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Distributing the Value of a Country's Tradeable Carbon Permits

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Abstract. A general proposal is made for initially distributing the total value of tradeable carbon permits in a developed country, which tries to balance allocative and informational efficiency, political acceptability, and equity. Because of the macroeconomic significance of carbon, the proposal is quite different from and more complex than, say, the distribution used for SO_2 permits in the US sulphur trading programme.

We suggest that acceptability requires a political (but not legal) principle of compensating for the profit that an industry loses because of carbon control. However, fossil fuel demand is relatively inelastic, so making all permits free (grandfathered) to industries while reducing total carbon use would give them large monopoly profits which would overcompensate for their losses. Compensation therefore requires only a small proportion (much less than half) of an industry's carbon permits to be free. Remaining permits would be auctioned, or given free to households. If a sizeable part of permits is auctioned with revenues recycled as lower rates of corporate and/or personal income tax, then most firms outside the fossil fuel industries would benefit from carbon control, and so need no compensation.

We argue that consumers also deserve compensation for higher prices of fuel and carbon-intensive products. The split of such compensation between lump sums (free permits or cash) and personal tax cuts depends on the desired balance between equity and efficiency. Arguments are also discussed for distributing permit value as assistance to workers that face unemployment caused by carbon control. Many other details of a distribution scheme are discussed, such as where permits should be acquitted, whether free permits distort competition, whether foreign-owned firms should get free permits, and whether free permits should be phased out.

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1. INTRODUCTION

In response to calls for reductions in greenhouse gas (GHG) emissions, economists since at least Pearce (1991) have suggested using market instruments such as tradeable permits or taxes to control CO_2 emissions from fossil fuel burning. In theory, market instruments can achieve any given total amount of emission control much more cheaply than direct emission regulation. However, such desirable efficiency will not be achieved unless the net costs of a control scheme are distributed[1] in a politically acceptable way. Given the large control and damage costs at stake,[2] finding an acceptable distribution scheme is therefore a high priority for environmental economics. To this end, we propose here a general approach to distributing the value of a given amount of tradeable carbon permits within one country. We do not consider the distribution of permits among countries. Like most similar work, the only GHG considered is CO_2 from burning fossil fuels. And the only point of acquittal considered is upstream, where fossil fuels are first supplied by domestic extraction or importing. Our aim is a distribution scheme which maximises total (allocative and informational) efficiency, subject to it being sufficiently acceptable (to the political process) and reasonably equitable.

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1. Many writers refer to costs being "allocated" rather than "distributed" among groups of people; but here we use "allocation" to refer only to how much labour, capital, fuel, etc, might be employed by firms under various policy options.

2. A rough measure for Australia is the value of its annual assigned amount of GHG emissions emissions for 2008-12 under the Kyoto Protocol, which is 415 Mt of CO_2-equivalent. At the central estimated permit price in AGO (1999b) of about US$20/tonne, this is worth about $9.3 bn/yr, about 10% of current Commonwealth (i.e. federal) tax revenues. Of this, fossil-fuel CO_2 accounts for about 70% (AGO 1999a). Very similar figures are calculated for the USA by Cramton and Kerr (1999, p258). No other single pollutant is close to this level of macroeconomic significance.

So our proposal is inherently political, and it relates to existing literature on the political economy of GHG control as follows. We argue that it is vital to distribute permits in a *hybrid* way: some permits should be given away free or "grandfathered"[3], and the rest should be auctioned. A hybrid approach avoids an artificial debate between the polar opposites of purely free and purely auctioned permits. It focuses instead on choosing a (politically) appropriate proportion of free permits. In this we concur with Koutstaal and Nentjes (1995, p224), Koutstaal (1997, p16), and Vollebergh, de Vries and Koutstaal (1997, p55). By contrast, we appear to disagree with Fischer, Kerr and Toman (1998, p457) and Cramton and Kerr (1999), who argued that permits should all be auctioned rather than all be free (the dichotomy which a hybrid scheme avoids). However, both also briefly suggested that initially some permits could be free, but with full auctioning be phased in over time, and this is in fact a hybrid distribution of the present value of the permit stream.

However, we go further than either set of authors, and consider in some detail how the government should use the large revenues from permit auctions. So our "distribution" scheme includes the total *value* of all permits, free and auctioned. We do this because without knowing how auction revenue is distributed, it is hard to gauge the overall acceptability of a scheme. Moreover, our overall principle is to compensate roughly for the net transition costs caused by carbon control. Such costs will change, perhaps into net benefits for some economic sectors, if the government recycles auction revenues as lower rates of corporate or personal income tax,

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3. We use "grandfathered" just to mean "given away free". But many writers use it ith the much narrower meaning of "given away free in proportion to some past level of emissions." This leads to a very different distribution of free permits from what we end up recommending here. We avoid "grandfathered" and talk just of "free" permits.

rather than as lump sums.

To this end we build on pioneering results from a computable general equilibrium (CGE) model of the US economy by Bovenberg and Goulder (2000) (BG), to suggest a basis for distributing free permits to key sectors of the economy. This will be shown to be quite different from Koutstaal's proposal to give free permits to cover the direct emissions of fuel-intensive industry sectors, while auctioning to fossil fuel suppliers the permits needed for all other emissions. It is also a more approximate basis for distribution than using past emissions data. CGE results vary from model to model, and considerable debate and modifications would be needed to arrive at detailed legislative proposals. But we feel it is better to get political acceptability approximately right rather than precisely wrong.

A distinctive feature of our analysis which at first seems limiting is that we often refer to the current debate in Australia about the possible use of tradeable carbon permits to help control domestic GHG emissions under the 1997 Kyoto Protocol. However, our approach is relevant to a much wider range of cases. It can be applied to any industrialised countries. It could also apply to any new, global scheme for GHG control which might eventually be expected to emerge if the Protocol itself is not ratified, as long as the new scheme effectively assigns emission amounts to each country. It also would apply to a scheme using carbon taxes rather than one using tradeable carbon permits, as long as tax offsets or tax credits in the former are used in the same way as free permits in the latter, as proposed by Pezzey (1992) and Farrow (1995).

The paper is set out as follows. Section 2 shows why a general principle of balancing allocative and informational efficiency with acceptability and equity leads to our proposal that some, but probably much less than half, of the carbon permits are given away as compensation for the net costs of carbon control. It also gives reasons why the distribution of carbon permits should be expected to differ greatly both from the distribution of allowances used in the 1990 US sulphur trading scheme (building here on ideas in Pezzey and Park 1998), and from the general principle of no compensation used in broad-based microeconomic reforms. Section 3 sets out the quantitative basis, derived from BG, for roughly how many free permits various sectors of firms should get, and how much auctioned permit revenue should be used to lower corporate income tax.

Section 4 completes the general outline of our proposal for distributing permit value by considering two out of three possible uses of the revenue from permit auctions, which would be the majority of the total permit value. There is a case that the distribution of this revenue should be decided separately from carbon control policy, which we support as far as the fine details go. But to get political acceptability for revenue-raising carbon control in the first place, we think it is important to include some general proposals for spending revenue to address the effects and shortcomings of tradeable carbon permits. So we discuss compensating consumers (individuals or households) for policy-induced price rises by giving lump sum payments to households and/or reductions in personal income tax; and compensating groups of workers for job losses. We also acknowledge, but do not discuss, using permit revenue to overcome failures in "carbon conservation" (renewable energy and energy efficiency) markets.

Section 5 addresses nine more detailed questions about a permit scheme which, though not novel, have recurred in many policy debates and need answers. These are whether permits are acquitted upstream, as we assume, or elsewhere; whether free permits are assigned to sectors or firms; the use of non-tradeable permits for trade-exposed sectors; the wealth effects of free permits on firms' exit and entry; the treatment of foreign or publicly-owned firms; the integration of tradeable permits with existing fuel taxes; the equivalent of our proposal using taxes and tax offsets rather than auctioned and free tradeable permits; and timing questions, such as whether permits are sold annually or as permanent streams, and whether free permits should be phased out over time. Section 6 concludes.

2. BALANCING EFFICIENCY WITH ACCEPTABILITY AND EQUITY IN THE CASE OF CARBON

2.1 General and specific principles for achieving balance

Our general principle, from which we derive our detailed proposal for distributing carbon permits, is that:

> *a distribution scheme should maximise total (allocative and informational) efficiency, subject to it being sufficiently acceptable and reasonably equitable.* [1]

This needs more explanation, as follows. Maximum efficiency means achieving a given carbon reduction goal at minimum total cost to a country, which is clearly desirable in itself (that is, ignoring any distributional effects it may have). Using tradeable permits or taxes to control emissions in theory achieves "allocative efficiency" by inducing more control effort to be allocated by emitters with lower control costs, and thus minimising the actual costs of control (Baumol and Oates 1971). But "informational efficiency", which is minimising a scheme's costs of administration, transactions, monitoring and enforcement, is no less important. However, information costs are hard to include in calculations of control costs, so the obvious goal of "total efficiency" (minimising the sum of both types of cost together) often requires paying separate attention to each type.

