation in the EU and the world carbon price under the Kyoto mechanisms. In the future, the EU ETS can be expected to establish a carbon price for all industrial greenhouse gas emission reductions for the whole of the EU, depending on the environmental integrity of monitoring and measurement mechanisms for greenhouse gases other than CO_2 and sectors other than the ones currently included. The linking Directive, which is to be published in the first half of 2003, will link the EU ETS with the Joint Implementation and Clean Development Mechanism, and so the EU ETS allowance price would be expected to converge with the world price. Moreover, the linking Directive will also set the framework for selling credits from domestic projects in the EU ETS, which would enable other policy initiatives to be linked to the EU ETS.

[26] A numerical example shows why: assume a business with an annual electricity consumption of 1GWh. Its CCL liability is £4,300. Assume it agrees to a CCA with promises to save 5% of electricity, or 50MWh in return for the exemption of 80% (£3,440) but it only achieves 40MWh. Hence, the company needs to buy allowances for 10MWh or 4.3tCO_2. At an allowance price of £20/tCO_2, that would cost £86. The cost of losing the exemption for two years would be £6,880.

3.1.4 Incidence of tax and allowance prices and double regulation

The tax incidence describes who pays the policy. Here it will also show who faces the inventive to reduce emissions

The impact of a tax is analysed in economic theory by making a distinction between the income and the substitution effect of a tax. Assuming a normal good, the income effect from a tax means that consumption of the good decreases because there is less overall purchasing power available.[27] The substitution effect of the tax means that less of the particular good is consumed because the relative price of substitutes has decreased. For example, an increase in employer's National Insurance Contributions, a tax on labour, leads to a decrease in income and hence, to less employment. It also leads to a decrease in employment because labour is relatively more expensive than technology. The extent of these effects depends on the price elasticity of, in the example, labour and capital.

In case of an upstream tax, the incidence depends on the available substitutes at the various levels in the supply chain. If an input factor can be easily changed for another, a tax on an input factor will change the mode of production, without much impact on the price of the downstream product and on the demand for it. In this case, the substitution effect of a tax would be high and the income effect limited. If the input factor is essential, the cost of the tax will be (partially) passed through, leading to a higher product price to the end-consumer. The impact of the upstream tax is then dependent on the price elasticity of final demand for the product. The impact on product demand can again be split between the income and the substitution effect.

There is a difference between the incidence of a tax and the incidence of emissions trading on the basis of grandfathered allowances. The latter has the same substitution effect as a tax, but a reduced income effect. Because the allowance for the targeted emissions is obtained for free, a company only has to pay for emissions reductions and/or excess emissions. However, the substitution effect is the same because the relative price of the input factor or product includes the marginal allowance price. In case of an upstream emissions trading system, the impact of the allowance price through the supply chain on the relative price of the final products will be the same whether or not the allowances are grandfathered.

Direct gas and coal consumption in the domestic sector is only indirectly regulated through the EEC, whereas the consumption of electricity is taxed both directly and indirectly. Direct electricity, gas and coal consumption by industry, commerce and the public sector is taxed through the CCL. Electricity prices will also be increased through the EU ETS' inclusion of electricity generators, the RO and the EEC. Consequently, the price of electricity is increased by three climate policies, and the electricity cost to industry, commerce and public administrations is increased a fourth time by the CCL. The cost of CCL and CCA liabilities would be expected to be passed through partly in product prices to final consumers, so the cost of the CCL will also partly be borne by consumers.

[27] This ignores the backward-bending labour supply curve, which implies that, at some point, increasing taxation would not lead to less but to more labour supply because people need the income.

Double regulation[28]

The EU ETS, the RO, the EEC and the CCL all imply a mark-up to the consumer's electricity price. The same double regulation applies to the EEC and the CCL on gas. The question is, first, how the different instruments lead to double regulation, and, second, whether it makes the policy mix more inefficient.

The reason for the double regulation in case of the EEC is a preference for moving away from taxing the domestic sector and for spreading the cost of investments in household energy efficiency over all consumers. The double regulation arising from the EU ETS results from its application to greenhouse gas emissions from combustion installations instead of energy consumption. The double regulation associated with the RO comes from a policy to pick and boost some low-carbon technologies rather than rely on the financial incentive offered by exemption from the CCL.

