# Emission Taxes and Tradable Permits:
# A Comparison of Views on Long Run Efficiency

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ABSTRACT: *We compare three different views on the long run efficiencies of emission taxes which include thresholds, and of tradable emission permits where some permits are initially free. The differences are caused by different assumptions about whether thresholds and free permits should be subsidies given only to firms that produce, or full property rights. Treating tax thresholds, as well as free permits, as property rights would depart from the conventional view, but would allow greater flexibility in making economic instruments both efficient and acceptable. Such flexibility could be very important in achieving efficent control of greenhouse gas emissions.* (JEL H23, Q28)

## 1. Introduction

Do emission taxes and tradable emission permits have the same long run efficiency properties? How much inframarginal emissions should firms pay for, to maximise the efficiency of either of these instruments? The conventional view, summarised by Baumol and Oates (1988), is as follows. To achieve optimal exit of firms from an industry, and thus long run efficiency (maximisation of the net social benefits of abating emissions), firms must pay for all inframarginal emissions under a tax. But in contrast, some or all inframarginal emissions can remain uncharged under tradable permits, through the initial issue of free ('grandfathered') permits, without harming long run efficiency.

However, there are at least two dissenting views on long run efficiency. Such dissent matters for policy applications where, for reasons that do not involve exit-entry effects, the form of uncertainty about marginal costs and benefits makes tax (price-based) instruments significantly more efficient than permit (quantity-based) instruments (Weitzman 1974). Controlling greenhouse gas (GHG) emissions is probably such an application, for geophysical reasons noted by Pizer (2002) and summarised below; it is also the largest potential use of economic instruments of environmental policy. But if, following the conventional view, exit-entry efficiency requires all inframarginal emissions to be paid for under a tax, then an efficient, price-based instrument will be politically unacceptable, because such a tax takes large amounts of revenue away from emitters who have considerable political power. On the other hand, if one of the dissenting views is followed, and inframarginal GHG emissions can be exempted from taxation without harming exit-entry efficiency, then large revenue transfers can be avoided, and efficient, price-based control can thus be made acceptable.

The GHG case thus motivates this paper, but it does not restrict the analysis, which can apply to many different emissions. Section 2 describes, but does not explain, the detailed disagreements among the conventional and two dissenting views about the long run (exit-entry) efficiency of taxes versus tradable permits. Section 3 explains the disagreements in terms of the underlying assumptions made about the charging of inframarginal emissions, and how this affects entry and exit. Section 4 discusses the possible merits of different assumptions, with particular reference to GHG (essentially carbon dioxide) emissions, and Section 5 concludes.

As will already be clear, our framework is political economy: we hope to improve the efficiency (overall welfare outcomes) of the environmental policies that are actually chosen and promoted by the political process. The formal analysis will abstract from many issues which influence such choices. These include innovation, uncertainty, trade, stranded capital, employment, general equilibrium effects of raising and refunding revenue, and hybrid mixtures of taxes and tradable permits.[1] However, a brief mention of the last two issues is relevant at the outset. First, there has been much debate in recent years about the general equilibrium (often called 'double dividend') effects of tax and tradable permit schemes. Broadly, this debate has concluded that it is more efficient for all such schemes to charge for all inframarginal emissions, so that revenues thereby raised can be used to reduce existing distortionary taxes (see for example Goulder, Parry and Burtraw 1997, or Bovenberg 1999 for a review). This argument is quite different to the entry-exit effects which concern us here, so discussion of general equilibrium effects is deferred until much later. Second, it is well-

1. See for example Jensen and Rasmussen (2000), who estimate empirically all these issues except innovation, uncertainty and mixed instruments, for the case of controlling carbon dioxide emissions in Denmark.

known that a hybrid of taxes and tradable permits is possible and may be desirable under uncertainty (Roberts and Spence 1976; Baumol and Oates 1988, pp75-77). But for simplicity, discussion of this is deferred until the very end, and taxes and tradable permits are treated separately until then.

