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PERMIT ALLOCATION METHODS, GREENHOUSE GASES, AND COMPETITIVENESS

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FORWARD

The political visibility of permit trading as a tool of environmental policy increased significantly in 1997, when they were adopted as one possible means of reducing greenhouse gas emissions within the Kyoto Protocol. Although the Kyoto Protocol focused on *international* emission trading, it also envisaged continuing efforts at the *national* level to reduce greenhouse gas emissions, possibly including emission permit trading systems at that level as well. This paper is concerned with the latter type of programme. In particular, it is concerned with the one question that has consistently hampered the implementation of proposed environmental policy measures — the potential adverse *competitiveness effects* arising from the introduction of these measures.

The paper focuses specifically on the case of permit trading for greenhouse gases (GHGs). In particular, it concentrates on the potential differences in terms of competitiveness, depending upon whether GHG permits are allocated free of charge to emitters ("grandfathering"), or sold by the government ("auctions").

The report was drafted by **Nick Johnstone**, International Institute for Environment and Development, London, UK. It also benefited from comments received by the OECD Working Party on Economic and Environmental Policy Integration.

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PERMIT ALLOCATION METHODS, GREENHOUSE GASES, AND COMPETITIVENESS [1]

I. Introduction

In recent years, tradable permits have been introduced by a number of OECD countries as a means of addressing some of the problems associated with air and water pollutants [see D. Adams (1997) for an overview]. However, the visibility of permit trading on the international political stage increased significantly in 1997, when they were suggested as a possible means of reducing greenhouse gas emissions during negotiations of the Kyoto Protocol. On the one hand, the Kyoto Protocol established an *international* emission trading programme, the implementation of which has recently been the subject of follow-up discussions at Buenos Aires among the Parties to the Framework Convention on Climate Change (UNFCCC). On the other hand, the Kyoto Protocol also envisaged continuing efforts at the *national* level to reduce greenhouse gas emissions, possibly including national emission permit trading systems.

This paper is concerned with the latter type of programme. In particular, it is concerned with the one question that has consistently hampered the implementation of proposed environmental policy measures — the potential adverse *competitiveness effects* arising from the introduction of these measures. While a previous paper (Johnstone, 1998) has examined some of the empirical evidence of competitiveness effects in existing programmes covering a variety of pollutants, this paper focuses specifically on the case of permit trading for *greenhouse gases* (GHGs). In particular, the report concentrates on the potential differences in terms of competitiveness, depending upon whether GHG permits are allocated free of charge to emitters (“grandfathering”), or sold by the government (“auctions”).

The first problem faced by any study which seeks to examine competitiveness effects of environmental policies is the need to identify appropriate indicators. Since the evidence on the effects of different permit allocations is quite limited, the net needs to be cast quite widely in the search for these indicators. Thus, the report looks at the potential differences in the effects of auctioned and grandfathered permit allocation mechanisms on direct firm-level compliance costs for permitted firms, on indirect consequences for other firms with supply links to permitted firms, on overall economic efficiency through revenue-recycling and investment rates, and on the technological trajectory of the economy, including abatement innovations. As such, without seeking to rank (much less quantify) their importance, the paper merely explores the effects of alternative allocation mechanisms on those factors which appear to influence competitiveness.[2]

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1. The author would like to thank Katia Karousakis, School of the Environment, Duke University for invaluable assistance in the preparation of this document. Valuable inputs from the participants in an OECD Workshop on “Domestic Tradable Permits: Issues and Challenges” (Paris, September 1998) are also gratefully acknowledged.

2. Indeed, the paper does not argue that these are even the most important determinants of competitiveness. Other structural and institutional factors are certainly important in this regard, but are not likely to be affected by the choice of allocation mechanism. However, one potentially significant institutional factor may arise. In particular, it is possible that grandfathering will lead to rent-seeking behaviour as firms seek to increase their permit allocations. This will “tie up” both firm and government resources without resulting in any social welfare gains. Lobbying prior to the introduction of the US Acid Rain Program was particularly intense.

On the other hand, the focus of the paper is quite narrow, dealing only with a subset of issues related to the competitiveness effects of tradable permit systems. It does not examine the competitiveness effects of tradable permit systems relative to other environmental policy measures, such as taxes and direct regulations. Nor does it examine the competitiveness effects related to the introduction of tradable permits relative to a situation in which there are no measures introduced at all (since this would conflate the effects of differences in *targets* with differences in *instruments).* And finally, it does not look at the competitiveness effects of different *international* distributions of grandfathered permits, focusing instead on the effects of different *national* allocation mechanisms.[3] In this way, the importance of the nature of the domestic permit allocation mechanism is brought more clearly into focus.

The report concentrates mainly on carbon dioxide (CO_2) emissions, but other GHGs are also mentioned in places. This focus is justified by the relative importance of CO_2 as a contributor to global warming. Expressed in terms of radiative "forcing", CO_2 was responsible for 83% of total GHG emissions from the Annex 1 Parties to the UNFCCC in 1995. Methane and nitrous oxide were responsible for 11% and 4% respectively. CFCs, which were once the second most significant source of GHGs, are no longer as important (UNFCCC, 1997). Moreover, given the close relationship which exists between fuel inputs and CO_2 emissions – except in some sectors such as the chemicals industry and cement production - markets for CO_2 are more likely to develop than for other GHGs. However, in those cases where a market develops for all three gases this will have implications for many of the issues (e.g. market power, revenue recycling, etc….) discussed on below. (See AGO 199A for a discussion of some of the implications of a joint market for different GHGs.) It will, of course, also have implications for administration costs and/or the credibility of the market, since monitoring emissions from other gases will be much more difficult.

The paper is structured as follows. Section II discusses the difference between auctioned permits and grandfathered permits in terms of direct compliance costs at the level of the individual firm (abatement costs and permit expenditures). Section III reviews the difference in the two schemes as a consequence of the potential for revenue-recycling under auctioned allocations (but not under grandfathered allocations). Section IV discusses potential differences in the two mechanisms in terms of profitability, investment rates and productivity, while Section V discusses indirect effects on other firms in the economy. The last two sections explore technological issues, first in terms of incentives to innovate and diffuse abatement technologies (VI) and then in terms of more general effects arising from barriers to entry for new firms (VII). There is also a brief concluding section (VIII), as well as an Annex which discusses climate change and competitiveness issues more generally.

3. For examples of discussions of the distributional implications of different initial permit distributions, see Bertram (1996), Larsen and Shah (1994), and Rose et al. (1998).

In order to focus the discussion in each of the sections, the issues are treated separately. For instance, the discussion of the effect of allocation mechanisms on investment rates and total factor productivity is treated separately from the discussion on environmental policy and technological innovation. Clearly there are important links, but in order to highlight the specific competitiveness effects of the different mechanisms it is important to distinguish between different issues. In addition, the report draws upon the rather limited evidence that is available. In many cases this means that specific issues can only be addressed through reference to the situation in a particular country. The wider relevance of the findings to other countries can only be assessed through further work.

II. Permit allocation mechanisms and direct compliance costs

Numerous empirical studies have documented the aggregate economic cost savings from the introduction of tradable permit systems [again, see Johnstone (1998) for a review]. However, from the perspective of the individual firm, it is less important to know whether the introduction of a TP system results in cost savings than whether that firm is likely to be the one which realises the savings. Most importantly, there is likely to be a large difference in financial expenditures by firms, depending upon whether or not the permits have been allocated through a grandfathered scheme or through an auction.

Examined in a strictly static manner and assuming (for the moment) that emissions can only be adjusted through changes in output, under an auctioned allocation, the firm will maximise profits by solving for the following production decision:[4]

1) $\pi_A = \text{Max } p.q - (c(q) + P_A * E(q))$

and in a grandfathered allocation, the decision will be as follows:

2) $\pi_G = \text{Max } p.q - (c(q) + P_G * (E(q) - G))$

where *p* is price of output *q; c* is the production cost; *P* is the permit price; *E* is the level of emissions; the subscript *A* refers to the auctioned allocation; and the subscript *G* refers to the grandfathered allocation.

Thus, the clearest difference between the two allocation mechanisms is revealed. In the case where permits are auctioned, control costs for firms (in aggregate) will equal abatement costs plus the costs of the permits themselves. In the case where they are grandfathered, total control costs for firms in aggregate will only equal abatement costs, since all expenditures for permits are between firms, and not between firms and the government. This single point is at the heart of most controversies concerning the introduction of tradable permit systems, with most firms understandably advocating the use of grandfathered allocations.

When are the benefits (for firms) of a grandfathered system likely to be greatest, relative to an auctioned allocation for permitted firms (in aggregate)? In one sense, it can be argued that the advantages of a grandfathered allocation are greatest when permit expenditures are at their greatest under an auction. For a linear marginal abatement cost — MAC (i.e. MAC''=0), permit expenditures will be at their maximum when 50% of emissions are abated. For a convex MAC (i.e. MAC''>0), maximum permit expenditures under an auctioned allocation (and thus rents under a grandfathered allocation), are likely to occur at a relatively higher rate of abatement.

However, in another sense, the relative advantages of a grandfathered allocation are greater when permit expenditures under an auctioned allocation (rents under a grandfathered allocation) are not at their

4. See Koutstaal (1997) for a more complete discussion.

highest *absolute* level, but rather when they represent a *relatively* high proportion of total control costs. In general, permit expenditures will tend to represent a relatively high proportion of total control costs if the environmental target is itself relatively lax. Although the absolute size of permit expenditures (and thus rents received under a grandfathered scheme) may rise initially with increasingly stringent environmental targets, the ratio of permit expenditures to total control costs will almost always fall.

This can be shown in Figure 1. Assuming that marginal abatement costs rise linearly from the origin, Area A equals (X*P)/2 and Area B = (100-X)*P, where X is the % emission reduction and P is the permit price. It can be shown that Area B (permit expenditures) is always 200/X - 2 times greater than Area A (abatement costs); thus, the ratio of permit expenditures to total control control costs always equals (200-2X)/(200-X). Thus, with a linear abatement cost curve as abatement increases (X rises), this ratio will fall, even though the absolute level of permit expenditures will continue to rise as regulations become more stringent up until 50% abatement. However, if the marginal abatement cost curve is convex, the ratio will not fall as quickly.[5]

Despite the controversy surrounding the introduction of limits on emissions on CO_2, most target emission reductions still represent a relatively small proportion of total emissions. Table 1 gives figures for the estimated emission reductions necessary for a sub-set of Annex I countries to actually meet their Kyoto Protocol commitments.