Double or multiple regulation is not necessarily less efficient, although it may be in some circumstances. For example, when there are important information failures, directly targeting policy at particular consumers or activities can enhance the effect of the price incentive given elsewhere. This is implicit in claims by the energy efficiency lobby that people fail to exploit win-win technology improvements (see OXERA, 2003), but it remains to be proven that it is really the lack of information or other barriers rather than the cost of switching technologies which prevents people from switching. This could be caused for example, by the failure of landlords to invest in the energy efficiency of their tenants' properties. Also, when there are additional externalities downstream when the tax or trading system is applied upstream, there would be a reason to correct for those at the downstream level. However, it is not clear which additional externalities come from the consumption of electricity that would justify the CCL on electricity in addition to the EU ETS. Finally, the 'infant industry argument' (ie, the theory that a technology needs to gain critical mass before being competitive) could be used in support of some technologies for a limited period in time. This argument could, with some plausibility, be applied to the RO.[29]

3.1.5 Design of UK tax and trading systems: revenue and competition implications

The design of tax and trading systems can have important consequences for equity. Much depends on how potential revenue is spent. Competition issues and administrative considerations should also be taken into account when assessing the efficiency of an instrument. This section explores these issues.

Equity implications

The fact that the domestic sector's gas consumption is only indirectly regulated reflects an equity concern. The government has opted not to impose a direct burden on households, although the indirect burden of the climate policies remain. An alternative way of dealing

[28] The issue of double regulation is also analysed thoroughly in Sorrell, S. (2002), 'The Climate Confusion: Implications of the EU Emissions Trading Directive for the UK Climate Change Levy and Climate Change Agreements', November.
[29] Amongst academics, the infant industry argument is generally seen as flawed because, unless there are additional market failures, the market would support infant technologies even in the research stages prior to commercialisation.

with such equity concerns would have been to recycle revenues to the benefit of households. The EU and UK climate policies offer some revenue recycling options.

The CCL was made more or less revenue-neutral by a decrease of the employer's National Insurance Contributions by 0.3% after the launch of the CCL. The lower National Insurance Contributions could be justified by the double dividend argument—ie, that increasing taxation on activities with negative externalities, while lowering distortionary taxes, leads to a double efficiency improvement.[30] An extension of the CCL to households combined with a recycling of the revenue through a decrease in employee's National Insurance Contributions would yield a similar double dividend.

The EEC does not explicitly tax and recycle revenue, but by putting the obligation for investment in (poor) households' energy efficiency and spreading the cost over all consumers, it has the equity considerations as a prime purpose of its design.

Under the current common position by the Council of European environment ministers, the EU ETS would allow Member States to auction up to 10% of the allowances in the second period of compliance years 2008–12. This also raises the possibility of revenue recycling, but details will only emerge from the second National Allocation Plans mid-2006.

The revenue recycling of a buy-out fund works in the ROC market, but it is unclear how it would work on a European level. For example, suppose that the penalty in the EU ETS is a buy-out price. The funds could be national or European. The problem with national funds is that, if the monies are returned in proportion to allowances surrendered in compliance with the EU ETS, a different price incentive would emerge in each EU country, and so the scheme would loose efficiency. Another way of recycling the revenue nationally would be required or, alternatively, the buy-out monies could go into a common European buy-out fund. However, in the latter case, the buy-out monies would need to be collected by the national government and then transferred to the EC, because the EC cannot levy taxes itself. If this were to be agreed, the revenue from the fund could be returned to allowance holders. However, with over 3,000 installations under the scheme, and possibly more eventually, the administration could be quite costly. There is no scope for double-dividend-type recycling as no taxes are levied at the European level, except that the money could be used to offset national contributions to the European budget. This exploration of a hypothetical European hybrid scheme shows that it is more complex than a national scheme.

New entry and competition

The barriers to new entrants are often cited as an argument against auctioning of allowances. When allowances are auctioned, new entrants need to buy their permits just as incumbents do. This is only the case, however, when *all* allowances are auctioned. If only a percentage of allowances is auctioned, an incumbent will face a lesser financial burden than a new entrant, unless it also received grandfathered allowances.

[30] Note that the double dividend argument would be more convincing if the CCL had been a carbon tax as the benefit for the environment would have been more explicit.

The case for auctioning in the EU ETS, or more generally, for taxing rather than imposing mandatory targets in a cap and trade system, should be made on equity grounds, and not on efficiency grounds. In a liquid market with many small buyers and sellers, like the EU ETS, there is no efficiency impact, however. All players, incumbents and new entrants are price-takers and would not be able to influence the price of allowances. The impact of auctioning is therefore purely distributional.