## 2. Three views on taxes versus tradable permits

The disagreements among the three views are most simply seen by starting with the 'uniform' case, which includes GHG emissions, where emissions from firms in different locations mix completely before having any environmental impact. The value of environmental damage $D$, caused by an industry of $n$ identical, perfectly competitive firms[2] each with a level $e$ of emissions (measured in say tonnes per year), then depends only on total emissions $ne$: $D(n,e) = D(ne)$.

The first, conventional view of the efficiency of taxes and tradable permits in the uniform case was laid down as the textbook approach by Baumol and Oates (1988, Chs. 12 and 14). It has been confirmed by recent texts such as Hanley et al. (1997, pp72-5 and 133-6), Lesser et al. (1997, pp157-9) and Xepapadeas (1997, pp16-9), and is taken as given by many non-economists (see for example Wiener 1999). It holds the following. Let the marginal damage cost of the desired level of total emissions be $t$ (measured for example in dollars per tonne). Let the general tax scheme be such that any firm with polluting emissions at level $e$ (measured for example in tonnes per year) pays the control authority at a rate

2. For our purposes, there is no loss of generality from assuming identical, competitive firms, even though identicalness actually eliminates the static efficiency advantage of economic over regulatory instruments. Before finally applying the findings here to any real cases, firm heterogeneity and market power would need to be considered.

$$t(e - e_0) \qquad (1)$$

dollars per year. The constant *threshold* $e_0$ is normally the level of inframarginal emissions which remains uncharged for; but it can also be 'supramarginal', for if $e_0 > e$, the authority pays the firm $t(e_0 - e)$ dollars per year. (Other possible names for $e_0$ in a tax system are 'allowance', 'baseline,' 'benchmark' or 'credit', though in normal practice a 'credit' excludes the supramarginal case.) The authority neutralises any spare revenue (or expenditure) that results from (1) by lump sum payments to (or taxes from) all consumers. The conventional view holds that long-run economic efficiency, with optimal output and emissions by both each firm and the industry, can be reached only if the threshold $e_0$ is zero for all firms, meaning a pure Pigovian tax (Baumol and Oates 1988, p228). Any positive threshold is held to create a subsidy worth $te_0 > 0$, which causes entrance by new firms, excessive industry size and total emissions, and hence long run (allocative) inefficiency.

However, this inefficiency result is held not to apply to the case of tradable emission permits, where a firm's payment (not necessarily to the control authority) is also given by (1), $t$ is the annual rental price of a perpetual permit,[3] and $e_0$ is the number of permits initially given free ('grandfathered') rather than auctioned to polluters. It is held that free permits do not affect exit-entry decisions, and long run efficiency is attained for any intermediate division between free and auctioned permits. A common variant of the conventional view is simply to ignore the possibility

3. A perpetual permit is for one tonne of emission per year forever. In a competitive market, the purchase (rather than annual rental) price of such a permit would be $t/r$, where $r$ is the annual interest rate.

of a positive $e_0$ in the case of taxes, but to fully accept it for tradable permits.[4]

A second, less common view was proposed by Carlton and Loury (1980) for taxes (which were actually on output not emissions, but the same result holds for emission taxes), and by Kling and Zhao (2000) for tradable emission permits. According to the latter's analysis, which we revisit below, "auctioned and free permits have different long-run [allocative] efficiency implications"; and "For uniformly mixed pollutants [including the problems of global warming, ozone depletion and acid rain]...*all permits should be auctioned"* (italics added).[5] This advice is radically different from the grandfathering of permits that actually happened under the U.S. sulphur trading program set up by the 1990 Clean Air Act Amendments, as analysed for example by Joskow and Schmalensee (1998) and Stavins (1998). It is also poles apart from current plans in many countries for implementing the Kyoto Protocol. Variants of the second view are found in Cramton and Kerr (1999), who argued for fully auctioned permits, but for reasons of transaction efficiency (to avoid the rent-seeking costs of deciding on the distribution of permits) and equity, rather than allocative efficiency; and in Spulber (1985), who considered only pure Pigovian taxes and fully auctioned permits, for reasons of equity.