"Sufficiently acceptable" means commanding enough political support to be passed into law by a country’s legislature. This is essential, since otherwise no scheme will happen and no efficiency benefits will be realised. "Equitable" means different things to different people. Our ideal (though only roughly achievable) notion of equity here is one of proportional compensation: permit value (free permits, or permit auction revenue) should be distributed to people in proportion to their individual losses of welfare caused by carbon control.

All three goals − (total) efficiency, acceptability and equity − can obviously conflict. Acceptability differs from equity, because welfare losses concentrated among a few firms result in far more political pressure than the same dollar losses spread over millions of people as consumers (Olson 1965, Williamson 1997, Ch 5). Acceptability and efficiency can conflict: giving more free permits may increase acceptability, but will leave less auction revenue to spend on reducing existing tax rates, and may reduce induced rates of technical progress (Milliman and Prince 1989). Efficiency and equity conflict in various ways. Using an efficient (tax or tradeable permit) mechanism to control carbon is somewhat regressive. Recycling permit auction revenues by giving equal lump sums to all households is more equitable, but less efficient, than lowering existing tax rates. Giving lump sums in proportion to each household’s welfare loss would be more equitable still, but impossibly expensive in terms of information costs.

However, while our general principle [1] contains no precise formula for balancing these conflicting goals, is it not toothless. We interpret the call for "maximising total efficiency subject to reasonable equity" as a requirement that the carbon permit price facing any sector unless it harms rather than helps efficiency there; but some efficiency in the more general economy may be lost in favour of equity when choosing how to recycle permit auction revenues. Aiming for efficiency and equity subject to *sufficient* acceptability imposes clear limits on how many free permits are given to powerful business interests. We argue that sufficient acceptability can be achieved by this specific principle of implicit compensation:

> *firms should receive enough free permits under a tradeable carbon permit scheme so that their shareholders suffer no significant overall loss of welfare*. [2]

The "significant" caveat here is important, as it would allow us to give no free permits to, say, large sectors of the economy which lose only around one percent or less of discounted profits.[4] But for firms which would otherwise suffer significant losses, which generally are the most carbon-intensive ones, this principle sounds, and is, over-generous. The economy as a whole will pay a real cost to reduce its total carbon emissions, but these firms will bear no part of that cost. Nevertheless, as explained in the next subsection, under the "no loss of welfare" principle, the free permits that many large emitters of CO_2 receive will cover only a small fraction (less than a third) of their total emissions. So if such industries are given free permits corresponding to *all* their emissions (as Koutstaal proposed), then they will be greatly overcompensated; political acceptability (at least by industry) will be excessive; and both equity and efficiency will suffer. But if industries get *no* free permits, as Cramton and Kerr (1999) propose, then

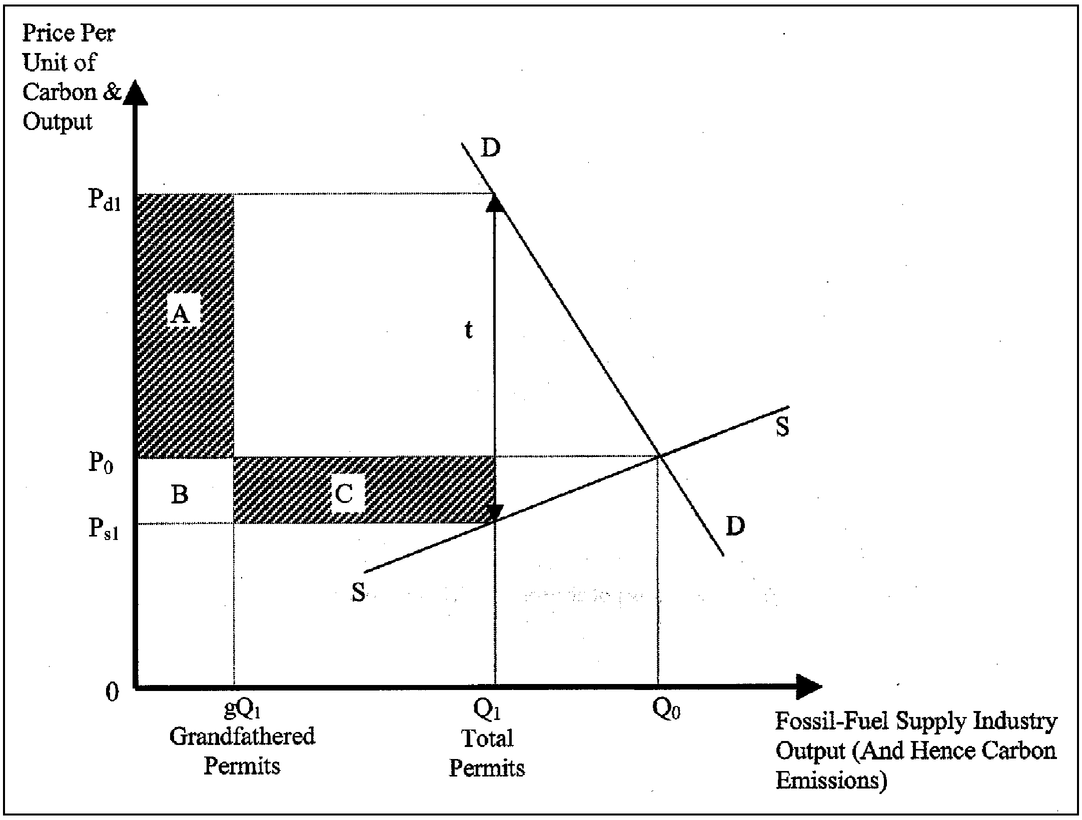
4. Alternatives to loss of profits are losses of equity value as defined by BG, or of capital value.

they are undercompensated.

2.2 How the compensation principle can result in only a small proportion of carbon permits being free

We give here a basic, qualitative explanation of why compensation results in such a small proportion of carbon permits being free. Our analysis is highly simplified in at least three key ways. First, in considering the market for just one fossil fuel, say coal, in **Figure 1** (based on Fig. 1 in Pezzey and Park 1998, and similar to Fig. 1 in BG), we assume a competitive industry. Second, the diagram is one of partial equilibrium: the supply and demand curves are treated as independent of the distribution of

Figure 1 Compensation for imposing tradeable permits or a tax



permits. This ignores the knock-on effects of recycling auction revenues, which are particularly significant when revenues are used to reduce rates of existing conventional taxes. Indeed, one cannot define the sectoral cost incidence of any scheme of carbon control unless one knows how revenues are recycled in the scheme. Third, throughout this paper unless otherwise specified, the analysis is in terms of the "present value" of all future flows. In particular, this means that carbon emission and permit totals on Figure 1 represent permanent flows, rather than just one year's flow.

The axes of Figure 1 are the price and quantity of fossil fuel carbon traded. Carbon emissions are proportional to carbon traded and burnt, as there is no viable technology for CO_2 emission control. Individual firms are competitive, but the whole industry has market power in both its input and output markets, so the supply and demand curves are respectively upward and downward sloping as shown. The tradeable permit scheme reduces the whole economy's carbon consumption and thus causes the industry's demand price to rise from P_0 to P_{d1}, just as if the industry was exerting monopoly power to restrict output and raise profits. The supply price falls from P_0 to P_{s1}, and the quantity sold falls from Q_0 to Q_1. The difference between demand and supply prices is t, the cost of a permit for one unit of carbon output.

Under our proposal a proportion $f := 1/(1+\varepsilon_s/\varepsilon_d)$ of permits would be given free to firms, where ε_s and ε_d are supply and demand elasticities at (P_0,Q_0); while the remaining $(1-f)$ of permits is auctioned. The formula for f is calculated like this. The loss of profit (producer surplus) caused by the fall in producer price is area B+C = $(P_0-P_{s1})(Q_1+Q_0)/2$. The value of the free permits is area A+B = $(P_{d1}-P_{s1})fQ_1$, and it is straightforward to show that the two areas are equal when $f = 1/(1+\varepsilon_s/\varepsilon_d)$. In terms of this diagram, BG's results imply that overall demand elasticity for carbon is much lower (at least in the US economy) than supply elasticity, thus making *f* significantly lower than 0.5, as shown on Figure 1. In Section 3 we discuss BG's detailed sectoral results, which come from a dynamic, CGE model and thus avoid the second and third three key simplifications mentioned above. Like most CGE modellers, however, they assume (and make explicit in their Conclusions) that all industries are perfectly competitive. To the extent that an industry is already exerting market power to reduce supply and enjoy some monopoly rents, carbon control will be less able to generate extra rents, so that the proportion of free permits needed for compensation will be higher.[5] But before that, we briefly digress to consider why the above principle of compensation does not apply in some other notable cases of microeconomic reform.