Transaction and administration costs

Low transaction costs are important for preserving the efficiency of a permit-trading system. The higher the transaction costs, the fewer trades and the more the initial allocation determines the final allocation. While the market must be liquid and involve sufficient buyers and sellers, there should not be too many small buyers and sellers. Expansion of the EU ETS to diffuse emitters (ie, small-and medium-sized enterprises), transport and households, would make the scheme administratively complex, hard to enforce and hence, less credible. Trading is therefore unlikely to be the most efficient option for the domestic, transport and commerce sector. Diffuse emitters of greenhouse gases could be subject to a carbon tax, with the revenue recycled as a reduction of other taxes.

A combination of a hybrid emissions trading system for point sources, alongside a carbon tax for diffuse sources, emerges as a likely optimal policy mix. It reflects the efficiency advantages of a hybrid system and the administrative complexity of such a scheme for small emitters.

Finally, administration and transaction costs should be taken into account when designing more complex tax and trading systems. The more complex a tax, the higher the cost of administrating it. Some schemes might not be implemented, although they could be more efficient, for that reason, (eg, sliding-scale-type schemes).

3.2 Waste policy

In recent years, waste policy has seen both taxation and permit trading introduced as a means of addressing environmental externalities. The landfill tax and the biodegradable municipal waste (BMW) allowance trading are discussed below.

3.2.1 Policy context

Current waste policy is mainly driven by the need to achieve the targets of the European Landfill Directive, rather than by a policy goal to internalise the externalities of different waste-disposal routes.

The Landfill Directive requires, among other things, Member States to develop a strategy to reduce BMW going to landfill. The Directive sets the following targets:

- by 2010, BMW must be reduced to 75% of the total amount of BMW produced in 1995; then
- by 2013, 50%; and

- by 2020, 35%.

The Landfill Directive has been transposed in UK law through the Landfill (England and Wales) Regulations 2002.[31] The Waste and Emissions Trading Bill, introduced into the House of Lords in January 2003, outlines the BMW allowance trading system, which aims to meet the Landfill Directive BMW targets.

The landfill tax was introduced by the Chancellor of the Exchequer in 1996 at a rate of £7/tonne for active waste and £2/tonne for inactive waste. In 1999, the Chancellor announced that the tax would increase annually by £1/tonne until 2004. In 2004, the tax rate will stand at £15/tonne. The recent Strategy Unit report on waste recommends an increase of the landfill tax up to £35/tonne in the medium term (Strategy Unit, 2002)

The government's waste strategy also differentiates between recycling and composting and waste recovery. In the waste hierarchy, waste reduction is the first aim, followed by re-use, recycling and composting, waste recovery, landfill with waste recovery and landfill (in that order). It is not clear whether this hierarchy is justified by cost–benefit analysis.

3.2.2 Instruments and uncertainty

The landfill tax and the BMW allowance trading can be analysed in the framework of the marginal damage and marginal abatement cost graphs shown in section 2.2.

The marginal damage of landfill has been researched by CSERGE. The total externalities, excluding disamenity costs, were found to be in the range of £3.5–£4.1/tonne of waste for sites without energy recovery and 1–1.7 tonne for sites with energy recovery (CSERGE et al., 1993) A recent study put the disamenity value of landfill at £1.52–£2.18/tonne of waste landfilled (see Defra, 2003). The marginal damage curve could be assumed to be quite flat, though rising over time as society's tolerance to environmental disamenities decrease as society becomes wealthier over time.

These values can compare with the current landfill tax level of £14/tonne for active waste at which little diversion takes place, and the BMW diversion target of 25% from 1995 levels by 2010. Given the evidence for low level of substitution delivered by the landfill tax, the BMW diversion can be expected to cost substantially more than the estimate of the external costs of the landfill. There might be additional benefits from diverting waste from landfill, attached to recycling or recovery. However, it would need to be shown that the benefits are not captured in the value of the resource recovered, nor already subject to another instrument.

Applying Weitzman's conclusions (see section 2.3) to the case of landfill of waste, a tax could serve as the more efficient instrument under uncertainty, given the relatively flat marginal damage curve and the seemingly steep marginal abatement costs. As with climate change, the question is whether abatement costs could be substantially lower in the future. If so, a tax set at the current optimal level should give incentives for innovation, and a

[31] Statutory Instrument No. 1559, Landfill (England and Wales) Regulations 2002.

trading system should be based on the optimal amount of emissions in the future. Combined with an incineration tax, set at the level of the externality from incineration, this would lead to an optimal allocation of waste to landfill. The tax rates should be set at the level of the externality.