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4. See for example Ekins and Barker (2001, p330): "In any scheme, a proportion of permits can be auctioned and the rest allocated free of charge: this flexibility gives permit schemes an advantage over corresponding carbon taxation where, conventionally, all revenues are received by governments."

5. The analogous result in Carlton and Loury is Theorem 3, though they mainly emphasised other theorems which hold for non-uniform pollution, when damage cannot be written as $D(n,e) = D(ne)$.

The third, also minority, view on the long run efficiency of taxes versus tradable permits was proposed by Pezzey (1992) and Farrow (1995, 1999). They independently claimed that payment (1) can achieve long run allocative efficiency, for both taxes and tradable permits, irrespective of the value of $e_0$. This then allows either tax thresholds or free permits to be distributed flexibly, by whatever criterion is needed to secure political adoption of either economic instrument. However, if the criterion is effectively that the instrument should leave an industry's profits unchanged, this need not mean giving thresholds or free permits to cover all of the controlled level of emissions. In the case of carbon dioxide emissions, Pezzey and Park (1998) noted that carbon-fuel suppliers as a whole have considerable market power, and hence will enjoy large rents if given free permits for all their carbon sales while total carbon sales are simultaneously cut back by the permit scheme. Bovenberg and Goulder (2000) quantified this idea using a computable general equilibrium of the US economy, and found that carbon suppliers need only a small fraction of their required tradable permits to be free, in order for the permit policy to leave their profits unchanged.

## 3. The different assumptions underlying each view

Which of the three views is right? All of them are, in that all of them draw correct conclusions from their underlying (though sometimes implicit) assumptions. It is the difference in assumptions that explains the difference in views. To show this, let us first clarify two different ways to apply the economic instrument defined by (1):

(a) $te_0$ can be a *lump sum subsidy*, that a firm gets if, and only if, it produces output. A lump sum subsidy thus adds $te_0$ to any existing or new firm's economic profit, defined as the financial difference between producing and not producing.

(b) $te_0$ can be a *lump sum property right*, that an existing firm (defined as a legal entity, not as a production facility) gets, but any new firm does not get, whether or not either type of firm produces output.[6] As analysis below will remind us, a lump sum right has no effect on a firm's economic profit from producing, in the same way that the amount of land that a competitive firm owns, rather than rents, has no effect.

With this terminology, the differences between the assumptions made about $te_0$ by the three views can be summarised in the following table.

<table>
<tr><td></td><td></td><td colspan="3">Treatment of lump sum $te_0$ by:</td></tr>
<tr><td></td><td></td><td>Conventional view (e.g. Baumol and Oates 1988)</td><td>Carlton & Loury (1980) (taxes) Kling & Zhao (2000) (permits)</td><td>Pezzey (1992), Farrow (1995, 1999)</td></tr>
<tr><td rowspan="2">Treatment of lump sum $te_0$ in:</td><td>Emission taxes</td><td>As a subsidy</td><td>As a subsidy</td><td>As a property right</td></tr>
<tr><td>Tradable emission permits</td><td>As a property right</td><td>As a subsidy</td><td>As a property right</td></tr>
</table>

6. By 'property right', it is understood that $e_0$ would have good characteristics in all six dimensions listed by Devlin and Grafton (1998, Ch. 3): exclusivity, quality of title, durability, transferability, divisibility and flexibility. In this context, it is perhaps unfortunate that Pezzey (1992) referred to payments made when emissions fall below a property right threshold as 'subsidies'.

The conventional view's asymmetry of assumptions explains its asymmetric conclusion about taxes versus tradable permits. If instead it treated free permits as a subsidy available to all producing firms, then $te_0$ would be added to a firm's economic profit, free permits would cause excessive firm entry, and the Carlton/Kling results would follow. Or if instead the conventional view treated a tax threshold as a property right and not a subsidy, then the sum $te_0$ would disappear from a firm's economic profit, long run efficiency would be restored, and the Pezzey/Farrow results would follow.

