



Emission Taxes and Tradeable 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 (inframarginal exemptions), and of tradeable 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 efficient control of greenhouse gas emissions.

Key words: efficiency, emission taxes, exemptions, thresholds, tradeable permits

JEL classification: H23, Q28

1. Introduction

Do emission taxes and tradeable 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 tradeable 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 the form of uncertainty about marginal costs and benefits makes tax (price-based) instruments significantly more efficient than permit (quantity-based) instruments, for reasons that do not involve exit-entry effects (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 (“market mechanisms”) of environmental policy. But if, following the conventional

view, exit-entry efficiency requires all inframarginal GHG emissions to be paid for under a tax, then an efficient, price-based instrument will be politically unacceptable, because such a tax takes too much 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 be made acceptable.

The GHG case thus motivates this paper, but it does not restrict the analysis, which can apply to many different emissions, or even to changes in price of resource commodities like energy and water. Section 2 describes, but does not explain, the disagreements among the conventional and two dissenting views about the long run (exit-entry) efficiency of taxes versus tradeable 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, the framework here is political economy: we seek to improve the efficiency (overall welfare outcomes) of the environmental policies that are actually chosen and promoted by the political process. In doing so we will assume the numerous “ideal” conditions listed in Pezzey (1992, p. 984), and thus will ignore many issues which influence policy choices. These include innovation, uncertainty, trade, stranded capital, employment, power in permit markets and imperfections in capital markets, financial option value effects, general equilibrium effects of raising and refunding revenue, and hybrid mixtures of taxes and tradeable 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 tradeable 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-known that a hybrid of taxes and tradeable permits is possible and may be desirable under uncertainty (Roberts and Spence 1976; Baumol and Oates 1988, pp. 75–77). But for simplicity, discussion of this is deferred until the very end, and taxes and tradeable permits are treated separately until then.

2. Three Views on Taxes *versus* Tradeable 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 firms² 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 tradeable 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, pp. 72–75 and 133–136), Lesser et al. (1997, pp. 157–159) and Xepapadeas (1997, pp. 16–19), and is taken as given by many non-economists (see for example, Wiener 1999). It holds the following. Let the marginal control cost of the target 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

$$t(e - e_0) \tag{1}$$

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 a “credit” normally 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 resulting combination of emissions level and price per emission unit is shown by point *A* on Figure 1. We suppose this combination is somehow desirable for society, either because e is an agreed target, or because the marginal damage cost of emissions is known to pass through *A*. We therefore call t the “full incentive rate” of the emission tax.

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, p. 228). 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. Such economists thus recommend there should be no tax threshold, keeping the tax pure. But we contend later that a pure emissions tax is often politically unacceptable at the full incentive level t . Only a much lower, less than desirable tax rate t' will be acceptable, resulting in higher than desirable emissions, $e' > e$, as shown by point *B* on Figure 1.

However, this inefficiency result is held not to apply to the case of tradeable emission permits, where a firm’s payment (not necessarily to the control authority) is also given by (1), with t being the annual rental price of a perpetual permit,³ and e_0 the number of permits initially given free (“grandfathered”) rather than auctioned to polluters.⁴ It is held that free permits do not affect exit-entry decisions, and long run efficiency is attained for any intermediate division ($0 < e_0 < e$) between free and auctioned permits. A common variant of the conventional view

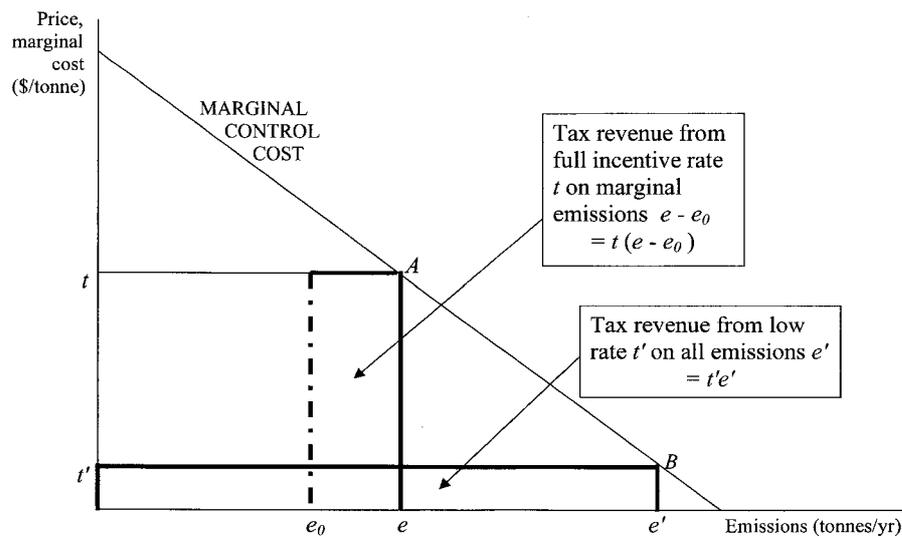


Figure 1. How exempting inframarginal emissions e_0 can make it politically acceptable to use the full incentive emission tax.

is simply to ignore the possibility of a positive e_0 in the case of taxes, but to fully accept it for tradeable permits.⁵

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 tradeable 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).⁶ 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.