Although there is considerable range in the “net” stringency depicted in Figure 1, in general the emission reduction requirements are quite low, relative to emission reductions in other existing tradable permit systems. For instance, while the Figure 1 emission reductions required under the Kyoto Protocol are generally less than 25%, relative to projected “business-as-usual” emissions for most countries, emissions of SO_2 under the US Acid Rain programme are projected to fall to just under 9 million tons in 2000, relative to emissions of 19 million tons in 1980 (i.e. approximately 53 per cent.) Under the CFC programme, emissions were to be reduced to 25% of 1989 levels by 1994, and to 0% by 1998. Under Los Angeles’s RECLAIM programme, NO_x and SO_2 are to be reduced by 8.3% and 6.8% p.a. respectively between 1994 and 2003 (see Harrison, 1998). Finally, lead was to be reduced more than ten-fold in one year in the lead trading programme.

CO_2 emission reductions are therefore likely to represent a lower proportion of total emissions than for many other pollutants which have already been the subjects of tradable permit systems. This means that a tradable permit system for CO_2 is likely to result in greater proportional expenditures on permit expenditures, relative to abatement costs (even though the absolute level of permit expenditures under an auctioned allocation —and thus, windfall profits under a grandfathered allocation — may well rise with increased stringency of environmental regulations).

5. If the marginal abatement cost (MAC) curve is sufficiently steep, the rise in the permit price will be sufficiently large to result in increased expenditures on permits, despite reduced purchases. However, in order for the ratio of permit expenditures to total control costs to rise under an auctioned allocation, the increase in permit expenditures must be proportionately greater than the increase in abatement costs. The MAC curve will have to be very convex in order for this to be the case.

Figure 1. The Financial Effects of Grandfathered and Auctioned Permits

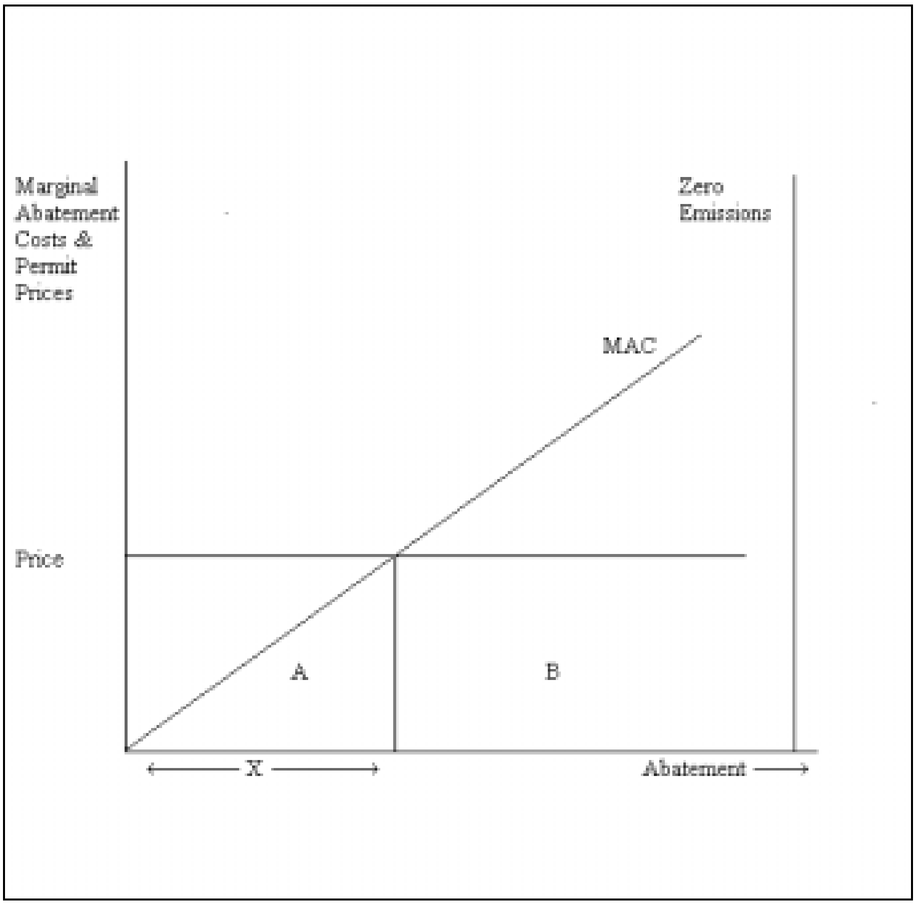


Table 1. Relative Stringency of Kyoto Commitments (1000 tons)

	Base Year (1990) Emissions	Commitment (% Emissions Relative to Base Year)	Projected Emissions in 2005	Estimated Emission Reductions in 2005	Reductions as a Percentage of Emissions
Canada	464000	94%	522900	86740	16.59%
Czech Republic	165490	92%	153000	749	0.49%
Germany	1014155	92%	867000	-66023	-7.62%
Ireland	30719	92%	38228	9967	26.07%
Netherlands	167550	92%	181000	26854	14.84%
New Zealand	25476	100%	33570	8094	24.11%
Sweden	55445	92%	62100	11091	17.86%
UK	583747	92%	593000	55953	9.44%
US	4965510	93%	5865600	1247676	21.27%

Sources: Base Year and Projected Emissions from UNFCCC (1997).

Another factor which determines the relative (dis)advantages of an auctioned system for firms compared to a grandfathered system is the extent of heterogeneity in initial abatement costs prior to the introduction of the tradable permit system. If existing methods of regulation are very inefficient (i.e. if marginal abatement costs differ widely), the potential efficiency gains from introducing the new tradable permit system are likely to be very high. Evidence presented in Johnstone (1998) shows just how wide the variation is for a number of air and water pollutants in the US. In this case, efficiency savings may be far in excess of permit expenditures, making the auctioned allocation relatively more attractive (less unattractive) than it would otherwise be.

For instance, if, prior to the introduction of a tradable permit system, abatement costs are approximately equal — perhaps because of the use of forms of direct regulation which account for relative marginal costs — then the "static" efficiency gains will be slight. In this case, from firms' perspectives, the introduction of a tradable permit system will involve only incidental costs under a grandfathered system. However, under an auctioned system, firms will now have to pay for their emissions, even though they will not change their production practices and emission rates. [6] The only real effect of the programme will be the change in "ownership" of the receiving environment. Thus, the effects of an auctioned system will be particularly adverse for firms if abatement costs had not differed widely previously, since there will be no "static" efficiency gains, but firms will now have to pay for pollutants which had previously been emitted free-of-charge.

Conclusion

The most direct effect of different permit allocation mechanisms on firms relates to the fact that, in one system, the firm pays for emissions (auction allocation), but not in the other (grandfather allocation). The relative advantage of a grandfathered allocation in terms of the firms' financial burdens is greatest when the environmental target is lax (relative to total emission levels) and when there is little heterogeneity in marginal abatement costs prior to the introduction of the tradable permit regime.

III. Revenue-recycling, aggregate economic efficiency and competitiveness effects

The preceding discussion of the net effects for firms under auctioned permit systems is only "partial", having concentrated on *direct* financial effects in terms of permit expenditures and abatement costs. This is significant, since a partial analysis implies that under an auction-based system, firms will have to bear the full costs of permit expenditures, but will not reap any of the benefits associated with increased government revenues arising from the permit sales. Such an assumption may be appropriate if one is only concerned with direct first-order effects on firms, particularly if the tradable permit programme covers only a small number of emitters, and if the revenues are accrued by a national authority.

However, for tradable permit regimes associated with problems as broad as global warming, "revenue-recycling" issues clearly need to be addressed, since the revenues raised by auctioned CO_2 permit systems are likely to be of such a magnitude that the disbursement (or retention) of any revenues may have at least as significant an effect on the economic and environmental consequences of the reform as the auction itself. For instance, the OECD (1995) estimated the revenues from a $50/ton carbon tax, and compared them with total government revenues and GDP. The OECD average is 2.62% of total tax receipts, which would have a considerable impact on the fiscal status of most OECD countries (see Table 2). It is this fact which inspired Nordhaus to remark that "the tail of revenue-recycling would seem to wag the dog of climate change policy" (Nordhaus, 1993).

6. In distributional terms, firms which are initially furthest from the equilibrium permit price will gain the most.

Table 2. Potential Importance of Tax Revenue from $50/ton Carbon Tax

	Tax Revenue ($US)	Tax as % of GDP	Tax as % of Tax Receipts
United States	69095	1.28	4.32
Japan	15348	0.51	1.63
Germany	9599	0.69	1.84
United Kingdom	6962	0.85	2.30
Canada	8296	1.10	2.97
Australia	3917	1.33	4.31
Netherlands	2723	0.96	2.15
Spain	3572	0.73	2.11
Sweden	815	0.36	0.63
Total OECD	147308	0.91	2.62

Source: OECD (1995).

In terms of economic competitiveness, this debate is important at the level of the firm, the sector, and the national economy. On the one hand, in the event that revenue-recycling reduces inefficiencies in the public finance system, it will have the effect of making the economy more competitive generally. On the other hand, the means by which the revenues are recycled will also affect competitiveness at the level of the firm and the sector, generating quite different effects.

Aggregate efficiency effects

Setting aside the environmental benefits of a permit (including those which affect the economy directly), Goulder (1994) has distinguished between the “weak” and “strong” forms of the “double dividend”.[7] The “strong” form asserts that revenues can be recycled in such a way as to actually yield negative economic costs. This situation would arise if an auctioned permit was a more efficient way of raising revenue than the tax(es) which are reduced. The “weak” form merely asserts that alternative forms of recycling will tend to have *less adverse* effects than lump-sum recycling, mitigating some of the adverse effects of the permit on the economy, but not actually producing non-environmental economic *benefits.* If the “strong” form of the double dividend holds, then there are net benefits to be attained from the tax switch, even without considering the environmentally-related benefits [see also Bohm (1997), Goulder *et al.* (1997), and Parry *et al.* (1997)].