A further insight, which also brings in the case of non-uniform pollution, comes from combining the Pezzey/Farrow and Kling and Zhao approaches as follows. Let $e_0$ in (1) be treated as a property right for each firm, independent of whether or not it produces, as in Pezzey or Farrow. Now add an extra policy instrument, a subsidy level $e_1$ that each firm gets only if it produces, as in Kling and Zhao, except that we apply the combined scheme to either taxes or tradable permits. Each firm's payment for emission level $e(q,a)$, where $q$ is its output and $a$ its abatement effort, is then

$$t[e(q,a)-e_0-e_1]. \tag{2}$$

If $n$ is the number of firms as before, $P(nq)$ is the industry's product price, and $c(q,a)$ is each firm's total cost of output, then a producing firm's *accounting* profit is $P(nq)q - c(q,a) - t[e(q,a)-e_0-e_1]$. However, the right $e_0$ is valuable whether or not the firm produces, so the accounting profit if the firm shuts down is $te_0$, *not* zero. (The profit $te_0$ would come either from payments by the control authority in the tax case, or from the firm renting out its unused permits.) The *economic* profit from producing, used to make entry-exit decisions, is then the difference between these two sums:

$$\pi = P(nq)q - c(q,a) - t[e(q,a)-e_1]. \tag{3}$$

The equilibrium of an industry of price-taking firms is given by $\pi = 0$,

$$\partial\pi/\partial q \quad = P(nq) - c_q(q,a) - te_q(q,a) = 0, \text{ and} \tag{4}$$

$$-\partial\pi/\partial a \quad = c_a(q,a) + te_a(q,a) = 0. \tag{5}$$

If the total cost of environmental damage is $D(n,e)$, more general than the $D(ne)$ assumed above in Section 2, then the government's optimisation problem (ignoring general equilibrium efficiency effects from revenue raised) is to choose policies so that the resulting $q$, $a$ and $n$ maximise the social surplus $u(q,a,n) := \int_0^{nq} P(x)dx - nc(q,a) - D(n,e(q,a))$. This requires the first order conditions

$$(\partial u/\partial q)/n \quad = P(nq) - c_q(q,a) - D_e(n,e)e_q(q,a)/n = 0 \tag{6}$$

$$-(\partial u/\partial a)/n \quad = c_a(q,a) + D_e(n,e)e_a(q,a)/n = 0 \tag{7}$$

$$\partial u/\partial n \quad = P(nq)q - c(q,a) - D_n(n,e) = 0 \tag{8}$$

Comparing the two sets of conditions ($\pi = 0$ and (4)-(5), with (6)-(8)), it is straightforward to show that the optimal government policy is

$$t^* = D_e/n; \qquad e_0^* \text{ is indeterminate}; \qquad e_1^* = (1 - \varepsilon_n^D/\varepsilon_e^D)\, e^*. \tag{9}$$

Here, $e^*$ is the optimal level of emissions per firm; $q$, $a$ and $n$ are implicitly also at their optimal levels; and the elasticities of pollution damage with respect to each firm's emission, and to the number of firms, are respectively defined as in Kling and Zhao:

$$\varepsilon_e^D(n,e) := D_e(n,e) \,/\, [D(n,e)/e]; \qquad \varepsilon_n^D(n,e) := D_n(n,e) \,/\, [D(n,e)/n]. \tag{10}$$

The efficient *and acceptable* policy thus has three elements:

(i) a per unit emission price $t^*$ as in (9). This is created directly by a tax, or indirectly by the market price of a tradable permit;

(ii) an emission right $e_0^*$. This should be set flexibly, and perhaps individually, for existing firms, at whatever intermediate value $0 \leq$