2.3 Why the compensation principle has such different implications for broad-based microeconomic reforms, and for sulphur trading

Our proposal for managing the distributional effects of carbon trading differs significantly from two other types of price reform. When broad-based price reforms are made such as major tax changes (e.g. the introduction of a Value Added Tax in Britain, or of a Goods and Services Tax in Australia in 2000) or tariff changes (e.g. the drastic lowering of trade tariffs in Australia), typically no lump sum compensation is paid to offset distributional effects. While some industry sectors are excluded altogether from the changes on distributional grounds (e.g. most food is excluded from VAT or GST), no sectors get credits which reduce the total cost of the changes while leaving their marginal effects undiminished. By contrast, for

5. This is perhaps the most controversial aspect of our proposal. It may be argued that compensation for loss of monopoly rent is unjustified; but this ignores the political reality that monopoly rents are by their very nature likely to be vigorously defended.

the narrow case of sulphur trading in the USA, distributional effects on sulphur-emitting firms were avoided (perhaps "over-avoided") by giving away almost all the permits to the emitting firms.

We think there is some logic behind these different approaches. In the broad-based cases, the lack of compensation was because none of the sectoral losses were "significant". Any protest from particular sectors was therefore muted, and could be withstood by the government architects of the reform. By contrast, the cost burden of the US 1990 sulphur trading program would have been proportionally quite significant for some major emitters if free permits had not been given out. This resulted in enough political pressure to make all but 2.8% of permits free to existing emitters (nearly all large power stations). This did result in some anticipated inequitable upstream and downstream effects. After the scheme was introduced, consumers generally paid a higher price for electricity, and coal-mines received less per worker from the sale of coal to the power stations. However, these were sufficiently small for political resistance to be stiff enough to wrest free permits from the government.

3. CGE MODELLING OF COST OF NEUTRALISING IMPACTS OF CARBON TRADING ON KEY INDUSTRY SECTORS

Here we discuss in various ways how well computable general equilibrium (CGE) modelling can be used to translate principle [2] above, that of compensating firms (or at least industry sectors) for the cost impacts of carbon control, into practice. To our knowledge, Bovenberg and Goulder (BG) are the only people so far to have used a CGE model to compare different distributional aspects of carbon permits. So despite the minor mismatch between BG’s U.S. data and our Australian context of policy debate, we briefly describe their model, and then discuss and interpret their results in some depth.

In doing so we try to explain the main general equilibrium implications of any permit distribution. For example, if a government chooses to give substantially less wealth in the form of free permits to a large sector like electricity generation, this in itself has no first order effect on prices and other marginal incentives in that sector. But fewer free permits means more permit auction revenue to spend on tax cuts (a change in marginal incentives) across the whole economy. This raises the welfare of the whole economy, and for some sectors could change a net welfare loss from carbon control into a net benefit. So as noted in the introduction, for both economic and political analyses, a permit distribution scheme is not complete unless it specifies what happens to the value of all permits, both free and auctioned.

To keep the main points clear, our analysis in Sections 3.1 and 3.2 leaves several detailed questions unanswered. In Section 3.3 we consider in more detail how well any CGE model can measure the "cost impacts" (adjustment costs, transition costs) of carbon control, both in theory and in practice. This reveals some fundamental problems on which further research is required. Then in Section 4 we consider some less difficult questions of detail, such as how individual firms (rather than industry sectors) should receive free permits, and how significantly competition is distorted by the wealth ("deep pocket" or "long purse") effects of free permit distribution.

3.1 A brief description of BG's model

BG use an intertemporal general equilibrium model of the U.S. economy with international trade. It generates time paths of equilibrium prices, outputs and incomes for the U.S. economy and the "rest of the world" under specified policy scenarios. All variables are calculated at yearly intervals beginning in the benchmark year 2000 and usually extending to 2075. The model combines a fairly realistic treatment of the U.S. tax system and a detailed representation of energy production and demand. It includes consideration of taxation effects on firms' investment incentives, equity values and profits, and household consumption, saving and labour supply decisions, but there is only one representative houshold (no breakdown into income classes). The energy supply specification includes the very finite nature of crude oil and natural gas, and transitions from conventional to synthetic fuels. Industry is divided into coal mining, oil and gas extraction, oil refining, electric utilities and nine other sectors, two of which (miscellaneous manufacturing, and services) account for more than half the economy. Consumer goods are divided into seventeen classes. CO_2 emission from burning fossil fuels is the only GHG modelled, and carbon permits are assumed to be acquitted upstream by fossil fuel suppliers (coal mining, oil and gas extraction, and importers of these primary fuels). There is no technical progress, other than that the technology for producing synthetic fules on a commercial scale is assumed to become known in 2020.

Unusual features of BG's analysis are the wide range of CO_2 abatement policies considered, and the focus on computing equity (share) values of industrial sectors, based on their profits, dividend payments and new share issues. (We discuss their treatment of equity values further in Section 3.3.) All policies simulate enough carbon control to yield approximately a US$25 permit price per ton of carbon[6], varied slightly among policies so as to give exactly the same path of CO_2 emissions in all cases. The relative sectoral effects of policies prove to be fairly insensitive to the level of the permit

6. In fact BG assume a $25/ton carbon tax. But the tax and tradeable permit instruments are equivalent in their model, for reasons noted in our Section 5.7.

price. What differs among the eleven policies considered by BG is the distribution of revenue from permit auctions, seven of which are summarised in Table 1.

Table 1 Selected distributional policies analysed by BG

<table>
<tr><td colspan="5">Definitions used: PIT = personal income tax; CIT = corporate income tax; FFI = fossil fuel industries (coal, oil&gas, oil refining, electric utilities). Permits are for permanent emission flows, not just for one year.</td></tr>
<tr><td>BG policy number & welfare cost in US$bn/yr</td><td>Main way of distributing total permit value</td><td>Any free permits? (Rest are auctioned)</td><td>Secondary way of distributing total permit value</td><td>Goal achieved by secondary distribution</td></tr>
<tr><td>(1): 817</td><td>Lump sums to households</td><td rowspan="3">No</td><td rowspan="3">–</td><td rowspan="3">–</td></tr>
<tr><td>(2): 471</td><td>PIT rate cut</td></tr>
<tr><td>(3): 374</td><td>CIT rate cut</td></tr>
<tr><td>(4): 345</td><td rowspan="4">PIT rate cut</td><td>No</td><td>Specific CIT rate cut for each FFI</td><td rowspan="2">No equity value change in each FFI</td></tr>
<tr><td>(5): 474</td><td>Yes</td><td>Specific free permits for each FFI</td></tr>
<tr><td>(10): 355</td><td>No</td><td>Specific CIT rate cut for coal, oil&gas</td><td rowspan="2">"Fiscal neutrality for acquitters" (coal, oil&gas make zero payments to state)</td></tr>
<tr><td>(11): 713</td><td>Yes</td><td>Coal, oil&gas get all permits free</td></tr>
</table>

BG's Policy (1) is a base case where all permits are auctioned and all revenue is recycled as lump sums to households. Under it, BG calculated that coal-mining loses around 30% of its equity value, and oil and gas, oil refining and electric utilities each lose around 5%, while all other sectors lose around 1% or less. This is the basis of our political judgment that it is only the four fossil-fuel industries (FFIs) which require special treatment in permit distribution. Policies (2) and (3) are simple "weak double dividend" policies which use all the auction revenue to cut existing distortionary on personal or corporate income. As seen in the table, this cuts (but does not eliminate[7]) the overall welfare cost of carbon control.

The other policies all distribute some of the permit value to specific fossil-fuel industries, with the aim of increasing the political acceptability of carbon control. Policy (4) uses just enough auction revenue to pay for cuts in corporate tax rates, which are individually tailored to each fossil-fuel industry so that it ends up with no change in its equity value. The rest (in fact the large majority) of the revenue is still refunded as a cut in personal income tax. We choose not to highlight policy (4) because we doubt if variable, industry-specific rates of corporate tax are administratively feasible.

Policy (5) achieves no changes in equity values in the same industries by instead giving them each just enough free permits.[8] (In BG's model, and in much of our own reasoning, firms are assumed to treat a given quantity

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7. The idea that recycling revenue as lower tax rates can yield a net welfare *benefit* is the "strong double dividend hypothesis". It is nowadays rejected in practice by most conventional economists; see for example Bovenberg (1999).

8. Since oil refiners and electric utilities do not actually acquit permits, they are assumed to sell the free permits they receive. The welfare cost of Policy (5) is higher than for (4) because there is no reduction of distortionary corporate taxes.

of free permits as no different from a lump sum of cash equal to the market value of the permits. Either way, "permit value" is being refunded to them.) Policies (10) and (11) use the same methods of refunding permit value, but with the aim of leaving domestic acquitters of permits with no net payments to state regulatory authorities. BG show that this leads to vast profit increases for the coal, oil and gas industries, because carbon control with all permits free gives them unfettered monopoly profits. So we consider these policies no further, and focus instead on Policy (5).