However, even at the current landfill tax rate, which is much higher than the estimated value of the externality costs of landfill, the targets of the Landfill Directive will not be met. Therefore, these targets do not appear to be justified under a cost–benefit analysis. However, non-compliance with the Landfill Directive could lead to fines of up to £180m a year. Although these sums represent no environmental damages, they do imply possibly real expenditures against which the marginal abatement costs should be measured. A BMW allowance trading system seems the optimal instrument to achieve the Landfill Directive targets.

The scope for combination of the two instruments in a hybrid scheme seems limited in the case of BMW, given that no relief from the target is foreseen in the Landfill Directive

3.2.3 Sources under the scheme

A further examination of the sources under the landfill tax and the BMW trading scheme illustrates the inefficiency introduced by the Landfill Directive targets.

The BMW trading scheme sets absolute targets to waste-disposal authorities (WDAs) on the amount of BMW going to landfill. The landfill tax is a tax levied on the amount of waste disposed in a particular landfill site. The tax is paid by landfill operators, who charge it to WDAs.

The WDAs are facing a landfill tax on all waste to landfill, and in addition, an allowance price when the waste concerned is BMW. The addition of BMW selects one type of waste to be diverted. This can only be efficient if there are clear additional externalities from BMW compared with any other type of waste. If this were to be the case, efficiency would require a mechanism to relate the value of the diversion of both streams of waste to the actual additional externality they produce.

3.2.4 Tax and allowance price incidence

The incentives generated by the landfill tax and BMW trading, by the way they are financed, are likely to have an impact only on the lower levels of the waste hierarchy (dealing with waste disposal), and to have no effect on waste minimisation and re-use.

As discussed above, the WDAs face the direct incentives created by the landfill tax and the BMW allowance trading. However, they are not the agents creating waste. For the incentive to extend to waste reduction and re-use, the price signal given by the tax and by the allowance price would need to be passed on to households. For the incentive to be efficient so that both income and substitution effects work and along the waste chain, the price signal would need to be made as explicit to households as to WDAs.

The question then is which instrument would best be used to extend the incentive to households and business? Households are diffuse polluters, so allowance trading is unlikely to be an efficient instrument for incentivising households as the transaction costs for doing trades, and administration costs for monitoring and enforcement would be too high. Hence, a waste tax based on the externality created for waste, or, more consistent with current policy, a charge based on the cost of disposal, the landfill tax and the BMW allowance price to WDAs, would be the most efficient instrument, if it could be enforced.

The question arises concerning the appropriate level for incentives to deliver the waste strategy. As incentives would need to reflect the type of disposal and the amount of waste produced, it is necessary to introduce them downstream, at the point of disposal.

3.2.5 Tax and BMW trading design: revenue implications and transaction costs

This section examines briefly the prospects for revenue recycling, market liquidity and administrative costs.

Equity concerns probably play a role in the decision not to charge households directly for waste. However, a waste tax may be progressive, since waste volumes increase with consumption, which suggests that poorer households generate less waste. Whether that leaves them worse off than under the current financing arrangements, which already have a progressive structure, is relevant but beyond the scope of this paper. Revenue recycling could address equity concerns as shown in the analysis of climate policy.

The landfill tax generates revenue which is partly used to decrease National Insurance Contributions and partly to invest in environmental services through the Landfill Tax Credit Scheme (LCTS). The National Insurance Contributions reduction creates a double dividend. It is less likely, however, that the LTCS delivers a double dividend. The Scheme has been criticised for its poor performance (see Strategy Unit, 2002, p. 103). When such projects do not pass a cost–benefit test, the tax revenue is being used sub-optimally.

The BMW allowances are grandfathered to the WDAs. This makes sense as the WDAs are publicly funded. Ideally, the allowance price would be reflected in direct waste charging to households with the most elastic demand for waste services.

Administration and transaction costs, on the other hand, do not seem to be high. The BMW allowance trading scheme is a straightforward design and the agents can be expected to have a sufficient degree of understanding of it. In the case of the landfill tax, no administrative problems seem to have arisen, although some complexity is created by the LCTS.

4. Conclusions

This paper reached the following conclusions on the basis of the literature review.

- The efficiency losses from taxes or permit-trading systems under uncertainty about the marginal damage are identical.

- The optimal instrument choice under uncertainty about the marginal abatement costs is dependent on the relative steepness of the marginal damage curve. When the curve is relatively steep (flat), a tax leads to greater (less) efficiency loss than a permit-trading system.