Goulder (1994) reviews the conditions which are most likely to lead to efficiency improvements:

- Significant inefficiency in the existing tax system;
- Revenues from the permit system are devoted to reducing tax rates on factors with relatively high marginal efficiency costs;
- The burden of the permit system falls on factors with low marginal efficiency costs; and,

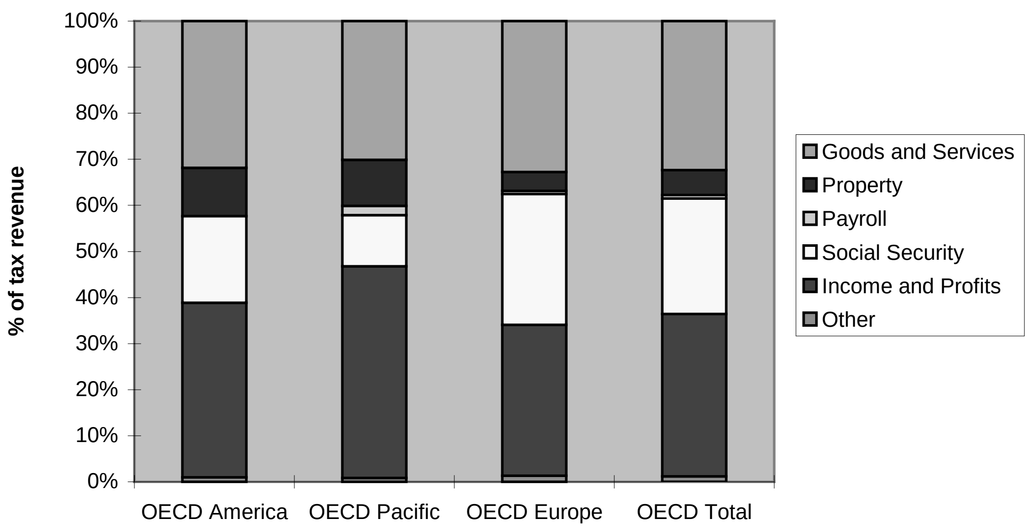
7. The discussion is carried out with reference to taxes, but the effects of an auctioned permit in which the government receives the revenue would be the same.

- The base of the permit system is relatively broad, so that it imposes few distortions in intermediate and consumer goods markets.

The first two of these relate to the nature of the existing tax regime, and it can be argued that they are entirely separable from specific environmental measures (i.e. that they reveal the extent to which the fiscal regime can be made more efficient, with or without the introduction of emission taxes or auctioned tradable permits for greenhouse gases). Even so, it is worth reviewing the extent to which there are inefficiencies in existing tax regimes, since this will reveal the extent to which a fiscal reform induced by auctioned permits might result in a more efficient fiscal system more generally.

For the case of the US, Shackleton *et al.* (1992) have argued that the optimal means of recycling is through investment tax credits, followed by reductions in marginal corporate income tax and payroll tax rates, reduced public sector borrowing requirements (tax retention), and reduced labour or employee social security contributions. The least efficient approach is, of course, lump-sum recycling. The situation in Europe is thought to be somewhat different. Reductions in marginal income tax rates or national insurance contributions may be the most efficient means of recycling, since labour is already heavily taxed, and since (as a rule of thumb) dead-weight losses associated with taxes tend to rise with the square of the tax rate. [Figure 2 gives data on the sources of tax revenue as a % of total revenue in the main OECD regions in 1995 (OECD, 1997).]

Figure 2. Source of Tax Revenue in the OECD in 1995



The degree of inefficiency in existing tax systems can be examined by comparing the "marginal efficiency cost" (a measure of the degree of distortion) of existing taxes. Table 3 gives estimated MECs for different taxes in the US suggesting considerable variation in the efficiency burdens associated with different taxes. Taxes with high MECs have relatively greater distortionary effects (are less efficient ways of raising revenue) than taxes with low MECs. At first glance, it would therefore appear that there may be considerable scope for improving the efficiency of the fiscal regime by shifting the burden from high MEC taxes to low MEC taxes. However, since tax regimes are motivated as much by political and distributional implications as they are by some notion of "economic efficiency", the real scope for improved efficiency may be much smaller than these differences would imply.

Table 3. Estimated Marginal Efficiency Costs of US Taxes			
Ballard *et al*. (1985)		Jorgenson and Yun (1990)	
Capital and Corporate Taxes			
Capital (at industry level)	0.463	Corporate Income Taxes	0.838
		Capital (ind & corp)	0.924
Labour and Income Taxes			
Labour (at industry level)	0.230	Labour Income	0.482
Income	0.314	Individual Income	0.598
Consumer and Sales Taxes			
Consumer Sales	0.388	Sales	0.256
Sales[8]	0.115		

The third determinant of the overall efficiency burden of the measure (i.e. the extent to which it falls on factors with low MECs) is directly related to the incidence of permit expenditures. Horton, Rollo and Ulph (1992) have argued that, given the relatively low level of existing taxation on energy in general, taxes as high as 25% would be needed to reduce existing distortions. However, perhaps the most interesting aspect of energy taxation is the degree of heterogeneity which exists within it. While much residential use of energy is taxed at higher levels, the industrial use of energy in most OECD countries tends to be taxed at much lower rates (Table 4). Bunker fuels for transport are often taxed particularly lightly. Since it will be administratively complex to weight permits according to end-use, it may be difficult to preserve this degree of heterogeneity after the permit system has been introduced.

Table 4. Tax Rates on Industrial Use of Fuels and Electricity (1996)

	Heavy Fuel Oil	Light Fuel Oil	Natural Gas	Steam Coal	Electricity
France	13.3	32.2	0.0	0.0	0.0
Germany	13.2	19.0	13.8		0.0
Italy	15.7	64.6	8.5	0.0	17.5
Japan	2.9	2.9	2.9	2.9	5.6
Netherlands	20.9		7.0		0.0
Spain	8.7	32.1	0.0		0.0
UK	18.7	17.3	0.0	0.0	0.0

Source: IEA, Energy Prices and Taxes (1997).

The fourth main determinant of the efficiency effects of the tax or permit (i.e. the breadth of the tax base) is particularly interesting, since it appears to be at odds with the objective of maximising the environmental efficiency of the tax or permit system in the first place. For instance, permits which target the source of environmental damages imperfectly (i.e. input-based permits) will tend to have a much broader base than those which target the source of environmental damages directly (i.e. emission permits). The former would be less distortionary in fiscal terms, but less efficient in terms of internalising environmental externalities, and *vice versa*. Thus, there appears to be a trade-off between increasing environmental efficiency and reducing economic distortions.

8. Other than alcohol, tobacco and, more significantly, gasoline.

This would also be true of permit systems aimed at other GHGs, such as methane and N_2O. However, CO_2 is exceptional. On the one hand, CO_2 emissions are emitted by firms in all sectors of the economy, and are not concentrated in a sub-set of sectors as they are with some other pollutants. On the other hand, CO_2 emissions are easily targeted as the direct source of environmental damages. Thus, insofar as the potential breadth of a permit system for CO_2 emissions is very wide, and since they are the direct source of environmental damages, the objectives of economic efficiency (in terms of reducing tax distortions) and environmental efficiency (in terms of targeting emissions directly) are complementary.

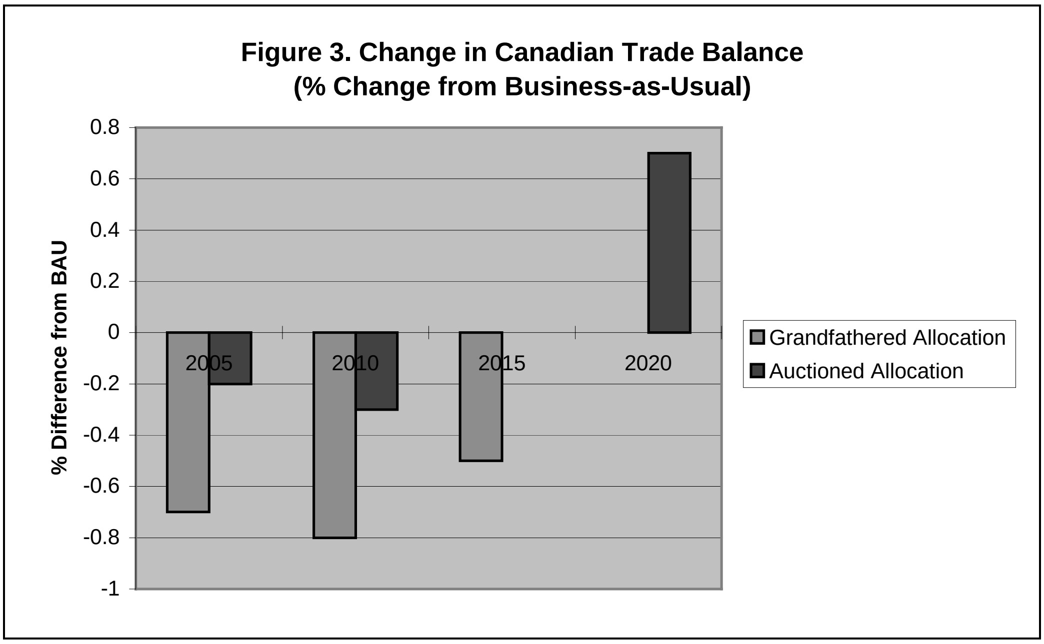
Some indication of the importance of recycling revenues generated by a carbon tax (or auctioned permit system) can be gleaned from simulation studies. Parry *et al.* (1997) explicitly compare the effects of an auctioned permit system (actually a tax) and a grandfathered permit system for CO_2 reductions in the US. For the auctioned allocation, the revenues are assumed to be recycled via reductions in labour taxes. They find that, with a 5% reduction in carbon emissions, the economic costs (as reflected in permit prices) of a grandfathered allocation are seven times greater than for an auctioned allocation. With reductions of 15% and 25%, the costs are still three and two times greater. Thus, even though grandfathered permits may well reduce aggregate control costs for permitted firms, the efficiency effects are such that overall costs for the economy as a whole are increased.

Indeed, comparing the cases of CO_2 and SO_2, Parry *et al.* (1997) also argue that the relative benefits of auctioning permits (and not grandfathering them) will be much higher in the CO_2 case. Since any likely CO_2 target will involve relatively small emission reductions compared to a programme in which emissions are to be reduced by over 50% (i.e. the Acid Rain Programme), there will be a proportionally larger number of emissions (and thus permits) involved in a CO_2 programme. This magnifies the adverse tax interaction effect, relative to the magnitude of compliance costs, and thus makes the use of an auctioned permit allocation even more important [see also Burtaw, 1998].[9]

Looking at the Danish case, Jensen and Rasmussen (1998) simulate the effects of reducing Danish CO_2 emissions by 20% (relative to 1988 levels) by 2005. They compare the effects of auctioning the permits and recycling the revenue via reductions in labour taxes, relative to the case where the permits are grandfathered. In the former case, sufficient revenue is raised to allow for a reduction in labour taxes from 58% to 52%. Due to the efficiency gains from reducing the distortionary effects of taxes on labour, the drop in aggregate economic welfare is much lower (-0.1% relative to “business-as-usual”) in the case where permits are auctioned than when the permits are grandfathered (-2.0%).