The third, also minority, view on the long run efficiency of taxes versus tradeable 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 tradeable 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 this 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 (2001) quantified this idea using a computable general equilibrium of the U.S. economy, and found that carbon suppliers need only a small fraction of their required tradeable 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 payment te_0 in the economic instrument defined by (1):

- (a) te_0 can be a *subsidy*, that a firm gets if, and only if, it produces output. This 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 *property right payment*, 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.⁷ As analysis below will remind us, a payment for a 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.

		Treatment of payment te_0 by:		
		Conventional view (e.g., Baumol and Oates 1988)	Carlton & Loury (1980) (taxes) Kling & Zhao (2000) (permits)	Pezzey (1992), Farrow (1995, 1999)
Treatment of payment te_0 in:	Emission taxes	As a subsidy	As a subsidy	As a property right payment
	Tradeable emission permits	As a property right payment	As a subsidy	As a property right payment

The conventional view's asymmetry of assumptions explains its asymmetric conclusion about taxes versus tradeable permits. If instead it treated free permits as a subsidy base available to all producing firms, then te_0 would be added to a firm's economic profit, free permits would cause excessive 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 base, then te_0 would disappear from a firm's economic profit, long run efficiency would be restored, and the Pezzey/Farrow results 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 tradeable permits. Each firm's payment for emission level $e(q, a)$, where q is its output and a its abatement effort, is then

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

Let n be the number of firms as before, $P(nq)$ be the industry's product price, and $c(q, a)$ be each firm's total cost of output. Then given the "ideal conditions" assumed for our analysis, it is simple to show that a producing firm's economic profit, used to make entry-exit decisions, is

$$P(nq)q - c(q, a) - t[e(q, a) - e_1]. \quad (3)$$

Note that *the right e_0 does not appear* in (3), and so does not affect the entry-exit decision, because it is valuable whether or not the firm produces. A formal industry-level analysis along the lines of Kling and Zhao, with a more general emissions damage function $D(n, e)$, can then show that their formula (7) for the optimal subsidy level e_1^* , in terms of the optimal level of emissions e^* and the elasticities of pollution damage with respect to each firm's emission and to the number of firms, does of course still hold. (For the case of uniform emissions, where the two elasticities are equal, the optimal subsidy level e_1^* is then zero.) The analysis also shows that the optimal per unit emission price is $t^* = D_e/n$, the marginal damage of a unit of emissions. This price is created directly by the control authority in the case of an emission tax, or indirectly by the market price of tradeable emission permits.

But because the initially allocated level of free property rights e_0 is absent from (3), the industry-level analysis says nothing about what an "optimal" level, e_0^* , should be in (2) (or in (1)). Instead, e_0^* should be set flexibly, and perhaps individually, for existing firms, at whatever intermediate value $0 \leq e_0^* \leq e^*$ is acceptable given the balance of political, administrative, and general equilibrium efficiency, considerations. And it should *not* be confined to the "all or nothing" opposites of

$e_0^* = 0$ or $e_0^* = e^*$, so often seen in the literature as the only alternatives. 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; Wilkinson 1994). Administrative costs may preclude giving rights to millions of small polluters like households and motorists, but some other form of "compensation" will then no doubt prove necessary politically.⁹ The general equilibrium efficiency consideration is the "double dividend" effect, noted in the Introduction but also omitted above, 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 (1) or (2) will inevitably generate. All in all, the emission right e_0^* is a vital tool, crucially affected by political considerations, to ensure that an economic approach to pollution control is acceptable and thus actually adopted.¹⁰

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, underlying the three views about taxes and tradeable permits. This comparison focuses especially on the expected political, administrative and economic characteristics of the control instrument analysed above, which does not yet exist in practice: the tax threshold e_0 in (1) which is a property right, not a subsidy base. Our conclusion is simple but contentious, and 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 Mummy (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 made 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 1988, pp. 218–220), is widespread, but is often implicit. It amounts to a decision to treat the tax threshold as a (production-dependent) subsidy, while the same author often treats free tradeable 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 tradeable permits be regarded as subsidies, which cause excessive entry and long run inefficiency, as Kling and Zhao assume?

This is indeed what happened in the U.S. 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 U.S. 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 tradeable permits, widespread proposals for carbon taxes in the early 1990s, made most notably by the European Commission, considered only pure taxes and ignored the possibility of tax thresholds. Political resistance to the amounts of revenue that would be raised by pure taxes, if set at anything like full incentive rates, was too great to be overcome. So the 1997 Kyoto Protocol instead adopted tradeable permits as the economic instrument of choice, because of the obvious option using free permits to avoid raising revenue. But the great uncertainty in the likely future permit price – precisely the point of Weitzman's analysis – seems to have been crucial in causing the effective withdrawal in 2001 from the Protocol by the U.S.A., by far the world's largest GHG emitter. The Kyoto-derived emphasis on permits still dominates much economic analysis of policy options (see for example, Dewees 2001). Analyses of GHG taxes typically still consider only pure taxes, continuing the tradition set by landmark authors such as Buchanan and Tullock (1975) and Hahn (1989).