$e_0^* \leq e^*$ is acceptable (not just the extreme values $e_0^* = 0$ or $e_0^* = e^*$), given the balance of political, and general equilibrium efficiency, considerations. However, $e_0^*$ should be zero for all new firms. The political considerations should include the effects of the industry's market power, noted at the end of Section 2 but omitted from the above model; and also perhaps the (distortionary, but persuasive) case for raising some revenue that is 'earmarked' for public spending on emissions abatement (see for example Teja and Bracewell-Milnes 1991 and Wilkinson 1994). The general equilibrium efficiency consideration is the 'double dividend' effect, noted in the Introduction but also omitted from our model, whereby lowering $e_0^*$, and thus raising more revenue to spend on reducing existing, non-environmental taxes, raises overall welfare. A final consideration is to create and distribute the rights $e_0^*$ on some historical basis, to minimise the rent-seeking costs that any legislative process of defining scheme (2) will inevitably generate;

(iii) an emission subsidy level $e_1^*$ (perhaps negative, since $\varepsilon_n^D > \varepsilon_e^D$ can happen, for example in the case of concave local damage, where $D(n,e) = nd(e)$, $d'(e) > 0$ and $d''(e) < 0$). The formula for $e_1^*$ in (9) is from Kling and Zhao, and it corrects for the difference between the number of firms and emissions per firm in determining total pollution damage.

In the case of uniformly mixed pollution (where $D = D(ne)$, as with GHGs), $\varepsilon_e^D = \varepsilon_n^D$, so by (10), the optimal subsidy level $e_1^*$ is zero. However, the emission right $e_0^*$ remains a vital tool, crucially affected by political considerations, to ensure that an economic approach to pollution control is acceptable and thus actually adopted.[7]

## 4. Discussion of assumptions made about tax thresholds or free permits

In this section, we aim to compare objectively the assumptions, clarified by the above analysis, that underlie the three views about taxes and tradable permits. This comparison focuses especially on the expected administrative, political and economic characteristics of a control instrument which was analysed above but does not yet exist in practice: the emission tax threshold which is a property right rather than a subsidy. Our conclusion is simple but contentious, and is worth stating now: Rather than being written off as counterintuitive, or impossible because it has never yet been implemented, the tax-threshold-as-property-right, an idea first proposed by Mumy (1980), deserves further investigation, particularly for GHG control.

The first step towards this conclusion is to argue that whenever institutional assumptions are made about treating tax thresholds or free permits as subsidies or property rights, they should be explicit. The assumption that a positive emission tax threshold $e_0$ in (1) lowers a firm's average cost, and hence gives a higher profit which encourages firm entry (see for example Baumol and Oates, pp 218-20), is widespread, but is often implicit. It amounts to a decision to treat the tax threshold as a (production-

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7. For the uniform pollution case (i.e. with $e_1^* = 0$), it has been shown (for example by Goulder, Parry and Burtraw 1997) that if marginal environmental benefits are below some critical value, then as a result of general equilibrium effects, even a small amount of abatement using a non-revenue-raising instrument (where $e_0^* = e^*$) reduces efficiency. In such a case, it might be that no level of $e_0^*$ can be found, for either taxes or permits, that is both acceptable, and results in (2) improving efficiency.

dependent) subsidy, while the same author often treats free tradable permits as property rights. This decision should be clarified and explained: it may be a good description of how current tax and permit schemes work, but they need not work that way forever.

The next step is to compare the second view of taxes and permits against the first, conventional view. Should free tradable permits be treated as subsidies, and thus cause excessive entry and long run inefficiency, as Kling and Zhao assume? Such treatment is always possible, and indeed it happened in the US lead trading program of the 1980s. Then, firms received permits based explicitly on their current output level, and thus had an incentive to stay in business to collect the implicit subsidy generated by free permits. But unless the efficiency loss from such entry-exit distortion is smaller than the cost savings from not having to administer permits owned by firms no longer producing, there is no need to create such a scheme. Indeed, the US sulphur allowance trading scheme that started in 1990, already mentioned in Section 2, effectively (if not legally) treats free permits as property rights rather than as subsidies.