Holling and Somerville (1998) compare the effects of using a tax and a grandfathered permit system to stabilise Canadian CO_2 emissions at 1990 levels by 2010. They examine the effects of applying a grandfathered allocation and an auctioned allocation (actually a tax), in which the revenues are recycled via reductions in other taxes in proportion to their existing burdens. Under the auctioned allocation, the fall in GDP in 2010 relative to the base case scenario is again much lower relative to grandfathered allocation (-0.3% relative to -1.7%). Significantly, the trade gap widens by rather more under a grandfathered allocation, with the trade balance actually improving (relative to BAU) by 2020 under the auctioned allocation (Figure 3).

9. Note that this assumes that the absolute value of the tax interaction effect exceeds the absolute value of the revenue-recycling effect.



Sectoral effects

While the aggregate efficiency effects are important, individual sectors and firms directly affected by the permit system are more concerned with the precise means of how the revenues will be recycled than with the question of whether or not there are overall efficiency gains to be realised when an auctioned system is used instead of a grandfathered one. This is particularly important for the GHG permit case. Unlike most other tradable permit systems, with GHG trading, it is plausible to assume that most firms would eventually have to buy permits to one extent or another (and also that they will realise the benefits of recycling to one extent or another) (see Johnstone (1998)]. Some firms will win from this process (those whose production processes are intensive in the use of the factor or good whose tax rate is lowered), and some will lose (those whose production processes are carbon-intensive).

Clearly, the revenues from an auctioned permit system might be specifically targeted to reduce competitiveness effects. To some extent, this might be analogous to giving vulnerable firms generous initial allocations under a grandfathered system. However, it is important to note that the effects would be quite different under the two measures. Grandfathering permits is a way of redistributing *rents*, while lowering tax rates is a way of reducing *costs*. Thus, the consequences of the two means of mitigating competitiveness effects will be quite different, with the latter possibly having more pronounced effects on the relative prices of the affected sectors' outputs.

Using their model of the Danish economy, Jensen and Rasmussen (1998) look at the effects of using the revenue generated by an auction to provide subsidies to firms in light of sector-specific emission levels and market shares within each sector. Thus, firms in carbon-intensive sectors will receive proportionately greater output subsidies to mitigate some of the potential adverse competitiveness effects. Not surprisingly, the trade effects for energy-intensive goods are much less adverse when an output subsidy is used than when the revenue is recycled via reductions in labour taxes, or even when the permits are grandfathered. The report does not, however, reveal what the trade effects are for other sectors. Presumably, labour-intensive sectors will be worse-off. Significantly, the fall in the discounted present value of aggregate economic welfare is greater (-2.1% relative to "business-as-usual") than it is in the other two cases.

Beaumais (1998) simulates the alternative effects of different grandfathered permit allocations for carbon permits in the UK and France with the introduction of a policy which results in a 10% fall in carbon emissions. Comparing the effects of an allocation which favours energy sectors with one which favours other sectors, he finds that the effects on the trade balance are 10% more adverse in the latter case in France. However, in the UK the trade balance improves when non-energy sectors receive favourable permit allocations. Differences in the responses in the two countries are thought to be largely attributable to differences in the fuel mix.

Alternatively, given that the motivation for the introduction of the permit system is primarily environmental, the revenue from an auctioned permit system could also be recycled in such a way as to maximise the effects of the reform in environmental terms. What are likely to be the competitiveness implications of such an approach? No existing studies have examined this issue with specific reference to tradable permit systems. However, Carraro and Galeotti (1997) do look at the competitiveness effects of subsidising research and development and innovation in abatement technologies. Not surprisingly, the adverse competitiveness effects are much lower in this situation than when taxes are applied to reduce emissions. Thus, an auctioned permit scheme which recycles the revenue in a way which helps firms to minimise the cost of meeting environmental objectives is also likely to mitigate competitiveness effects. This is particularly likely for greenhouse gases, where many of the measures which reduce emissions also have secondary positive consequences for the efficiency of production more generally.

Recycling the revenues in order to mitigate competitiveness effects or to maximise environmental benefits may not be the most realistic scenarios. In their model of the Canadian economy, Holling and Somerville (1998) try to avoid “second-guessing” likely governmental responses to increased revenue from auctioned permits by positing a “neutral” scenario in which tax rates are reduced in proportion to the revenue presently raised by each tax. The sectoral effects of the grandfathered allocation and the auctioned allocation can then be compared. Ranking the sectors in ascending order of % changes in value-added under the grandfathered allocation, relative to the BAU scenario in 2010, it is clear that there are very different effects under the two schemes (Table 5.)

The correlation between the two rankings is only 0.46. Depending on relative carbon-intensity and existing tax burdens, some sectors fare very differently under the two allocations: furniture and fixtures (5 and 28), wood products (9 and 24), retail trade (11 and 29), non-metal minerals (15 and 5), non-metal mining (16 and 3), chemicals (20 and 11), forestry (27 and 8), miscellaneous manufacturing (28 and 13), transportation and storage (29 and 10) and. In ten sectors, the sign for the change in value-added actually changes, depending on which allocation mechanisms is used.

Table 5: Effects of CO_2 Stabilisation in Canada

	Grandfathered Allocation		Auctioned Allocation	
	% Change	Rank	% Change	Rank
Petroleum & Coal	-15.3	1	-14.4	1
Other Utilities	-13.1	2	-12.3	2
Mineral Fuels	-7.0	3	-6.1	4
Wholesale Trade	-4.2	4	-4.8	7
Furniture & Fixtures	**-3.7**	**5**	**1.9**	**28**
Electr. Prod's	-3.6	6	-5.4	6
Machinery	-3.1	7	-3.8	9
Electr. Power	-3.0	8	-2.2	15
Wood	**-2.7**	**9**	**0.5**	**24**
Construction	-2.4	10	-2.2	14
Retail Trade	**-2.4**	**11**	**2.2**	**29**
Communications	-2.3	12	-1.5	17
Serv. To Mineral Extraction	-1.9	13	-1.1	18
Fab'd Metals	-1.8	14	-3.7	12
Minerals except Metals	**-1.8**	**15**	**-5.6**	**5**
Nonmetal Mining	**-1.6**	**16**	**-8.1**	**3**
Rubber and Plastic	-1.6	17	-1.6	16
Finance and Insurance	-1.5	18	1.7	26
Printing and Publishing	-1.2	19	0.9	25
Chemicals	**-1.1**	**20**	**-3.7**	**11**
Agriculture	-0.6	21	0.5	23
Comm., Bus. & Pers. Services	-0.6	22	3.4	30
Primary Metals	-0.5	23	-0.3	19
Transp. Eqpmt	-0.5	24	6.1	31
Paper and Allied	-0.4	25	0.3	22
Food, Bev's and Tobacco	-0.2	26	1.7	27
Forestry	**-0.1**	**27**	**-4.4**	**8**
Misc. Manuf.	**-0.1**	**28**	**-2.5**	**13**
Transp & Storage	**-0.1**	**29**	**-3.8**	**10**
Fishing and Trapping	0.0	30	0.0	20
Leather, Textiles and Apparel	0.8	31	9.7	32
Metal Mining	**1.2**	**32**	**0.3**	**21**

Conclusions

Although direct control costs tend to be much higher under auctioned allocations, some of this difference is likely to be mitigated by revenue-recycling. First**,** auctioned allocations tend to be more efficient in aggregate terms, putting less of a burden on the national economy generally. For most pollutants, however, this is of little interest to individual firms, since the value of aggregate efficiency gains will not improve their own competitive position appreciably, relative to the costs of purchasing the permits. However, for CO_2, this is less clear, since the efficiency gains of using an auctioned CO_2 system seem to be particularly high. Second, individual firms and sectors may benefit directly or indirectly from the revenues that are eventually recycled. In general, the relative effects on different sectors will vary, depending upon whether the revenue is recycled in order to minimise competitiveness effects, to maximise the reduction in existing tax distortions, or to maximise environmental gains.

IV. Windfall rents and investment rates

The competitiveness effects of tradable permits have been discussed in terms of abatement costs, as well as in terms of the costs incurred in the purchase of permits and any mitigating effects arising from revenue-recycling. However, in terms of the firm's actual decisions with respect to pricing and production, the difference between the two systems may be unimportant in the short-run, since in both cases, the possession of a tradable permit implies the existence of an opportunity cost equal to the value of the permit. Opportunity costs arise (even if permits are granted freely) because profits are foregone if the firm retains the permits. As such, a profit-maximising firm will behave as though its marginal costs have increased, even if permits are grandfathered. Incorporating opportunity costs into equation 2 yields the following:

$$3)\ \pi_G = \text{Max } p.q - (c(q) + P_G * (E(q) - G) + P_G * G)$$

which is equivalent to the decision faced by a firm which is producing under an auctioned allocation (Koutstaal, 1997). In the short-run, therefore, the difference between auctioned permits and grandfathered permits is not necessarily primarily reflected in terms of output and pricing decisions.

Thus, opportunity costs may not give firms which have been grandfathered permits any short-run competitive advantage in terms of product prices (relative to firms which have been auctioned permits). However, they will generate windfall profits. In order to clarify this point, assume that markets are perfectly competitive and that total emission control costs (abatement costs and permit expenditures) rise relative to the previous regulatory system under auctioned permits, and fall under grandfathered permits. This will be the case when aggregate permit expenditures exceed efficiency gains. Since market prices are the same for the two permit systems, this means that profits will rise for firms which were grandfathered the permits, and fall for firms which had to purchase the auctioned permits. In Jensen and Rasmussen's (1998) model of the Danish economy, "extant" capital earnings (earnings on existing capital stock) fall by 9.4% relative to the base case under an auctioned allocation, but by just 8.6% under a grandfathered allocation. Depending upon how these earnings are used, this may generate longer-run competitive advantages for grandfathering relative to an auctioned allocation.