True, many analyses pay close attention to different ways of refunding the carbon tax revenue as reduced income or other taxes; see for example, Svendsen et al. (2001) and Felder and Schleiniger (2002). The latter, and also Ekins and Speck (1999), noted that some carbon taxes have been implemented in Northern Europe, but all schemes either give substantial exemptions to energy-intensive sectors, or use a low tax rate (as depicted by t' in Figure 1). But none of these writers considered the use of inframarginal carbon tax exemptions to avoid raising so much revenue in the first place.¹¹ 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 taxes will not be politically acceptable without exemptions, preferably of inframarginal rather than sectoral emissions, to avoid the huge revenue transfers from wellorganised, carbon-intensive industries that pure taxes cause.

The fourth and fifth steps in the argument for at least investigating taxthresholds-as-rights are defensive, and address their perceived or actual weaknesses in ways that go beyond allocative efficiency. The fourth step 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 clear why such perpetual payment should be *infeasible*, as Baumol and Oates (1988, p. 216) argued. 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 interest and dividends forever on its bonds and shares, why cannot a pollution control authority pay at its currently chosen rate t forever to legal holders of e_0 in emission tax thresholds?¹² 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 step in the 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" $t(e - e_0)$ in (1) large and negative. 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 disadvantage of tax threshold schemes compared to 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 in competitive cases where such arguments do not apply, budgetary cost could be limited by phasing out the e_0 thresholds over time, or making other departures from the pure scheme (1). One could for example replace (1) by:

$$\begin{array}{l} \text{the firm pays } t(e - e_0) \quad \text{if } e \geq e_0, \\ \text{but is paid } ft(e_0 - e) \quad \text{if } e < e_0, \text{ for some } 0 \leq f < 1 \end{array} \quad (4)$$

This would limit the authority's maximum payment to a firm to fte_0 . It would prevent payments altogether if $f = 0$, when e_0 would be like a conventional tax credit or allowance, except that it would not be available to new firms. Any limit $f < 1$ would give some firms too little incentive to keep reducing emissions, so

again some allocative efficiency is lost. But this loss might be necessary, given the legal (and political) constraints on the authority, and in any case could be greatly outweighed by the efficiency gain from having some emission tax system implemented, rather than the probable alternative of no economic instrument at all.

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 tradeable emission permit schemes, can be explained by different underlying assumptions made about the thresholds (inframarginal exemptions) or free permits built into such schemes. Only if thresholds are treated as property rights rather than subsidy bases, 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 simple 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 1988, pp. 75–77) extended Weitzman's analysis of instrument choice under uncertainty, to show that a hybrid mixture of taxes and tradeable permits is possible, and can be more efficient than either pure taxes or pure tradeable permits. For the case of GHG control, McKibbin and Wilcoxon (1997a, 1997b) and Pizer (1997, 2002) have proposed such a hybrid system. Control would be by tradeable permits, but permit price uncertainty would be capped by governments selling unlimited permits once some ceiling price is reached.¹³ Pizer (2002), who follows the conventional view on tax thresholds, finds that

“This [hybrid] 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 it is not just permits, but also tax thresholds, that can flexibly distribute the rents created by an emissions control policy, so the latter 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 (efficiency, administrative, and “political”), before the best instrument for any particular application can be found.

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Notes

1. See for example, Jensen and Rasmussen (2000), who estimate empirically many of these issues for the case of controlling carbon dioxide emissions in Denmark.
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.
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.
4. Note that a quantity control regime *could* mimic a tax instrument, through an infinitely elastic supply curve of permits; and indeed this is a feature of the hybrid scheme proposed by McKibbin and Wilcoxon, mentioned in our concluding section.
5. See for example, Ekins and Barker (2001, p. 330): “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”.
6. The analogous result in Carlton and Lorry is Theorem 3, though they mainly emphasised other theorems which hold for non-uniform pollution, when damage cannot be written as $D(n, e) = D(ne)$.
7. 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 in Pezzey (1992) I referred to payments made when emissions fall below a property right threshold as “subsidies”.
8. See an earlier version of this paper, Pezzey (2002).

9. Administration costs could include transaction costs, which our “ideal” conditions also assume to be zero. Stavins (1995) showed that non-zero transaction costs for permit trading can affect the *economically* efficient level of free permits e_0^* .
10. 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 $e_0^* = e^*$) actually *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 (1) or (2) improving efficiency.
11. See also Boemare and Quirion (2002), whose politically aware comparisons were only of emission trading schemes (but not just for GHGs) implemented worldwide. However, they started by noting “the failure of the European Commission [carbon] tax proposals in the 1990s, in spite of their widespread support from environmental economists”, without addressing *why* these proposals failed, or whether giving inframarginal (rather than sectoral) tax exemptions might have averted such failure.
12. 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 an open-class qualification rule.
13. 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 budgetary problem of how governments would pay for such buying at the floor price.

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