3.2 Some BG results for a hybrid permit distribution: Why free permits to the electricity industry would be inequitable

Table 2 gives our presentation of the results of BG's Policy (5) for the U.S., using extra figures for initial equity values and the present values of permanent free permits given to each fossil-fuel industry kindly supplied by Larry Goulder. The first four rows of columns 2, 5 and 6 show that by giving specific amounts of free permits to the coal, oil & gas, oil refining and electricity sectors, these sectors end up with no net change in equity values as a result of carbon control using tradeable permits. Yet the Other sectors row shows that the rest of the economy, which gets no free permits, enjoys a small (0.1%) net *gain* in combined equity value, though there may be sectors which individually lose equity value. Intuitively, how does this happen? The answer is that most of the permits are auctioned; the auction revenue all goes on cutting the personal income tax rate; and because permit trading makes carbon more expensive throughout the economy, people spend most of their tax cuts on low-carbon goods, thus giving a small net boost to the rest of the economy's profits. With this result, there is then no general case for any compensation for other sectors (though specific manufacturing industries which are both carbon-intensive and trade-exposed, like aluminium or cement in Australia, may require special treatment).

Table 2 CGE results for U.S. economy from Bovenberg and Goulder (2000)

Limited amount of tradeable carbon permits issued for combustion-related emissions.
Resulting permit price is US$25/ton. Total present value of permits is 186 $bn.
Distribution Policy (5): some free permits given to primary & secondary fossil-fuel industries; all remaining permits auctioned; all auction revenue recycled as lower personal income tax rate.

Sector of economy	**1.** Initial equity value of sector	**2.** Value of free permits given to sector	**3.** Free permits relative to sector's equity value	**4.** Free permits relative to total permit value	**5.** Absolute gain in sector's equity value	**6.** Relative gain in sector's equity value
	$bn	$bn	%	%	$bn	%
Coal mining	18	3	16	1	0	0
Oil & gas extraction	188	12	7	7	0	0
Oil refining	147	6	4	3	0	0
Electric utilities	245	13	5	7	0	0
(Electric utils' current share of combust.-related emissions				36)		
Total fossil industries	597	34	6	18	0	0
Other sectors	12106	0	0	0	13	0.1
Total economy	12703	34	0	18	13	0.1
Percentage of permits auctioned				82		

Source of electric utilities' current share of emissions: US EPA, Draft US Greenhouse Gas Emissions and Sinks, 1990-98

Columns 3 and 4 of the table show two measures of the relative amounts of free permits given. Coal mining gets free permits worth about 16% of its initial equity value, whereas electricity gets free permits worth about 5% of its equity value. Yet because electricity is a much bigger sector than coal in the U.S., its free permits are about 7% of total permits in circulation, whereas coal gets only about 1% of total permits. Note also that in all, only 18% of total permits need to be given away free in order to protect the four fossil-fuel industries from equity losses. And electricity needs free about 7% of total combustion-related permits, a far smaller share than its current share (36%) of combustion-related emissions, a share which is unlikely to change much when carbon is controlled.[9] These margins are based on a sample of just one policy in one model of one country, and they ignore the extent of pre-existing monopoly power in fossil-fuel industries, they are so wide that we feel confident in suggesting two broad conclusions, at least for all industrial countries:

(a) If free permits are intended to compensate industry for loss of profits, then **much less than half of all permits need to be free.** To give all permits free ("full grandfathering") will create huge monopoly profits for industry overall, and give nothing as such to households to offset the impact of higher prices for fossil fuels and carbon-intensive goods.[10]

(b) Partly as a result of (a), **the combustion-related carbon permits which are given free to an industry should probably be much less than its direct, combustion-related emissions.** Again, to give free permits for all emissions would amount to giving industry free monopoly profits.

We predict (in advance of CGE calculations yet to be done) that (b) will be particularly true for Australian electricity, which accounts for over 45% of emissions (AGO 1999a, Table 4.2). This would remain true even if the electricity industry was responsible for acquitting permits to cover its own

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9. It would have been interesting to compare percentages of free permits and emissions for the other three industries, but these data are not available for the USA. However, unless fugitive emissions (mainly of methane) from extracting fossil fuels are effectively controlled outside the carbon permit scheme, it could also show the other industries in a falsely favourable light. Table 4.2 of AGO (1999a) shows that for Australia, coal's combustion-related emissions are about 130 times smaller than electricity's, but its total GHG emissions are only about 8 times smaller.

10. Many householders are obviously shareholders in fossil-fuel industries, but very unevenly. So the distributional effects are considerable. For example, sizeable profits would go to foreign shareholders. See Section 5.5 for further discussion.

emissions, rather than buying "permitted" coal from coal mines, for reasons explained in Section 5.1. Intuitively, even if electricity had to pay the permit price, much of this would be passed backwards as a lower price paid for coal inputs to electricity, and forwards as a higher price charged to electricity users. However, conclusion (b) does not apply to an industry’s *share* of *free* permits. In our table, U.S. electricity’s share of free permits ($13bn/$34bn = 37%) just happens to be close to its share (36%) of emissions, because free permits all go (by the realities of political acceptability) to fossil-fuel industries.

3.3 How accurately can CGE models measure sectoral losses (adjustment costs) from carbon control?

At the heart of this paper is the pragmatic argument, stated in our principle [2], that gaining political acceptability for carbon control requires compensation for significant losses caused by control in major sectors of firms. We therefore need to explain how reliably such losses could be predicted. Losses (and profits) inevitably require some departure from perfect competition, for in the textbook theory where all factor inputs are always perfectly competitive and flexible, free entry and exit means that firms always make zero profits, and inputs such as labour are never unemployed and are always paid their marginal product.

BG assume that profits arise because a typical firm, although perfectly competitive in all other respects, cannot change its capital input K instantaneously in response to changing market conditions, simply by hiring a different level of K. Instead, it has to adjust its capital stock by investing at a finite rate I, and investment incurs an adjustment cost which is deducted from the firm’s gross output, leaving net output to be sold. The adjustment cost is $\phi(I/K)\cdot I$ where

$$\phi(I/K) = (\xi/2)[(I/K) - \delta]^2/(I/K), \qquad [3]$$

so ϕ is dimensionless and ξ and δ are parameters with dimensions of (1/time), δ being the physical depreciation rate of capital. Capital is thus quasi-fixed, which in any dynamic situation gives rise to non-zero profits. The discounted present value of profits in turn gives a firm its equity value,[11] which is kept constant under the permit distributions of Policies (4) and (5) in Table 1.

The use of adjustment costs in CGE analyses is not new (see for example Summers 1981, Zodrow 1985 and Goulder and Summers 1989), but BG appear to be the first authors to have applied them to CGE calculations of GHG control. Almost all other CGE/GHG models to date give sectoral results for prices and quantities, and often employment levels, but not profits. While employment levels can obviously be important from a political point of view, including profits based on adjustment costs does seem to be an improvement for the purposes on political analysis.

However, the shortcomings of adjustment cost modelling also need to be mentioned, to avoid giving the impression that other CGE models just need to incorporate such costs so as to provide useful results for permit distribution.[12] In fact there are several types of adjustment costs, including costs arising from the rate of change of capital; the fixed costs of any change, which may be incurred either at one moment or over a period; and

11. BG compute equity values from profits in a complex way which allows for debt issue, new share issues and company taxes, but these are details which do not affect the fundamental issues discussed here.

12. For Australia, the main existing CGE models or model suites are Monash, ABARE's GTEM/AUSTEM, G-Cubed, and the Murphy model, as recently surveyed by Pezzey and Lambie (2001).

costs that relate only to the quantity of the change (Dixit and Pindyck 1994). Empirical analyses usually consider only adjustment costs which depend on the rate of change of capital, i.e. on investment. Going further and including fixed costs, which are irreversible, can result in nonlinear dynamics, and therefore is likely to be impossible to estimate (Carruth et al. 2000).

Moreover, in order to estimate investment cost parameters such as ξ from observing Tobin's *q* ratio (Tobin 1969), the ratio of the marginal effect of capital on discounted profits to its marginal replacement (purchase) cost, a quadratic form such as [3] must be assumed. But non-quadratic or even non-convex forms (caused by the inherent "lumpiness" of some investments) may well exist in reality. Non-quadratricness makes accurate estimation impossible; and non-convexity makes computing a general equilibrium impossible, even if microeconomic parameters could be estimated.

When added to all the many different assumptions that may be incorporated in different CGE models of carbon control,[13] these difficulties with adjustment costs emphasise that using CGE models to compute sectoral "losses" as a basis for distributing free permits is more inaccurate and more debatable than using CO_2 emissions data. But we still believe it is worth

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13. A frequent assumption in such modelling is that there is no induced technical change (ITC). That is, the higher carbon price resulting from an imposed carbon control policy is assumed to make no difference to future technological options in the economy. This attracts criticism (e.g. Hamilton and Quiggin 1997) from "bottom-up" proponents of carbon-conserving technologies. Careful formal analysis by Goulder and Schneider (1999) confirms that ITC generally makes carbon control policies more attractive, although it is empirically implausible that it results in the possibility of zero-cost carbon abatement. Another policy variable is how much in total is paid to government for purchases of auctioned permits. According to Milliman and Prince (1989) and subsequent literature, this could have significant long run effects on technical progress.

using the CGE approach to inform negotiations, on the basis that it is better to be approximately right about major losses, rather than precisely wrong by giving out all permits in proportion to direct emissions.