Firms which have been grandfathered permits can use the economic rents (the windfall profits) in any number of ways: increase dividends to shareholders, increase investment rates, give managers and employees bonuses, etc. These different strategies have different implications for employment levels, regional objectives, and other factors. They also have different implications for competitiveness. Assuming that some proportion of the rent goes toward undertaking investment, this might help firms increase their productivity, making them more competitive in the medium- and long-runs. They may also be able to shift more easily into new product markets. Firms which have to buy their permits in auctions will not be in as strong a position to do so, and may even find that earnings which had previously been retained under the previous system (and thus available for investment) now have to be devoted toward expenditures on permits.

What does this mean for the firm? Effectively, it means that under perfect competition (where all firms are price-takers) and assuming that there are no transaction costs (since these would drive a wedge between opportunity costs and the market price of permits), firms which are grandfathered permits may *not* increase their market share in the short-run, relative to firms which have to buy their permits in an auction. However, this process *could* increase the retained earnings of the firm. This is likely to be significant in the longer-run and in situations where capital markets are not perfect, since firms which have received the windfall profits may use the retained earnings to undertake investment which they would not otherwise be able to undertake.

These effects are likely to be more pronounced in the case of global warming since the capital equipment in many carbon-intensive sectors is long-lived and sector-specific. For instance, electricity utilities, gas distribution companies, and even some manufacturing sectors with on-site boilers will all possess capital equipment which is long-lived and sector-specific [AGO (1999B); Cramton and Kerr (1998); Rutherford (1996).] As such, the existence of rents which help to ease the transition in the capital stock is likely to be particularly valuable. Since adjustment costs can be considerable, these "transitional" effects should be recognised and it can be argued that receiving windfall profits may help firms deal with these effects. However, compensation through the distribution of windfall profits is not likely to be the best way to address concerns about adjustment costs since the extent to which firms will actually use the rents gained from grandfathering for these purposes is inherently uncertain. (See AGO 1999B.) Targeted use of the revenue from auctioned permits would seem to be a much more promising strategy.

Although there is no direct evidence of the importance of these issues, using the Holling and Somerville (1998) study, it is possible to compare the effects of auctioned allocations and grandfathered allocations on profits and investment rates for the Canadian economy. In this model, the rents from grandfathered permits are taxed at the corporate tax rate, and a proportion of the post-tax rents are allocated to dividends, with the rest going to investment. Using a grandfathered allocation, pre-tax profit rates in 2010 rise by 1.5% relative to the base case, but fall by 1.1% with an auctioned allocation. Investment rates fall by 5.8% in the grandfathered permit scenario, but by considerably more (11%) with an auctioned allocation. As a consequence, the capital stock is much smaller under an auctioned allocation (4.9% less than BAU), relative to a grandfathered allocation (3.4%).

Thus, in a situation where the opportunity cost of retained earnings is less than the cost of borrowing or raising capital, grandfathered systems may reduce competitiveness effects by allowing firms to finance the transition to less carbon-intensive production technologies at lower cost. However, grandfathering is certainly not the best way to realise these benefits. Other aspects of tradable permit systems will certainly have a more positive effect on helping firms to invest in a way which reduces the costs of compliance, with or without grandfathering. For instance, if there is a lag between the proposal of the policy and its actual implementation, firms will be able to anticipate the consequences and begin to adjust their capital stock prior to implementation. Similarly, if banking of permits is allowed, firms will be able to adjust their permit holdings temporally, in line with the composition of "vintages" of their capital stock (see Johnstone [1998] for a discussion.)

Moreover, recycling the revenue from an auctioned allocation is likely to be a much more effective way of mitigating any adverse competitiveness effects than merely granting rents. Since there are no real constraints on the use to which the revenues generated by an auction can be used, it is quite likely that discretionary use of the revenue to assist adversely affected sectors and regions —such as those wherein capital (and labour) is immobile and non-malleable —will be preferable to the use of grandfathered permit allocations. In the latter case, the only means by which vulnerable sectors can be assisted is through windfall profits. Thus, as a means of mitigating such effects, grandfathered allocations are a very blunt instrument (Cramton and Kerr, 1998).

Conclusion

The competitiveness effects of tradable permits will partly arise through the realisation of windfall profits, and not just through the reduction of production costs. Thus, while there may not be any short-run consequences for firms in terms of market-share, there may be longer-run benefits. The rent from the grandfathered allocation does not lower production costs directly, but may instead become instead the vehicle through which lower costs can be achieved indirectly (or through which firms can shift into new product markets). This may give a region which grandfathers permits a competitive advantage, relative to a region which auctions permits. However, it must be noted that it is a very inefficient way to achieve this objective. Appropriate policy design (irrespective of the allocation mechanism) and targeted use of the revenues raised by auctions are likely to be much more effective tools.

V. Opportunity costs and indirect effects

As discussed earlier, ownership of a tradable permit has an “opportunity cost”, even if the permit is grandfathered to firms. What does this mean for other firms (i.e. those which have not been grandfathered permits)? While it is quite likely that the most important cost (and competitiveness) effects associated with the introduction of a tradable permit programme are likely to be incurred by firms which are directly involved in the programme itself, in some cases this might not be so. Others (firms and households) may face more significant effects following the introduction of a tradable permit regime which does not target them directly. Moreover, for such firms, there may be little real difference between the two allocation mechanisms. Thus, the effects of tradable permit systems needs to be understood at the level of the entire supply chain.

For example, under the US SO_2 allowance trading programme, permit allocations were restricted to the most important emitters, which are almost all commercial generators of electricity. The competitiveness implications for the generators themselves were mitigated by the fact that the permits were grandfathered to them. However, for the reasons cited above, the implications for “downstream” users may not be mitigated. In a competitive market, where the full opportunity cost of permits is reflected in prices, the implications for “downstream” users of a permitted sector’s output will be the same, irrespective of whether the permits have been auctioned or grandfathered.

For instance, for reasons of administrative simplicity, it may eventually be decided to grandfather CO_2 permits to the carbon-intensive energy sectors (coal, oil and gas distributors), rather than to emitters/householders further “downstream” in the economy. Since there are no economically-feasible means of abatement, permits might be issued on the basis of the carbon-content of the fuels prior to emission, so there will be no difference between the two allocation systems in environmental terms. However, the sectoral economic effects will be quite different. If the permits are grandfathered to the distributors, they will receive the rents, but “downstream” users will face increases in the costs of their material inputs. If, however, the permits were grandfathered to them instead, they would be able to capture these rents themselves.

This can be illustrated by examining the carbon cycle related to the use of transport by manufacturing sectors. In theory, CO_2 permits could be issued to petroleum refineries, petrol distributors, or industrial users of transport services. To reduce administrative costs, it may be decided that it is preferable to distribute the permits to the refineries. Since there is a uniform relationship between the carbon content of fuels and emission levels (except for sectors which use fuels for non-combustion purposes), this will not reduce the overall environmental efficiency of the trading programme. However, for some sectors, the consequences might be very significant. Table 6 provides data on UK road freight by type of good transported. If the permits are issued to the refineries (or distributors), rather than to the emitting firms, then freight-intensive sectors such as foodstuffs and building materials, will be much worse-off than if they received the permits themselves.

Table 6. Freight Moved by Road in the UK in 1995 (billion ton kilometres)

Agricultural Products	12.1
Foodstuffs and Animal Fodder	29.7
Solid Mineral Fuels	2.7
Petroleum Products	5.7
Ores and Metal Waste	1.5
Metal Products	7.8
Minerals and Building Materials	22.7
Fertilisers	1.4
Chemicals	11.4
Manufactured Articles	54.5

Source: DOT (1996).

Similar sorts of arguments apply to other cases. For instance, N_2O permits could be grandfathered to the chemical firms which manufacture fertilisers, to the retailers of farm products, or to the agricultural producers. However, in the N_2O case, there is no uniform relationship between the characteristic of the input and the level of emission. As such, it is much less likely that environmental policy-makers will allocate permits to non-emitting points in the product cycle.

Adminstrative costs are, of course, not the only factor which determining the government's choice of permit incidence. The relative bargaining power of different agents up and down the production-consumpton chain is also an important factor, with large and organised sectors in a better position to ensure that it is in their interests. (See AGO 199B.) This issue is particularly important for households. For instance, in a discussion of CO_2 tradable permit systems, Koutstaal (1997) advocates the use of grandfathered permits for manufacturing firms which are vulnerable to competitiveness pressures, but auctioned permits for household emissions, distributed indirectly through fuel distributors and the electricity supply industry. The justification for such a system is based on two assumptions:

- the administrative costs of grandfathering permits directly to households would be excessive; and
- fuel distributors are not subject to competitive pressures and would, therefore, capture the rent from grandfathered permits without themselves being able to undertake any emission reduction.

However, what would this imply in distributional terms? Since the opportunity costs of grandfathered permits will be largely reflected in the price of goods and services produced by productive sectors of the economy, when households make their consumer expenditures, they will be paying indirectly for the rents accrued by the "grandfathered" firms. Thus, as with "downstream" industrial users, they will have very little to gain from the use of grandfathered permits, relative to auctioned permits. Indeed, they may be worse-off under the grandfathered allocation, since the government will not be able to lower other taxes in this case, because it has not received any rent itself (unlike the situation under an auctioned allocation).

Conclusion

While grandfathering permits is the most common way to deal with some of the adverse competitiveness effects associated with the introduction of tradable permits, it is important to remember that firms and sectors which are not directly permitted are not likely to benefit. Depending upon the extent to which opportunity costs are reflected in product prices, “downstream” firms may be no better-off than under an auctioned allocation. This is also true for households, who are particularly unlikely to be grandfathered permits (for reasons of administrative cost). Moreover, both “downstream” firms and households may be even worse-off under a grandfathered allocation, since (unlike under an auctioned allocation) the government will not be raising revenues which might otherwise be used to reduce other taxes. Thus, grandfathering is a blunt means of alleviating competitiveness effects, not only because it can only do so by granting windfall profits, but also because it can only target “permitted” firms.

VI. Technological change in pollution abatement

While the relative efficiency of tradable permit systems (and other market-based instruments) is usually expressed in terms of their *static* abatement cost equalisation effects, their *dynamic* benefits on the technology of abatement may be even more important determinants of their relative efficiency. In fact, as far back as the mid-1970s, it was pointed out that “over the long haul, perhaps the most important single criterion on which to judge environmental policies is the extent to which they spur new technology towards the efficient conservation of environmental quality.” (Kneese and Schultz, 1975). Analogously, the effect that policy measures have on incentives to innovate in abatement technologies are certainly a more important determinant of their long-run economic costs (and thus, of their competitiveness effects) for firms than short-run compliance costs.