- A hybrid system (ie, a permit-trading system with an upper price ceiling set by a tax and, potentially, a lower price floor, set by a subsidy) is more efficient than either a tax or a permit-trading system. The tax ceiling should be set above the rate that would have been used for a pure tax.

- If marginal abatement costs are expected to decrease over time, a tax gives greater incentives for innovation than a permit trading system if the tax or total quantity is set at the current optimum. If the tax or total quantity is set at the future optimum, permit trading gives greater incentives for innovation.

- A sliding scale approach offers even greater efficiency because it approximates the marginal damage function more accurately and it does so by allocating tranches of permits which have a different tax or subsidy attached to them. However it may be administratively costly.

- Tax and trading systems can be designed so that revenue implications are equivalent (eg, when all permits are auctioned). Tax and trading systems can also be designed to be revenue-neutral. Revenue can be used as part of general taxation, including for tackling market failures which impede responsiveness to the tax where such measure passes a cost-benefit test.

- Grandfathering perpetual permits leads to barriers to new entry and hence, gives incumbents an advantage. However, the problem can be mitigated by issuing permits with an expiry date, holding back a number of permits to allocate to new entrants, and having a liquid market in which all incumbents and new entrants are price-takers.

- Trading and hybrid systems imply costs of search and information, bargaining, decision-making, monitoring and enforcement. Taxes have lower costs if there are many agents and a convenient tax base is available. Trading systems can have lower costs in other situations. High transaction costs can lead to less trade in permits and higher abatement costs.

The application of this literature leads to the following conclusions to the current climate policy.

- The United Nations Framework Convention on Climate Change anticipates a marginal damage curve that rises relatively steeply, suggesting that emissions trading may be a more optimal instrument than a tax. The Kyoto Protocol and the consequent UK and EU climate programmes have all included emissions trading as a policy instrument, although the targeted greenhouse gas emission reductions do not yet reflect a relatively steeply rising marginal damage curve nor are they set at the future optimum level, limiting incentives for innovation.

- Given the high uncertainties about marginal abatement costs, hybrid systems could bring large efficiency gains.

- The UK climate policies combine several instruments inefficiently. At point sources, fossil fuel consumption is taxed directly via the CCL, with the exception of electricity generation which is taxed indirectly via the CCL and the RO, and also directly when the EU ETS enters into force. Oil consumption by diffuse sources is taxed directly via excise duties. Electricity and gas consumption are taxed indirectly via the EEC.

- The UK climate policies include three inefficiencies compared with optimal carbon taxation or emissions trading: first, the inverse hybrid CCL system does not cap the allowance price when it is high and caps the quantity when the allowance price is low; second, neither the CCL, nor the RO nor the EEC distinguish adequately between the carbon content of the energy types; and, third, there is no mechanism to let the implied carbon prices converge to an optimal level across energy types and sectors. The EU ETS avoids these inefficiencies but has no price ceiling.

- The UK climate policy mix, including the EU ETS, leads to multiple regulation of electricity and double regulation of gas. Double regulation could be efficient in the case of informational failures, different levels of externalities upstream, in downstream and/or infant industry situations, or to address equity concerns.

- Only the CCL and the auction of a limited amount of allowance under the EU ETS offer the prospect of revenue raising and recycling.

Efficiency improvements to the current climate policy could be made:

- by extending the EU ETS to all point sources, and turning the CCL into a carbon tax on fossil fuel consumption of all non-trading sources. The split between trading and non-trading source marks a point where administration and transaction costs would become too high. Turning the EU ETS into a hybrid scheme might also be difficult to administrate, but is likely to be an efficient improvement;
- by turning the CCL into an EU economy-wide carbon tax. This option is potentially less efficient than a hybrid scheme but has the advantage of having the same carbon value for trading and non-trading sectors;
- by turning the EU ETS into an hybrid system at the point of extraction or importation of fossil fuels. Although administrative costs would be lower than for the current ETS, the limited numbers of players would possibly result in reduced market liquidity and market power.

The analysis interaction of the tax and trading systems in the waste market has led to the following conclusions:

- the relatively flat damage curve favours a tax approach rather than emissions trading;
- the Landfill Directive, the targets of which would not pass a cost–benefit analysis, does, however, create a strong argument for BMW allowance trading;

- the efficiency of the combined landfill tax and BMW allowance trading depends on whether there are additional externalities for BMW, and whether price signals are passed on from WDAs to households and businesses;
- households and small business are diffuse polluters, so a tax or charge would be the more administratively efficient instrument;
- revenue recycling could address the equity issues that arise when extending the price signal to households and business.

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