4. DISTRIBUTING THE REST OF THE PERMIT VALUE

In Section 2 we proposed that free permits be distributed to selected industry sectors to neutralise any significant, net costs imposed on them by market-based carbon control. In Section 3 we acknowledged that quantifying these costs can be difficult, both in principle and in practice, but we still concluded that, under plausible circumstances, the total net costs will be much less than half the total value of all permits. Whatever the difficulties, under our proposal a large proportion of permit value (be it 82% as for the US in our Table 2, or 62%, or 42%) should therefore be not be given to firms, but to other parts of society. So far, though, we have said nothing about how this majority of permit value should be distributed.

There is a standard argument put forward by finance ministries that nothing need be said. All permits not given free to industry should be auctioned, and auction revenue should not be "earmarked" or "hypothecated" for any particular purpose. Instead, distribution of the auction revenue should follow existing priorities for taxation reduction and public expenditure, which should be decided quite separately from carbon control policy. We reject this argument on two grounds. First, raising large amounts of revenue from permit auctions is unlikely to be politically acceptable in the first place unless the revenue is "weakly hypothecated", that is, some broad but credible promise of how it is to be spent is included in the original policy package (see Teja and Bracewell-Milnes 1991 and Wilkinson 1994 for further discussion). Second, how it is spent affects how much is available. Using auction revenue to lower conventional tax rates increases the demand for "other" (non-fossil-fuel) industries' outputs, which can convert net losses from carbon control into net gains, and hence greatly reduce the required free proportion of permits.[14] So we briefly discuss the main spending priorities here.

There seems little case for spending permit auction revenue on a general increase in public expenditure. Having to control carbon emissions gives no reason in itself to expand the public sector at the expense of the private sector. So we suggest that revenue should mainly be returned to consumers as tax cuts or lump sum transfers (regarding the latter as not being public expenditure); but some money should also go to groups of workers affected by carbon control, and to the promotion of "carbon conservation" (expanding renewable energy use or increasing energy efficiency, both of which reduce net carbon emissions). However, unlike for the amount of free permits, we offer no suggested basis for deciding how much revenue each of these uses should get, or for how to balance equity and efficiency concerns. A good deal of political and economic judgment will inevitably required to agree on actual numbers.

4.1 Compensating consumers: allocative efficiency versus information efficiency versus equity

Three main questions about using permit auction value to compensate consumers need to be answered:

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14. Indeed, BG found that giving back auction revenue as lump sums rather than income tax cuts (Policy (1) in our Table 1) resulted in net losses of equity value to other sectors which were nearly twice as big as the combined losses of the fossil-fuel industries. In percentage terms, these were much smaller losses, being about half a percent rather than at least five percent, and could therefore be perhaps ignored as insignificant politically. But using a revenue distribution policy which completely avoids net losses to other sectors obviously strengthens the political case for generally giving no free permits to non-fossil-fuel industries.

(a) What should be the split between increasing total welfare by reducing the rates of existing personal taxes (the "weak double dividend" or "revenue recycling" effect, highlighted by Goulder 1995 and Parry 1995 among others), and equity goals, achieved for example by increasing personal tax allowances or by lump sum redistribution?
(b) Can lump sum payments be tailored to individual losses?
(c) Should lump sum payments be made with permits, or with the cash revenue obtained from auctioning them?

As just suggested, question (a) has no easy answer. The equity-efficiency trade-off in personal taxation is inescapable (Brown and Jackson 1990, Ch. 14), and is largely a matter of political judgment, albeit aided by economic calculations. For example, it is useful to know if politically awkward, net losses (albeit small ones) may result in non-fossil-fuel sectors if not enough permit value is spent on reducing tax rates.[15] We suggest that equity does have some claim, because carbon pricing in developed countries is mildly regressive (Aasnes et al 1996, Proost and Van Regemorter 1995, Smith 1992), and reductions in the personal income tax rate only exaggerate this.

In answer to (b), it is impossible to get the data on every person's or household's purchases (informational efficiency again) that would be needed to estimate individual losses of welfare because of carbon trading. However, this does not mean that lump sum payments would have to be uniform

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15. According to BG, reducing the corporate income tax rate in the US is more efficient than reducing the personal income tax rate at reducing the net losses of industry. However, there is probably a strong degree of "acquittal illusion": little of the benefits of corporate income tax cuts is perceived by the average consumer. So reducing personal income tax seems politically preferable, even it is less efficient.

nationwide. Fossil-fuel industries are typically concentrated in some parts of a country, and scaling them back may cause locally significant net costs beyond an industry's workers and shareholders. So under a natural extension of our compensation principle, there may be a case to use CGE estimates of regional cost impacts to make lump sum payments vary by region. Another possibility would be to reduce taxation on vehicle ownership as a rough compensation for the increased price of fuel.[16] Another detail about lump sums that would need to be decided is whether they should be paid to households or individuals. From the difficult experience of Britain in the late 1980s with "poll taxes" (Besley et al 1997), one would guess that "poll subsidies" per citizen would be generally harder to administer than payments per household; but countries with more precise documentation of citizenship than Britain may not face severe problems.

As for (c), payment with free permits rather than with cash from permit auction revenue would incur some extra administrative costs, since all changes of permit ownership (both initial distribution and subsequent sales) would have to be registered. But in countries where government promises are much distrusted, free permits might be more acceptable, especially if the choice was between a one-off distribution of free, legally permanent shares of the nation's assigned amount of permits, and a promise of a year-by-year cash handout which might be rescinded later. An alternative form of payment would be to use auction revenue to raise the threshold or allowance before personal income tax becomes payable. This has the added informational efficiency of taking more people right out of the tax system, but the disadvantage that it does nothing to improve the welfare of the poorest people who already pay no personal tax.

16. Strictly speaking, both these last options are not "lump sum", and have a small impact on incentives, e.g. to relocate or to buy a vehicle, respectively.

4.2 Compensating workers: information problems again?

Undoubtedly some groups of workers will be harmed by carbon control. Control may well result in permanent unemployment for some of those working in a carbon-intensive industry who are occupationally and/or geographically immobile. Workers owning human capital suffer adjustment costs, just as do shareholders owning physical and financial capital. Such workers therefore might seem to deserve compensation for their loss of welfare. But at least until now, this appears to have been an unpopular view, both in terms of principle and practice.

In principle it is argued that groups of workers harmed by the indirect, economic effects of government policy have not been compensated in the past, so why should they be now? A good example in Australia would be workers made redundant, but not especially compensated, as a result of electric utilities being privatised in Victoria. In the USA, proposals to compensate high-sulphur coal miners and others who might lose their jobs because of the sulphur trading program were defeated (Hausker 1992, p566). However, if one can estimate the significant welfare losses that identifiable groups of workers suffer from prolonged unemployment or long-distance dislocation, the lack of precedent does not seem a strong argument, on equity or acceptability grounds, for giving no compensation. If shareholders are to be compensated, why should not workers be as well?

The problem may be more a practical one. In contrast to the well-known (albeit flawed, as discussed in Section 3.3) theory and practice of modelling the costs of adjusting physical capital, modelling the costs of adjusting human capital is unknown. Data for human capital (both marketable skills and non-marketed social capital, sense of belonging, etc) in different labour and geographical sectors are unavailable and likely to remain so. So it is not surprising that BG modelled labour as perfectly mobile across sectors, and therefore suffering no net costs (equivalent to lost equity values) from carbon control, in contrast to physical capital.

Nevertheless, it will harm the acceptability of a tradeable permit scheme for a firm to be able to close down in response to changed prices under carbon trading, leave its shareholders the value of permits which were given free by the state, but leave its unemployed workers nothing. So this suggests that however difficult it might be to arrive at consistent decisions − some combination of a large percentage employment loss and high degree of occupational concentration in a locality might be a basis − some permit value should be set aside for compensating workers. Compensation would be particularly by assistance with retraining and relocation (thereby improving labour market efficiency as well as equity), but also perhaps by lump sum payments.

4.3 Correcting failure in carbon conservation markets

There is a case for spending some permit auction revenue to correct energy market failures. As with employment problems, using a specially identified, weakly hypothecated fund to do this could improve the acceptability of carbon trading in the first place. The way in which money can usefully be spent are varied: providing information; changing market institutions and regulations to enable greater use of energy service contracts or renewable sources; researching, introducing and enforcing tighter efficiency standards for the many cases where chooser/user splits are unavoidable; direct subsidies for energy efficiency in order to achieve economies of scale, for example in insulation of existing dwellings; and maybe for direct subsidies for renewable energy sources, though market failure is more difficult to prove here. Such proposals are controversial and provoke much debate which we do not discuss here; see for example Levine et al (1995), Rose and Lin (1995), Lovins (1996), Sutherland (1996) and Wirl and Orasch (1998) for recent contributions.