The dynamic case for market-based instruments, such as tradable permits, hinges on the fact that although the benefits of technological innovation are largely lost to the firm under more direct forms of regulation, under a market-based regime, the firm itself is able to realise some of the economic benefits of technological innovation and adoption [see Downing and White (1986), Milliman and Prince (1989); and Nentjes and Wiserman (1987)]. This much is well-documented in the literature. What is less well-documented is the effect that alternative economic instruments have on incentives to innovate, and what work that has been conducted in this area has tended to be concerned with the relative merits of subsidies on the one hand, and permits and taxes on the other.[10]

Milliman and Prince (1989) compare the effects of emission subsidies, permits and taxes in terms of incentives to innovate, and in terms of incentives to adopt innovations. They find that each has the same effects in terms of incentives to innovate (as reflected in terms of net benefits), and each is superior to technology-based rules. However, they may each have very different effects in terms of incentives for innovators to encourage diffusion of the resulting innovations. While taxes and subsidies perform well, the effects of the two permit systems are very different, with auctioned tradable permits having much stronger incentives of this type than grandfathered tradable permits.

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10. For the most part, the latter have been advocated by economists, since (in the long-run) subsidies may lead to firm entry, and thus potentially have perverse environmental consequences. Although pollution-intensity of production may fall, aggregate pollution emissions may rise. (See Wallace 1995 and Baumol and Oates 1988 for a discussion.) Wallace (1995) also reviews some of the literature on differences between the effects of permits and taxes in terms of innovations. However, since these arise largely from contextual issues (such as market structure), are not discussed here.

This result is not surprising since, in the auctioned permit case, the innovating firm will still get the benefit of lower permit prices if other firms adopt the original innovation.[11] However, under a grandfathered system the innovator may face adverse financial effects from reduced permit prices since it is likely to be a net seller of permits after adopting the innovation itself. Significantly, grandfathered permits may perform even worse than direct controls such as mandated emission reductions in terms of incentives to induce diffusion. This latter result holds for the same reason given above. Under direct controls, the only costs are those associated with abatement, but under grandfathering, permit sellers will lose from increased diffusion.[12] Thus, if the innovating firm is a seller of permits, it will have no incentive to encourage diffusion. Reduced permit prices resulting from increased diffusion might also have "upstream" effects in terms of reduced incentives to innovate in the first place (i.e. if firms innovate not only to reduce their own costs, but also in anticipation of gains from commercial sales of the innovative technology).[13]

Grandfathered permit systems may also result in less innovation in cases where firms anticipate the introduction of a tradeable permit system in the future. In expectation of the policy, firms may behave strategically, delaying emission-reducing innovations in order to secure a greater allocation of permits for themselves when the policy is introduced. This can be mitigated by providing credits for early abatement action. Alternatively, and more realistically, governments should say at the outset that past years are to be used for determining the allocation. (See AGO 1999B.) In order to puncture expectations and undermine any incentives for strategic behaviour it is vitally important that the government state that it will adopt such strategies as early as possible, even before specifying other aspects of the permit scheme.

Kemp (1997) points out that many studies assume that most innovations are internal to the sector — i.e. generated by the firms themselves, and not by specialist environmental technology firms. This may be true for some sectors, but in others, it is clearly not the case, so the implications for innovation and diffusion will be quite different. Moreover, the relevance of these insights to the specific case of GHGs needs to be further qualified, since they mainly relate to "end-of-pipe" abatement innovations (i.e. sulphur scrubbers or catalytic converters), or to changes in material inputs which have a clear and important environmental component (i.e. the substitution of CFCs by HCFCs, or the use of aqueous solvents). This is less clearly the situation for CO_2, where post-combustion abatement is not economically-feasible and where most reductions in emissions are likely to be associated with the general turnover of capital equipment. In the CO_2 case, in other words, there is only a relatively small market for "environmental" equipment *per se*, with most reductions related to capital stock turnover in a more general sense.

In the case of methane and N_2O as well, some of the biggest sources of emission reductions are likely to be more closely related to more general changes in production processes, rather than to the application of specific technologies (e.g. improved livestock management, reduced agricultural burning, etc.). As such, the effects of different permit allocations on technological change are likely to be less-pronounced. However, there may be some areas (such as fertiliser types and application technologies), for which the differential effects of alternative allocation mechanisms *are* important. This may also prove to be true of some of the more recent developments in biotechnology, which may allow for increased yields with lower methane and N_2O emissions.

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11. Note that this assumes that the innovating firm must also have a demand for the permits. Thus, it would be more relevant for cases in which the innovations come from within affected sectors, and not from specialist environmental control firms, for example.

12. However, it must again be emphasised that this distinction is not important if innovations are generated by specialist firms which are external to the sector, and thus not themselves involved in the permit market.

13. Grandfathered permit systems may also result in less innovation if the policy target is endogenous. In anticipation of the introduction of a tradeable permit system firms may behave strategically, delaying emissin-reducing innovations in order to secure a greater allocation of permits. This

Conclusions

Tradable permits in general are more effective than more direct forms of regulation in providing incentives for technological changes which reduce GHG emissions. However, for the most part, there is little real difference between the incentives provided by auctioned allocations and grandfathered allocations, since there are few "separable" abatement technologies *per se* for any of the main GHGs. Nonetheless, in some specific cases (i.e. if innovations are internal to the sector and innovators are net sellers of permits), this may prove to be important. By providing different incentives for the diffusion of innovations, different permit allocation mechanisms may have consequences for technological trajectories.

VII. Market power, barriers to entry and productivity

A great deal of concern has been expressed about the potential for firms to exercise power in the market for permits [see Koutstaal (1997), Misiolek and Elder (1989), Xepapadeas (1997) and Hahn (1984)]. This is relevant for the choice of allocation mechanism since it is thought that if there is a large discrepancy between a firm's initial allocation of permits in a grandfathered allocation and the number of permits it would own in a competitive market, firms will be more likely to manipulate permit prices strategically. When large firms are allocated more permits than their optimal allocation, they will exercise monopoly power, driving up the permit price. When they are granted too few permits, they will behave as monopsonists, driving the permit price below the efficient level [Hahn (1984); Koutstaal (1997); and Tietenberg (1998)]. The most obvious consequence in terms of competitiveness relates to the distribution of control costs between firms and sectors in a given regime, with those firms with the power to set prices able to gain a competitive advantage relative to their rivals (Johnstone, 1998).

More significantly, grandfathered permits can also become a means of restricting entry into product markets. In effect, permits can become a vehicle through which "insiders" can reduce the contestability of markets by restricting the access of "outsiders". For instance, if foreign firms are not grandfathered permits and have difficulty obtaining them from secondary markets, this may give domestic firms a competitive advantage in output markets. The permits thereby become a barrier to entry, and the likelihood of this arising is greater than under auctions in which any firm (domestic or foreign) is eligible to bid. Indeed, many American tradeable permit systems based largely upon grandfathering retain a small number of permits to auction precisely for this reason.

Even more significantly for overall economic competitiveness, firms with power in the market for permits may be able to exclude new rivals (Misiolek and Elder, 1989). In effect, there is a danger that permits may become the vehicle through which existing firms are able to exercise power in product markets by excluding new firms. This "exclusionary" behaviour may have far-reaching consequences for competitiveness, since new firms are often important instigators of new products and production processes [see Geroski (1991) and Baldwin (1995) for very full treatments of the role of firm entry in the dynamics of the economy]. Thus, market power may reduce competitiveness by slowing down both the rate of technological change and the rate of product development.[14]

In order for a firm to exclude others from the market, it must be able to increase the costs of entry into the market. (Indeed, in the extreme case, if the "insiders" are able to cooperate fully then it is possible that access for "outsiders" will be restricted entirely, with no permits available at any price. However, this seems unlikely, since at a certain point the benefits from permit sales will exceed the benefits from the firms' traditional activities.) The extent to which a firm will be able to increase the cost of entry will

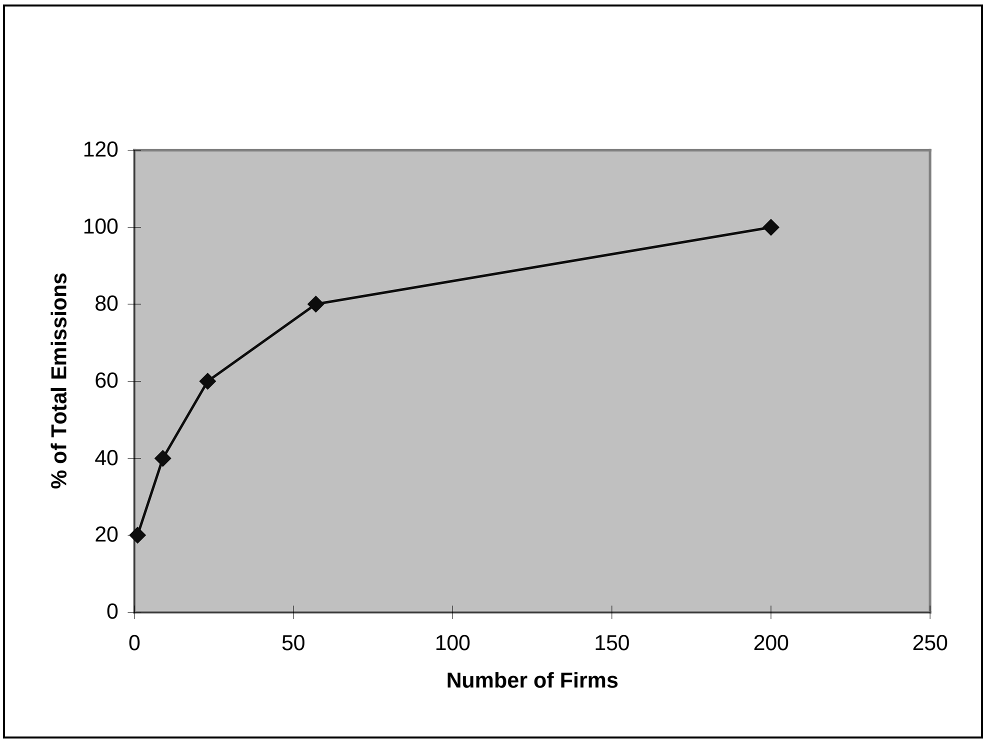
14. It is important to emphasise that a number of empirical studies have shown that technology-based rules have tended to have particularly adverse consequences for firm entry, capital turnover and productivity growth [see Maloney and Brady (1988) and Nelson et al. (1993) for examples].

depend upon the degree of concentration in the allocation of permits[15] and the price elasticity of permits (Tietenberg (1998)]. Moreover, in order for permits to serve as effective barriers to entry, the same firms must compete against each other in both permit markets and product markets.