The third step in our argument is about the empirical relevance of tax thresholds to GHG control, economically the world's biggest pollution control problem. Though there is great uncertainty about both the costs and benefits of control, the stock effect caused by the long atmospheric lives of most GHGs almost certainly makes the marginal benefit cost curve much flatter than the marginal control cost curve (Pizer 2002, Philibert 2002; and this argument may well also apply to other long-lived stock pollutants). Therefore, following Weitzman (1974), it would be better to use a tax-based instrument to control the price of GHG emissions, than to use permits to control the quantity of emissions. However, this observation has had no effect on the international debate on GHG control until recently. Arguably because of the conventional view of the efficiency of taxes versus tradable permits, widespread proposals for carbon taxes in the early 1990s considered only pure taxes, and ignored the possibility of tax thresholds. (As noted by Ekins and Speck 1999, many proposals exempted key emitters altogether, but that is different.) Political resistance to the amounts of revenue that such pure taxes would raise was too great to be overcome. So the 1997 Kyoto Protocol instead adopted tradable permits as the economic instrument of choice, because free permits obviously raise no revenue. However, the great uncertainty in the likely future permit price − precisely the point of the Weitzman analysis − seems to have been crucial in causing the effective withdrawal from the Protocol by the U.S.A., by far the world's largest GHG emitter, in 2001. The Kyoto-derived emphasis on permits still dominates much economic analysis of policy options (see for example Dewees 2001); and comparisons of GHG permits and taxes typically consider only pure taxes, albeit with tax revenue refunded by reduced income or other taxes (see for example Svendsen et al 2001). So the GHG case shows that it is indeed crucial for policy analysis to consider a full range of economic instruments, including taxes; and that making taxes politically acceptable requires the use of thresholds, to avoid the huge revenue transfers from well-organised, carbon-intensive industries that pure taxes cause.

The fourth and fifth arguments for at least investigating tax-thresholds-as-rights are defensive, and address their perceived or actual weaknesses in ways that go beyond allocative efficiency. The fourth tackles a common criticism of their possible administrative costs. For the control authority to pay out $te_0$ forever to firms that have shut down, as required by $e_0$ being a full property right, would obviously be costly to administer. This is particularly true if international transfers of rights are allowed, as might occur with GHG control. But it is not at all clear why such perpetual payment should be *infeasible*, as Baumol and Oates (1988, p216) suggested.

If a government can pay interest on perpetual bonds, a bank can pay interest forever on its accountholders' balances, and a limited company can pay dividends forever on its shareholders' balances, why cannot a pollution control authority pay at its currently chosen rate $t$ forever to legal holders of $e_0$ in emission tax thresholds?[8] But if such administration is indeed too expensive, then added rules, like a minimum holding size or maximum holding life for threshold owners which are not producing firms, could reduce the cost. Or, one could justifiably go further and make thresholds dependent on production like normal tax credits (so they are then no longer property rights), if the resulting loss of exit-entry efficiency is smaller than the saving achieved in administrative costs (Farrow 1999).

The fifth argument addresses not administrative, but net budgetary, cost to the authority. Such a cost would happen with a tax threshold scheme if average emissions per firm eventually fall below the average of the initial thresholds given to firms, making the average firm's 'payment' $t(e-e_0)$ large and negative (using the uniform formula (1) here for simplicity). This might well happen because the authority overestimates firms' emission control costs when initially setting $t$ and $e_0$; and it would be a serious comparative disadvantage of tax threshold schemes, since it does not happen with free permit schemes, where revenue neutrality is automatic. One could hope that budgetary cost could be avoided by initially setting $e_0$, the average threshold, low enough. In the GHG case it should be low anyway, to offset the monopoly power of carbon suppliers in the GHG case, as already noted. But