5. EIGHT QUESTIONS ABOUT THE PROPOSED DISTRIBUTION SCHEME

For completeness we address here several questions, some well-known and some new, which have been raised by critics about our proposal for permit distribution. Where practical details are helpful, we give examples from Australia.

5.1 How much does the point of acquittal matter?

This is not actually a question about distribution, but it is an important one to clarify. Does it make much difference if permits have to be acquitted by emitters of carbon fuels, or further upstream by fuel suppliers of carbon? The answer is basically no in terms of allocative effects, but yes in terms of information costs.

In theory, it makes no difference to tax incidence whether a seller or buyer has to acquit a sales tax (which is what a tradeable permit amounts to here). In Figure 1, if the seller has to acquit the tax, both the market (exchange) price and the demand price will be P_{d1}, while the supply price is $P_{d1} - t = P_{s1}$; whereas if the buyer has to acquit the tax, the market price will be P_{s1}, leaving the demand and supply prices unchanged. We see little reason to think that practice will depart from this theory: would an electricity generating firm which pays \$20 per tonne of non-permitted coal, and then has to buy a \$30 carbon permit to burn it, really pay more attention to abating its CO_2 emissions than if it simply had to pay \$50 for a tonne of permitted coal, as some have claimed?

However, Figure 1 ignores information costs, and these are much higher if millions of fuel buyers have to acquit permits rather than a few dozen primary fuel sellers. So it is for strong reasons of informational efficiency that our proposal, in line with most government proposals, is for fossil fuel wholesalers to be the points for permit acquittal.

5.2 Are free permits assigned to sectors or firms?

In contrast to the previous question which was easy to answer, this is very difficult, and important. With sulphur trading in the USA, free permits were given to individual emitters, in proportion to historic emissions. For carbon, our proposed distribution for free permits starts from some CGE model calculations of profits and losses for whole economic sectors, and assumes that subsequent political debate decides on final figures for a sectoral distribution. But firms, not sectors, are the legal entities which would own permits. On what basis would a sector's free permits then be subdivided among firms in the sector? One basis might be in proportion to firms' sales revenues, but this runs into the information problem that conglomerate firms would have to have their revenues administratively assigned to the different sectors where they occur. Another basis might be in proportion to firms' CO_2 emissions, but these may not be known with much accuracy. Further detailed administrative research would clearly be needed in each country before a workable scheme could be found.

5.3 Might it be useful to give non-tradeable permits to trade-exposed sectors?

Vollebergh, de Vries and Koutstaal (1997, p54) suggested that some permits given freely by the state should be non-tradeable (they reserve the term "grandfathered" for free permits which are tradeable).[17] The motive seems (p54) to be "preventing exposed industries [from making] windfall profits by selling their permits before moving abroad". Because of the particular nature of the Kyoto Protocol, which does not control emissions in all countries, this is a valid concern. In Australia, it could obviously apply to sectors such as aluminium and cement, which compete mainly with imports from non-Annex B countries in Asia. Non-tradeable permits would obviously raise the domestic economy's cost of achieving a given target for carbon emissions, and might set off demands for similar treatment from non-trade-exposed industries. This has to be weighed against the equity benefits of preventing sudden closure of the affected sector; and the possible global efficiency benefits from avoiding the sector's activity being relocated in a developing country not subject to emission controls, and thus causing to a net rise in global carbon emissions. Further research would be needed to estimate appropriate levels of non-tradeable permits, and what time limits they might be subject to, before reverting to being tradeable.

5.4 Do free permits distort competition by creating barriers to entry?

We summarise here the detailed investigation by Koutstaal (1997, Chapters 3-4) into the possible distortion of competition and efficiency caused by giving free carbon permits to incumbent firms, but not to potential entrants (as our proposed distribution requires). First, "[free] permits have an opportunity cost when they are used...equal to the price at which they can be sold, and therefore established firms do not have a cost advantage over entrants just because they received permits free" (p61). An analogy with land argues (p35) that "the fact that new firms have to buy land does not

17. Somewhat asymmetrically, they do not accept the possibility that exemptions to a carbon tax (the price-based equivalent of free permits) could be tradeable.

[itself] create an entry barrier". Second, the transaction costs of buying permits is unlikely to be any kind significant source of distortion, given the unrestricted, global nature of the carbon permit market assumed here, and the fact that all acquitting firms would have to buy most of their permits under our proposal.

A more serious effect is likely because capital markets are not perfect, so firms' external borrowing is limited. Giving free permits to incumbent firms then allows them to use this form of extra wealth (a "long purse" or "deep pocket"), both as a source of cheaper capital, and as means of deterring potential entrants who have to buy all their permits at auction. It is often suggested that this will cause serious harm to competition and hence efficiency in the economy, thus building a case for no free permit distribution. The results from Koutstaal's theoretical analysis supported this view. However, in his empirical analysis he calculated that unless the degree of carbon control is much higher than currently envisaged, the cost of buying permits would be less than about 2% of the total capital needed by new entrants in the worst-affected sector, the petroleum industry. Koutstaal concluded that "[free permits] and imperfect capital markets will raise entry barriers only to a small extent", whether by access to cheaper capital or the threat of entry deterrence. While his calculations suggest that "deep pockets" may not be an issue in the distribution of free permits to firms, his analysis only relates to the Dutch economy and, as acknowledged by him (p86), the method used only provides a rough indication of the likely impact on capital requirements for the sectors analysed. More detailed research is therefore needed before conclusions can be drawn on whether there is likely to be any affect on competition and efficiency arising from the distribution of free permits to firms.

5.5 Should free permits be given to foreign-owned firms as to domestically-owned ones, and to publicly-owned firms as to privately-owned ones?

Whether or not giving valuable permits free to firms irrespective of their degree of foreign ownership is equitable, depends crucially on the proportion being given free. Under our principle [2], the purpose of free permits is to compensate for a firm's loss of profits caused by a government policy, and thus achieve overall cost *neutrality*. Such neutrality should raise no equity questions, regardless of how much of the firm is owned by foreigners. If many more permits were to be free, the unfairness of non-neutrality (overcompensating firms' shareholders) would be compounded by the fact that many of the shareholders would be foreign. But such overcompensation is not part of our proposal.

The answer to the second question is as for the first. If the quantities of free permits given are fair compensation for profits (and hence shareholder value) that is lost because of government action, as we propose, then there is no reason to discriminate between public and private firms. In principle, one could give more or fewer free permits to publicly-owned firms without harming or benefitting taxpayers, because taxpayers are the notional owners of such firms. However, such reliance on the managers of public firms acting purely in the public interest seems unwise. A possibly greater problem is that blunted commercial incentives within a public firm might cause permits to be undervalued in the firm's marginal decisions, but we would see this as an argument for greater commercial discretion in the public sector rather than a reason for changing permit distribution.

5.6 Can and should tradeable permits be incorporated with existing taxes on carbon fuels?

In many countries, the pricing of carbon fuels is by no means left to the free market. Typically, coal is subsidised at the production stage, while oil products such as gasoline are heavily taxed during distribution. Administratively, such taxes can be used at the same time as a tradeable permit system: the two sources of price change will just be added together. Economically, the case for doing this would have to rest on the argument that existing taxes on carbon fuels serve purposes unconnected with the external costs of global warming. One such purpose is to internalise the local environmental costs of fuel use, such as the pollution and congestion caused by motor traffic. Another is to raise government revenue in an efficient way, given the low price elasticity of much energy demand and the low administration costs. Unless existing taxes are felt to be unjustified on these grounds, there seems little case for abolishing them once tradeable permits are introduced.

5.7 Can the proposal work if taxes are used rather than tradeable permits?

The basic answer is Yes. Pezzey (1992) and Farrow (1995) independently showed that an emission tax scheme is fully equivalent to a tradeable emission permit scheme in terms of long run and short run efficiency, providing that the tax scheme includes tax "offsets" or "baselines" which are treated in the same way as free permit allocations. In the simplified view given in Figure 1, industry would get a tax offset of fQ_1, so its tax payment would be $t(1-f)Q_1$), and the value of the offset is tfQ_1, or area A+B. Choosing the same free proportion f as in for permits will again make A+B equal to A+C, the industry's loss of producer surplus because of carbon control, and thus exactly compensate industry. Just as an unused permit can be hired out, an unused part of an offset still yields income (at a rate equal to the prevailing tax rate), either from the regulatory authority, or from some other firm which hires it. An offset is thus different from the *non-tradeable* tax exemption proposed by Vollebergh et al (1997, p50), and already discussed in Section 5.3, which works like a standard tax allowance or credit, in that the emitter gets no income if its emissions are actually less than the allowance or credit. It also differs from the complete exemption from paying a carbon tax at all, which is given by some European countries to carbon-intensive sectors.