Since there are many significant emitters of CO_2 and since these are widely dispersed by sector, it is unlikely that there will be a significant degree of concentration in most countries. This is true even if the public authorities try to reduce administration costs by concentrating the incidence of the permit scheme on “upstream” sectors. There will still be over 1,700 permit buyers in the US if the incidence is targeted at oil refineries, coal preparation plants and natural gas pipeline companies and processing plants (Cramton and Kerr, 1998).

However, there will, of course, be far fewer in other countries. Svendsen (1998) reviews the Danish case and argues that if permits are issued to electricity generators the market structure is likely to lead to market power. With 55% of total emissions attributable to 10 firms split into two consortia, he argues that there is significant potential for market power. However, since the utilities are price-regulated local monopolies, rather than profit-maximising competing firms, the motivation to exercise such power is reduced. If permits are issued only to manufacturing firms (excluding electricity generators, households and transport), 20% of the emissions are attributable to a single firm. Cumulative percentage of emissions from manufacturing are depicted in Figure 4.

Figure 4. Cumulative % of Emissions by Manufacturing Firms in Denmark



Methane and N_2O are more interesting. Oil refineries are important sources of the latter, and there is a considerable degree of concentration in the sector. On the other hand, livestock is an important source of methane, and despite increased concentration in the sector in most OECD countries, it is still very decentralised. As such, it is very unlikely that market power could be exercised. However, in the likely

15. Thus, the likelihood of market power developing is correspondingly less if domestic tradable permit systems are linked in an international market.

event that non-point sources are excluded from the permit market then there may well be sufficient concentration for market power to arise.

The potential consequences of permits serving as barriers to entry are most clearly illustrated through empirical studies of the effects of new firms on total factor productivity (TFP). In the UK, Geroski (1989 and 1991) finds that while relatively few entrants can be characterised as “innovators” (in terms of products or processes), firm entry still has appreciable effects on innovation, both directly through the innovators themselves, and indirectly as a spur for insiders to innovate. He concludes that approximately 30% of productivity growth can be attributed to firm entry, and the effect is even greater in the long-run. Looking directly at the relative productivity rates of new entrants and incumbents, Baldwin (1995) finds that as much as 29-30% of growth in total factor productivity in North America can be attributed to new firms and plants. Overall, plant turnover may be responsible for 40-50% of productivity growth. Some of these effects may be quite indirect. For instance, new firms (or even the possibility of their entry) may also encourage more efficient use of given productive resources and spur innovation amongst incumbents (Geroski, 1991).

Conclusions

Grandfathered permits have the potential to introduce barriers to entry through the existence of “market power”. In some senses, the danger of market power emerging in a permit scheme for GHGs appears to be rather less than it is for other pollutants. This is because emissions are not highly concentrated. However, even if market power can not be exercised, grandfathering does place new firms at a relatively more disadvantageous position than existing firms than is the case under auctioning, and this may have adverse consequences for the long-run dynamism of the economy.

VIII. General conclusions

Grandfathered permits and auctioned permits are likely to have quite different economic consequences. This includes differences in terms of the competitiveness effects for firms and for economies more generally. This has, of course, long been recognised by the firms themselves, and the history of the implementation of tradable permit systems is one of firms seeking to ensure that permits are grandfathered, rather than auctioned. The reason is simple — in grandfathered permit systems, firms are able to avoid paying for emissions. Since they did not do so under most of the regulatory systems which the tradable permit systems are replacing or complementing (e.g. technology-based regulations), this is hardly surprising. Firms will naturally resist efforts to redefine property rights (rights to use the receiving environment) in a way that is contrary to their financial interests.

Despite these purported “competitiveness” advantages of grandfathered permits relative to auctioned permits, it is important to be clear about what this means in practice. Using a permit incurs an “opportunity cost”, even if the permit is grandfathered. This means that the real effect of grandfathering is reflected in profit rates, more than in pricing decisions. Thus, in the short-run, firms which have been grandfathered permits may not gain market share, relative to firms which have been auctioned permits, but they will capture windfall earnings. In a sense, therefore, grandfathering has more to do with wealth distribution than with competitiveness. However, in the longer run, it is possible that firms may use these rents to increase investment. Conceivably, this may help them in terms of new product development and increased productivity levels — two key factors behind “increased competitiveness”. The difference relative to an auctioned permit system is likely to be greatest when capital markets are imperfect.

However, the case in favour of grandfathered permits on the grounds of increased competitiveness effects is by no means straightforward. Indeed, a number of other factors need to be recognised:

- Revenue-recycling may mitigate some of the adverse competitiveness effects of auctions, both because revenue-raising instruments are more efficient in general, and because some firms will benefit from the specific means by which the revenues are recycled;

- Other firms (and households) in the economy which have not been granted permits will not benefit from grandfathering. Thus, if there are significant supply links between sectors, the “incidence” of permit allocation in the production cycle is very important;

- Under certain circumstances, incentives for the diffusion of abatement innovations between different firms may be somewhat greater under auctioned allocations than under grandfathered allocations; and,

- Barriers to entry may be lower under auctioned allocations than under grandfathering, resulting in greater “new firm” entry, which is likely to result in greater dynamism in the economy.

More importantly, grandfathering is not even likely to be the most efficient way to mitigate adverse effects for the affected firms, since it is a very blunt instrument. Under an auction system, there are no constraints on the means by which the revenues raised can be used to obviate “competitiveness effects.” The beneficiaries can be targeted through compensatory measures such as adjustments in various taxes or through direct financial assistance. Under a grandfathered allocation, the only compensation that can be provided is through granting windfall profits. While this rent may be used to facilitate adjustment of the capital stock, there is no *a priori* reason to expect that it will be used in this way. There are better (more flexible and more transparent) ways of easing the adjustment and these can be financed through the revenue from an auctioned system. Moreover, grandfathered allocations can only provide such support to permitted firms, while the revenue from an auctioned allocation can be used to support whichever regions and sectors are most adversely affected. Some of these may be required to possess permits under the policy measure, but others may be “upstream” or “downstream” of the incidence of the scheme.

In effect, the problem needs to be reformulated. The question is not so much whether or not auctioned permits or grandfathered are more likely to lead to adverse competitiveness effects, but rather which of the two allocations is best suited to dealing with any adverse effects that might arise. Policy-makers should therefore be conscious of the needs of those sectors which are likely to be most directly affected by the introduction of permit trading, but should not accede to their demands for the use of grandfathered permits if it is not an efficient means of addressing such concerns.

ANNEX: CLIMATE CHANGE MITIGATION AND COMPETITIVENESS

There is a vast body of empirical literature on the international competitiveness effects of environmental policy.[16] However, there are few studies which actually look at the competitiveness effects of different types of environmental policy *instruments*. Intuitively, one would suppose that the effects of market-based instruments would be less, due to their relatively greater efficiency. By equalising marginal abatement costs, and by generating incentives for technological innovation, a given reduction in emissions should be achieved at lower aggregate economic cost with market-based instruments than with other tools. How this is actually reflected at the level of the firm will depend upon the precise nature of the policy that is introduced, and on the particular characteristics of the firms and sectors involved. This seems to be especially important for tradable permit systems, since one of the main attributes of these systems (flexibility in implementation) will also result in a large variation in potential "winners" and "losers".

The literature which examines the competitiveness effects of climate change mitigation options is extensive [see Barker and Johnstone (1998) for a recent review]. In particular, there are numerous studies which look at the competitiveness effects of introducing carbon taxes. These studies find considerable variation in the estimated effects. However, these studies are not especially relevant for this report because they focus on the cumulative imposition of a "carbon constraint", and are therefore more interested in the environmental *target* than the policy *instrument* itself (the latter is the subject of this report).

However, the reasons for differences in results obtained in the studies reviewed here *are* relevant. Many of these reasons are methodological (degree of disaggregation; the modelling framework used; treatment of the trade sector; etc.). Others are related to the means by which the measure is implemented (sectoral coverage, spatial scope, etc.). Still others are related to more fundamental economic characteristics (trade elasticities, supply conditions, etc.). The first set of reasons (methodological issues) are not discussed here, since they relate to how the studies were conducted, and not to the fundamental issues involved. Most of the issues related to the second set of reasons (policy implementation) are addressed in the next sections, with specific reference to the role of tradable permits. Some of the more general economic determinants of competitiveness effects which are not specific to particular policy types are reviewed in this section.

16. See J. Adams (1997) and Jaffe et al. (1995) for recent reviews.

Trade-intensity of GHG-intensive sectors

The "vulnerability" of a firm to competitiveness pressures is determined in large part by the extent to which it is subject to competition from overseas producers.[17] If the policy measure increases (reduces) costs, firms will have a competitive (dis)advantage, relative to producers who are based overseas. For a given level of emissions, firms in sectors which are highly tradable are more likely to be affected by negative or positive competitiveness effects, following the introduction of a policy measure to reduce GHG emissions. Thus, due to its greater tradability, oil may be more affected than coal, despite being a much less carbon-intensive source of energy. Similarly, some of the service sectors which are particularly trade-intensive (e.g. air and sea transport) will also be affected more than others.

Figure A.1 compares the carbon-intensity[18] of different US manufacturing sectors with their trade-intensity.[19] The labels refer to the relevant 2-digit SIC sector[20] and the dashed lines are the weighted means. Significantly, only one of 20 sectors (chemical and allied products) is in the north-east corner, indicating that it is both carbon-intensive and trade-intensive. This suggests that, at least for the American case, carbon-intensive manufacturing sectors do not tend to be particularly trade-intensive, and *vice versa*.

The trade-intensity of the main methane-emitting sector (landfills) is very low. While there is some trade in solid waste disposal and treatment, the vast majority of waste is disposed in its country of origin. The other important sources of methane emissions (livestock, coal and gas production) are traded in significant quantities. However, even in these cases, trade represents a relatively small proportion of total output.

The case of N_2O is more ambiguous, since the data here is much less reliable, with a large variety of "non-combustion" processes being the primary anthropogenic sources. Fertiliser use in agriculture seems to be the largest source, although there is considerable variation between countries. Fertiliser production and the chemicals industry are also large sources. In addition, increased use of catalytic converters has resulted in a large increase in N_2O emissions from road transport. However, this is more likely to affect households, since most commercial vehicles (freight and other) are diesel-powered.