8. A further point is that, contrary to Baumol and Oates' suggestion, there is no need for "...potential entrants into the polluting activity [to] be eligible for the subsidy to prevent them from initiating waste generation simply to qualify for the lump sum payment". The rules of a thresholds-as-*rights* scheme would clearly rule out such a open-class qualification rule.

in competitive cases where such arguments do not apply, budgetary cost could be limited (or prevented, also as normal with tax credits) by instead departing from the pure scheme (1). One could for example replace (1) by:

$$\left.\begin{array}{lll} \text{the firm pays} & t(e-e_0) & \text{if } e \geq fe_0, \text{ for some } 0 < f \leq 1; \\ \text{but pays} & -t(1-f)e_0 & \text{if } e < fe_0. \end{array}\right) \tag{11}$$

This would limit the authority's maximum payment to a firm to $t(1-f)e_0$, and thus prevent payment altogether if $f = 1$. Such a limit would give some firms too little incentive to keep reducing emissions, so again some allocative efficiency is lost; but this might be justified if such loss is less than the welfare (and political) cost avoided of the authority having to raise other taxes to fund a net budgetary cost.

## 5. Conclusion: the need to consider a full range of instruments, and a full range of costs

Our aim has been to show that the differences among three distinct views, about the long run efficiencies of emission tax and tradable emission permit schemes, can be explained by different underlying assumptions made about the thresholds or free permits built into such schemes. Only if thresholds are treated as lump sum property rights rather than subsidies, can a tax-with-thresholds scheme achieve long run efficiency, and thus be added to the list of schemes which can be both efficient, and acceptable because they avoid raising too much revenue from politically powerful emitters. In the last section we built up an argument for taking such a thresholds-as-rights scheme seriously, by debating various aspects of institutional design.

However, we are arguing only for further investigation, not for definitely adopting a scheme of tax-with-thresholds-as-rights, even for the case of GHG emissions where the probable flatness of the marginal benefits of emission control favours price-based over quantity-based control. For one thing, we have already given administrative or budgetary cost reasons why the pure designs (1) and (2), which are allocatively efficient for uniform and non-uniform emissions respectively, may need to be modified. For another, there are doubtless important legal questions to be answered, jurisdiction by jurisdiction, of which we have said nothing. Lastly, there is a whole class of hybrid economic instruments of control, which we mentioned in the Introduction but have ignored since. It now deserves further comment.

Roberts and Spence (1976; see also Baumol and Oates pp.75-7) extended Weitzman's analysis of instrument choice under uncertainty, to show that a hybrid mixture of taxes and tradable permits is possible, and can be more efficient than either pure taxes or pure tradable permits. For the case of GHG control, McKibbin and Wilcoxen (1997a, 1997b) and Pizer (1997, 2002) have proposed such a hybrid system. Control would be by tradable permits, but permit price uncertainty would be capped by governments selling unlimited permits once some ceiling price is reached.[9] Pizer (2002), who follows the conventional view on tax thresholds, finds that

> "This system turns out to be only slightly more efficient than a pure tax system. However, it achieves this efficiency while preserving the political appeal of permits: the ability to flexibly distribute the rents associated with emission rights."

Such a mixed system may well turn out to be the most workable, efficient and acceptable system for some pollutants in some places. But we have argued that tax thresholds can also flexibly distribute the rents created by an

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9. The Roberts and Spence scheme also requires governments to buy permits once a floor price is reached, but this is omitted from recent proposals. Pizer gives the dynamic inefficiency of subsidies as a reason, citing the Baumol and Oates argument. We have contested this argument in Section 4; but even so, there would also be the problem of how governments would pay for such buying at the floor price.

emissions control policy, and so may deserve consideration for other pollutants and places. Our overall conclusion is that policy design needs to consider both a full range of instruments (taxes, permits, and hybrids of taxes and permits, with intermediate levels of tax thresholds or free permits, and possible limits on market incentives), and a full range of costs (allocative, administrative, and 'political'), before the best instrument for any particular application can be found.

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