The tax offset idea has received little consideration from either academics or policymakers so far. As just one recent example, it is ignored by Cramton and Kerr (1999), who consider only the asymmetric trio of a pure carbon tax, but both auctioned and free tradeable permits. This may well have been a costly oversight for environmental-economic policy. In Europe and elsewhere the carbon tax proposals of the early 1990s have been abandoned, to be replaced by the Kyoto Protocol's focus on tradeable carbon permits. This shift was arguably caused by the perceived political acceptability of permits (thanks to free permits), but unacceptability of taxes (because the offset option was not considered). However, it loses a major political advantage of the tax instrument. A tax gives direct control over the marginal cost of controlling emissions, whereas the cost under tradeable permits (i.e. the permit price) is inherently unpredictable, depending on how market conditions change. Consideration of a carbon tax with offsets might therefore have avoided the currently widespread hesistance to start serious carbon control by ratifying the Protocol, for fear of uncontrollable permit costs.[18] This fear rightly gets worse as time passes. The cost of achieving any given level of control in 2008 is inevitably growing while uncertainty persists, and low cost, long term control measures are not being taken.

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18. A basically similar point is made by McKibbin and Wilcoxen (1999), who propose using taxes rather than permits. However, for symmetry, tax offsets would be internationally tradeable under our proposal, whereas McKibbin and Wilcoxen specifically exclude the possibility of international trade, and defend this as a virtue of their scheme.

5.8 Should an instrument exist for a permanent flow of permits?

We have so far ignored issues of permit distribution over time. In this and the next section, we address two such issues: permanent as well as annual permit distribution, and (in Section 5.9) phasing out free permits.

We have implicitly assumed up till now that, by international agreement, a country is allowed to emit a constant Q tons of total carbon per year, and chooses to make fQ tons per year free, with the proportion f remaining constant, as shown in **Figure 2a**. Even within this simple plan, a macroeconomically significant choice needs to be made about whether or not to create a permanent, flow form of permit instrument. Without such a flow instrument, the government would auction $(1-f)Q$ permits and give fQ permits free each year, where each permit allows one tonne of carbon to be emitted, just once. Or, it could create a permanent instrument, say an *endowment*, one unit of which allows one tonne of carbon to be emitted not just once, but every year in perpetuity.[19] At the start of carbon control, the government would auction $(1-f)Q$ endowments and give out fQ endowments free, and no further permit distribution could occur after that. The main advantage of an endowment scheme would be to end the political debate about permit distribution, with its deadweight costs of lobbying and rent-seeking, at the start of carbon control. Given finite credibility of government promises, an annual issue of auctioned and free permits would always be vulnerable to further lobbying, and this would bring further uncertainty and hence inefficiency to the permit market.

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19. More precisely, one endowment unit would probably be defined as a legal right to a one-tonne permit each year from the government (McKibbin and Wilcoxen 1999).

Alternative time paths of distributing free permits

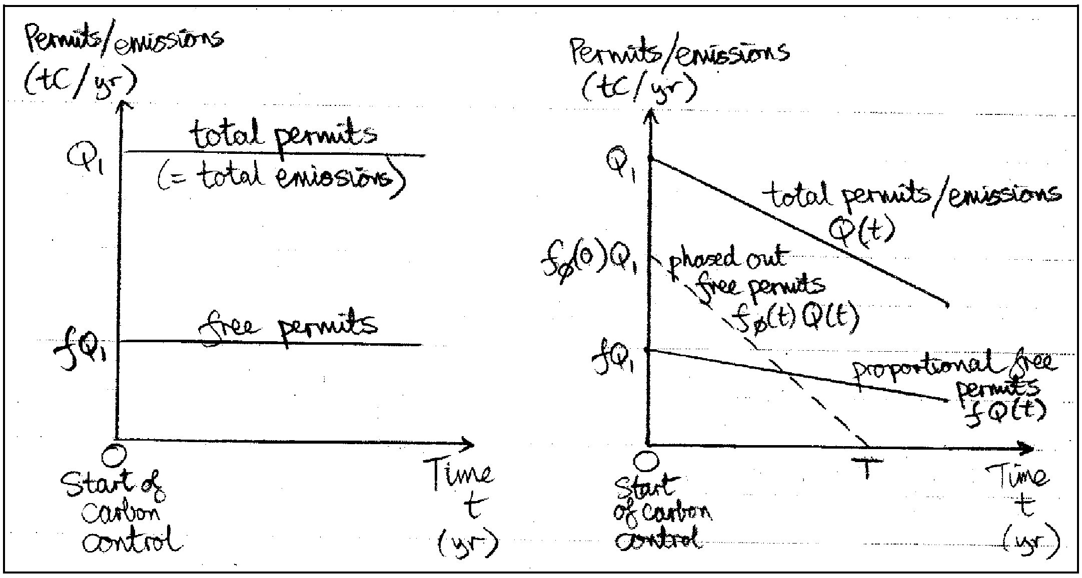

Fig. 2a: Constant total permits and proportional free permits

Fig. 2b: The need for permit shares, so as to administer constant (or phased out) proportions of free permits within a falling total

However, one endowment would probably be worth at least ten times as much as one permit, depending on the effective discount rate used in the permit market. Assuming from Section 3.2 that the free proportion *f* is quite low (about a quarter, say), and using the rough figures for *Q* and the value of a permit given in Footnote 2 above, (1-*f*)*Q* endowments in Australia would be worth about the same as one year's federal tax revenues (Pezzey and Lambie 2000). Auctioning permanent carbon endowments, or even just five years of permits (for 2008-12 inclusive) at once, would thus be a macroeconomically significant event, which might even affect a country's interest rate or exchange rate in the short term. Careful planning of endowment auctions would thus be needed to avoid causing unnecessary macroeconomic disruption.

Another consideration is that over time, a country's assigned emission total should fall, though unpredictably, in response to growing concern over climate change. To allow for this, the permanent instrument created would actually need to be the right to emit a small proportional *share* of a country's total. At the start of control, proportions (1-f) of all shares can then be auctioned and f given away free, subject to the same concerns about managing the macroeconomic effect of auction revenues. This would retain a country's ability to keep its assigned emissions within changing, internationally agreed limits, and would share the unavoidable uncertainty about assigned emissions evenly round the market. The idea is illustrated in **Figure 2b** by paths $Q(t)$ of total permits and $fQ(t)$ of free permits starting initially from Q_1 and fQ_1.

5.9 Should the proportion of free permits be reduced, or phased out?

The Introduction noted that even strong proponents of pure auctioning of permits have acknowledged a need to improve political acceptability by giving some permits free initially, but with free permits then being phased out. This is shown in Figure 2b as the dashed free permit line $f_\phi(t)Q(t)$, with $f_\phi(t)$ being a legally defined, declining proportion of free permits which reaches zero at time T. For annually issued permits, this is a fairly easy idea to administer, though in practice the proportion $f_\phi(t)$ would fall in discrete steps rather than continuously as shown.

A permanent share rather than annual scheme would again have the major advantage of avoiding credibility and lobbying problems, although it would be more complicated to define and administer. One way would be to divide the $f_\phi(0)$ free shares given away initially into say five equal classes, with classes lasting one, two, three, four and five time periods from the start of control, and therefore fetching five different prices on the share market.

(So with a time period of two years, it would take ten years to the phase-out time *T*.) Each year the authority would need to auction another $[f_\phi(0)]/5$ permanent shares to make up for the $[f_\phi(0)]/5$ free permits in the class which has just expired.

The free permits under such a phase-out scheme would obviously have a finite present value, and so could be regarded as another form of hybrid permit distribution. One would expect the big debate will be over the proportion of present value which is actually free, which is why we have drawn line $f_\phi(t)Q(t)$ starting above and then crossing the alternative line $fQ(t)$ on the figure. Although there would always be some constant free proportion f which has the same present value as some phase-out scheme, nevertheless the latter has some real advantages. Emitters will find that receiving more free permits now and fewer later eases their cash-flow problem, even though the permit price and therefore adjustment pressure will be unchanged. Proponents of full auctioning (because of its undeniable efficiency advantages) may be more supportive. And by setting the initial proportion $f_\phi(0)$ quite high, governments can phase permit auction revenues over time and thus avoid the macroeconomic disruption mentioned above.

6. CONCLUSIONS

A scheme to distribute tradeable carbon permits as part of a country's policy to reduce its greenhouse gas emissions will always be controversial and require political judgment. Nevertheless, we have proposed a few key principles which any scheme can and should follow. The basic principle is that the scheme should aim to maximise total (allocative and informational) efficiency, while being sufficiently acceptable to pass the political process, and reasonably equitable. Without acceptability, carbon trading will not happen, so none of its cost-saving benefits will be achieved. But sufficient acceptability is not "over-acceptability". It means that firms should be compensated, but not overcompensated, for any proportionally significant, net losses in discounted profits caused by carbon control using tradeable permits. Assuming that the existing degree of monopoly profits in fossil-fuel industries is much less than the theoretical maximum, carbon control effectively creates some new monopoly rents, which must then be recognised as a significant part of this compensation. Our principles therefore imply that permit distribution must be *hybrid*. Some permits should be given away free as compensation to significantly affected sectors of industry, but the value of the rest should be given to other parts of society. The latter can be both by giving away free permits; and by auctioning the remaining permits to provide revenue for purposes, such at reducing mainstream tax rates, that are at least weakly connected to the introduction of carbon control.