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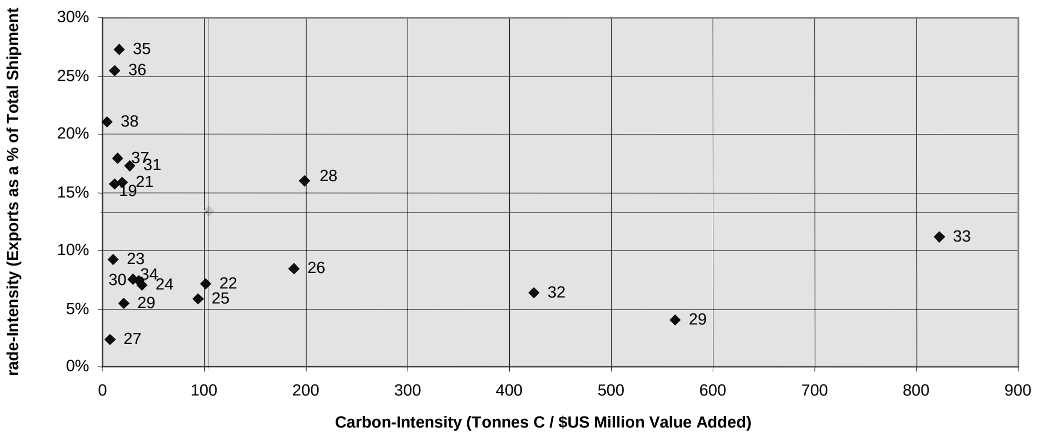
17. Since global warming is an international environmental problem, it is unlikely that any tradeable permit system designed to mitigate its effects will be implemented at the sub-national level. As such, local and regional competitiveness issues are less important.

18. Carbon-intensity was calculated on the basis of energy use by fuel (EIA 1996), carbon conversion factors, and value-added (USDOC 1997) in 1991. It excludes fuels used for non-combustion purposes (i.e. as material inputs in the petrochemical sector).

19. Trade-intensity was calculated as the percentage of total exports in total value of shipments ((US BOC 1996a,b) in 1992. The same year could not be used for carbon-intensity, since trade data was not available using the same (SIC 3-digit) means of disaggregation, so 1991 data was used.

20. Food and Kindred (20), Tobacco (21), Textile (22), Apparel and Other Textile (23), Lumber and Wood (24), Furniture and Fixtures (25), Paper and Allied Products (26), Printing and Publishing (27), Chemicals and Allied Products (28), Petroleum and Coal Products (29), Rubber and Misc. Plastics Products (30), Leather and Leather Products (31), Stone, Clay and Glass Products (32), Primary Metal Industries (33), Fabricated Metal Products (34), Industrial Machinery and Equipment (35), Electric and Electronic Equipment (36), Transportation Equipment (37), Instruments and Related Products (38), Misc. Manufacturing Industries (39).

Figure A.1. Carbon-Intensity and Trade-Intensity of US Manufactures



Demand elasticities of GHG-intensive sectors

While trade-intensity is an important factor determining the "vulnerability" of sectors to adverse competitiveness effects, the import and export price elasticities of these sectors will ultimately determine the extent to which they do, in fact, suffer from environmental policies which affect their prices. The more price-elastic the demand for imports and exports of GHG-intensive sectors, the more they will lose (gain) market share as a result of the implementation of policies which increase (decrease) costs. Thus, if trade flows are determined in large part by factors other than relative prices, the competitiveness effects are likely to be less pronounced.

There are surprisingly few empirical studies of the price-sensitivity of trade flows. Table A.1 reports estimates from a study (Brenton and Winters, 1992) of the substitution elasticities between imports and domestic products for a number of sectors in Germany and Italy. Only rubber and tyre products appear to be both carbon-intensive and relatively price-sensitive in terms of the pattern of trade flows for both countries. Conversely, the results from a more comprehensive (but dated) study (Stone, 1979) indicates that trade flows in carbon-intensive sectors in three OECD regions (Europe, United States and Japan) appear to be quite price-sensitive relative to other sectors.

Thus, it is difficult to determine whether traded demand for carbon-intensive products is particularly price-sensitive, and thus whether policy measures which increase (reduce) prices will have a significant effect on trade flows. However, environment-related price increases may introduce an additional factor which mitigates likely effects on the pattern of trade flows. If adherence to stringent environmental policies allows firms to differentiate their products in environmental terms, price-sensitivity will be correspondingly lower. For instance, if consumers and firms attach value to products which are produced by means which are less GHG-intensive, producers may be able to pass on some of the costs of compliance without losing market share. This issue has not been analysed extensively in analyses of the competitiveness effects of environmental policies.

Table A.1. Estimated Price Elasticities of Substitution Between Domestic and Imported Goods

	Germany	Italy
Tobacco Manufactures	-0.69	-0.80
Manufacture of Footwear	-1.14	-0.79
Manufacture of Furniture and Fixtures	-1.91	-0.69
Manufacture of Pulp, Paper and Paperboard*	-0.37	-0.82
Rubber and Tyre industries	-1.61	-1.00
Manufacture of Glass and Glass Products*	-0.61	-0.69
Manufacture of Cement, Lime and Plaster*	-0.35	-0.68
Manufacture of Cutlery, Hand Tools and General Hardware*	-0.77	-0.95
Manufacture of Special Industrial Machinery*	-1.13	-0.71
Manufacture of Office, Computing and Accounting Machinery	-1.41	-1.48
Manufacture of Radio and Television Equipment	-1.20	-0.94
Manufacture of Electrical Appliances	-0.95	-1.24
Manufacture of Motor Vehicles	-1.60	-1.50
Manufacture of Motorcycles and Bicycles	-0.96	-1.64
Manufacture of Professional and Scientific Equipment	-0.67	-3.61
Median	-0.94	-0.96
Unweighted Averages	-1.02	-1.17

Note: * indicates relatively carbon-intensive sectors.
Source: Brenton and Winters, 1992.

The practical importance of the degree of price-sensitivity in trade flows is revealed in a recent comparison between one model (12RT), which assumes perfect substitutability between domestic and foreign goods, and another model (GREEN), which assumes that domestic and foreign goods are not homogeneous (i.e. Armington elasticities are assumed to exist). The researchers (Manne and Oliveira Martins, 1992) find that competitiveness effects are much greater in 12RT than they are in GREEN. In a separate study using GREEN, it was found that tripling trade elasticities in the non-energy sectors increased the "leakage" rate[21] from 2.4% to 6.8% (Oliveira Martins *et al.*, 1992*a*, p. 136). While not all of this "leakage" can be attributed to "competitiveness" effects *per se*, it does suggest the potential importance of such effects. Also using GREEN, Oliveira-Martins (1995) compares the effects of EC member countries unilaterally stabilising carbon emissions at 1990 levels with different substitution elasticities for energy-intensive industries between domestic and foreign goods (3-4 in one simulation, and 15 in the other). The sensitivity analysis reveals a 33% increase in the "leakage" rate, indicating the existence of some adverse competitiveness effects, although it must be emphasised that this arises from a very large increase in the degree of substitutability.

The main methane-emitting and nitrous oxide-emitting sectors (principally agricultural products) have traditionally been seen as homogeneous commodities, in which import and export elasticities are not likely to differ from domestic demand elasticities. However, this appears to be changing, with many agricultural products increasingly being differentiated, including by country-of-origin. This implies that the competitiveness effects of policies which affect the relative costs of production may *not* have as significant consequences for trade flows as was thought to have been the case previously.

21. The percentage increase in overseas emissions relative to the decrease in emissions in the country imposing the carbon constraint.

Abatement cost elasticity

The competitiveness effects arising from a constraint on GHG emissions also depend on the slope of the abatement cost curve. Ignoring the potential for sequestration (e.g. through reforestation) in the case of CO_2, this is largely a consequence of the extent to which firms are able to substitute other factors of production for energy, and the extent to which they are able to substitute less carbon-intensive fuels within their fuel mix. If this can be done at little cost, the competitiveness effects will be mitigated.

In an extensive review, Atkinson and Manning (1995) provide evidence of the estimates of the degree of substitutability between energy and other factors of production. They conclude that cross-price elasticities between energy and material inputs, and between energy and labour, are in the order of 0.5. This suggests that energy is a moderate substitute for both labour and materials. However, the relationship with capital is more complex, and it is generally thought that they are complements in the short-run, but substitutes in the long-run (Atkinson and Manning, 1995). Cross-price elasticities between different fuels are generally positive, but relatively low. Atkinson and Manning's (1995) estimated cross-price elasticities are all less than 0.26, and the elasticity of demand for the least carbon-intensive fuel (gas) from an increase in the price of the most carbon-intensive fuel (coal) is only 0.12.

The importance of the degree of substitutability in fossil fuels is illustrated through the results of a number of studies. For instance, using GREEN, Oliveira-Martins *et al.* (1992*b*) examine the effects of reducing short-run and long-run inter-fuel substitution elasticities by half, when reducing CO_2 emission growth rates by 2% per annum. They find that the economic cost in 2050 (as reflected in average global tax rates) increases from \$230/ton to \$400/ton when these elasticities are changed (Oliveira-Martins *et al.* 1992b). The relative supply elasticities of different fossil fuels are also important, since prices will adjust considerably more if supply is inelastic than when it is elastic. Thus, supply elasticities will determine the extent to which demand shocks arising from carbon constraints are passed through to the fuel prices faced by downstream firms.

Estimates for other greenhouse gases are not as readily-available. The slope of the abatement cost curve for methane emissions from landfills might well be quite flat over the relevant range, but as noted above, this sector is not highly traded anyway. In the agriculture sector, the cost of emission reductions for cultivation is largely a function of the cost of increasing yields through measures other than increased fertiliser application. Methane emission reductions from livestock are closely related to improved management (e.g. feeding practices). Reduced emissions of N_2O can also be achieved through changes in fertiliser use (particularly synthetic fertilisers), improved forest management, and reduced agricultural burning [see Leggett (1990) for a discussion]. Costs will vary widely, depending upon present practices.

Conclusion

In general, the competitiveness effects of the introduction of a GHG abatement policy will tend to rise with the trade-intensity of the affected goods and services, the elasticity of traded demand, and the slope of the abatement cost curve. This will vary by pollutant, by country, and by sector. However, to a great extent, these factors are unlikely to change with the introduction of a specific environmental policy, much less a different type of allocation mechanism for tradable permits.

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