If results from computable general equilibrium modelling by Bovenberg and Goulder (2000) of the US economy are broadly applicable to most industrialised economies, then the principal sectors of industry that should receive free permits under our compensation proposal are the "fossil-fuel industries": both primary suppliers such as coal mines and oil and gas wells, and secondary processors such as oil refining and electricity generation. No other firms need to receive free permits, apart from special but small manufacturing sectors which are both carbon-intensive and very trade-exposed. The overall proportion of permits that thus needs to be given away free as compensation may be as low as 20%. The remaining permit value should be divided, according to judgment, among compensation for consumers (both as reduced personal tax rates to increase efficiency, and as a uniform per capita distribution of money or free permits to increase equity), compensation for workers (both as retraining assistance to increase efficiency, and as lump sums of value to increase equity), and perhaps as subsidies for the development and adoption of more carbon-efficient technologies (to overcome market failure and thus increase efficiency).

The detailed figures that define such a distribution would be subject to much recalculation and change before they could emerge as a serious policy proposal in any country. First, CGE models that are able to measure losses of profits under various distribution policies would have to be developed (in the USA as well, since results are bound to vary among models, and BG's results on their own will not carry sufficient weight to provide a basis for policy). Second, technical refinements such as allowance for pre-existing monopoly power in the economy, and for the effects of long run technical change induced by carbon control policies, may need to be incorporated. Third, the equity (lump sum) and efficiency (tax-reducing) uses of the permit value not given to firms would have a general equilibrium effect on the total amount of compensation required by firms, so there is no single figure for this amount, even in principle.

Many other details of a scheme were discussed, and the following conclusions reached. (1) To minimise information costs, permits should be finally acquitted upstream by primary suppliers or importers of fossil fuels. (2) Calculations from CGE models may influence an overall, initial distribution of free permits, but one also has to decide how many free permits each firm is given. This is the single most difficult issue of our proposed scheme. Various firm-level rules for are possible, but none are ideal, and detailed negotiation would be needed to reach a workable and acceptable scheme. (3) For some sectors very exposed to trade with countries that do not control carbon, non-tradeable permits may be appropriate, at least for some period. It may be worth losing some efficiency from non-tradeability in order to reduce the adjustment costs from such sectors selling their free permits and closing down. (4) Empirical research suggests that free permits may not significantly distort competition by creating barriers to entry, but more evidence supporting this conclusion is still needed. (5) As long as the proportion of free permits is chosen to compensate for the costs of carbon control, this proportion should not be altered to allow for foreign rather than domestic ownership of firms, or for public rather than private ownership. (6) If existing taxes on carbonaceous fuels were imposed for reasons unconnected to controlling GHG emissions, then they should not be altered as a result of introducing carbon permit trading. (7) An analogy to the entire scheme of tradeable permits exists for a tax mechanism, using tax offsets rather than free permits. This should be considered if capping carbon control costs is more of an immediate concern thatn capping damage costs. (8) In order to improve credibility and reduce rent-seeking costs, a permanent share of a country's allowable carbon emissions should be created in addition to "one-tonne" emission permits. (9) There are advantages to reducing (or phasing out) the proportion of free permits over time, in terms of improving both the government's and firms' cash flows, and in terms of political perception.

REFERENCES

Aasnes, J., T. Bye and H. T. Mysen (1996). "Welfare effects of emission taxes in Norway." *Energy Economics*, Vol 18 No 4, 335-346.

AGO (Australian Greenhouse Office) (1999a). *National Emissions Trading: Establishing the Boundaries*. Discussion Paper 1. Canberra: Commonwealth of Australia.

AGO (1999b). *National Emissions Trading: Issuing the Permits*. Discussion Paper 2. Canberra: Commonwealth of Australia.

Baumol, William J. and Wallace E. Oates (1971). "The use of standards and prices for protection of the environment." *Swedish Journal of Economics*, Vol 73 No 1, 42-54.

Besley, T., I. Preston and M. Ridge (1997). "Fiscal anarchy in the U.K.: modelling poll tax noncompliance." *Journal of Public Economics*, Vol 64 No 2, 137-152

Bovenberg, A. Lans (1999). "Green tax reforms and the double dividend: an updated reader's guide." *International Tax and Public Finance,* Vol 6, 421-443.

Bovenberg, A. Lans and Lawrence H. Goulder (2000) (**BG**). "Neutralizing the adverse industry impacts of CO_2 abatement policies: What does it cost?" In C. Carraro and G. Metcalf, eds., *Behavioural and Distributional Effects of Environmental Policies: Evidence and Controversies.* Chicago: University of Chicago Press.

Brown, C. V. and P. M. Jackson (1990). *Public Sector Economics*, 4th Edition. Oxford: Blackwell

Carruth, A., A. Dickerson and A. Henley (2000). "What do we know about investment under uncertainty." *Journal of Economic Surveys*, 14 (2), 119-153.

Cramton, Peter and Suzi Kerr (1999). "The distributional effects of carbon regulation: Why auctioned carbon permits are attractive and feasible." In T. Sterner, ed., *The Market and the Environment*. Cheltenham: Edward Elgar.

Dixit, A.K. and R.S. Pindyck (1994). *Investment Under Uncertainty*. Princeton University Press, Princeton, New Jersey.

Farrow, Scott (1995). "The dual political economy of taxes and tradable permits." *Economics Letters*, Vol 49 No 2, 217-220.

Fischer, Carolyn, Suzi Kerr and Michael Toman (1998). "Using emissions trading to regulate U.S. greenhouse gas emissions: An overview of policy design and implementation issues." *National Tax Journal*, Vol 51 No 3, 453-464.

Goulder, Lawrence H. (1995), "Environmental taxation and the double dividend: A reader's guide". *International Tax and Public Finance,* Vol 2 No 2, 157-183.

Goulder, Lawrence H. and Stephen H. Schneider (1999). "Induced technological change and the attractiveness of CO_2 abatement policies." *Resource and Energy Economics*, Vol 21, 211-253.

Goulder, L. H. and L. H. Summers (1989). "Tax policy, asset prices, and growth." *Journal of Public Economics*, 38, 265-296.

Hamilton, C. and Quiggin, J. (1997). "Economic analysis of greenhouse policy: a layperson's guide to the perils of economic modelling." The Australian Institute, Discussion Paper Number 15, Canberra.

Hausker, Karl (1992). "The politics and economics of auction design in the market for sulfur dioxide pollution." *Journal of Policy Analysis and Management*, Vol 11 No 4, 553-572.

Koutstaal, Paul (1997). *Economic Policy and Climate Change: Tradable Permits for Reducing Carbon Emissions*.

Koutstaal, Paul and Andries Nentjes (1995). "Tradable carbon permits in Europe - feasibility and comparison with taxes." *Journal of Common Market Studies,* Vol 33 No 2, 219-233.

Levine, M. D. et al (1995). "Energy efficiency policy and market failures." *Annual Review of Energy and the Environment*, Vol 20, 535-555.

Lovins, Amory B. (1996). "Negawatts: twelve transitions, eight improvements and one distraction." *Energy Policy*, Vol 24 No 4, 331-343.

McKibbin, Warwick and Peter J. Wilcoxen (1999). "Designing a realistic climate change policy that includes developing countries." Manuscript, Australian National University, Canberra, October.

Milliman, Scott R. and Raymond Prince (1989). "Firm incentives to promote technological change in pollution control." *Journal of Environmental Economics and Management,* Vol 17, 247-65.

Olson, Mancur (1965). *The Logic of Collective Action*. Cambridge, Mass.: Harvard University Press.

Parry, Ian (1995). "Pollution taxes and revenue recycling." *Journal of Environmental Economics and Management*, Vol 29 No 3 Pt 2, S64-S77.

Pearce, David W. (1991). "The role of carbon taxes in adjusting to global warming." *Economic Journal*, Vol 101, 938-948.

Pezzey, John (1992). "The symmetry between controlling pollution by price and controlling it by quantity." *Canadian Journal of Economics*, Vol 25 No 4, 983-991.

Pezzey, John C.V. and N. Ross Lambie (2000). Comments on *Designing the Market*, the Australian Greenhouse Office's Discussion Paper 4 on tradeable emission permits. Canberra: CRES, Australian National University. Available on http://cres.anu.edu.au/~pezzey.

Pezzey, John C.V. and N. Ross Lambie (2001, forthcoming). *Computable General Equilibrium Models for Evaluating Domestic Greenhouse Policies in Australia: A Comparative Analysis.* Melbourne: Productivity Commission.

Pezzey, John C.V. and Andrew Park (1998). "Reflections on the double dividend debate: The importance of interest groups and information costs." *Environmental and Resource Economics*, Vol 11 Nos 3-4, 539-555.

Proost, S. and D. van Regemorter (1995). "The double dividend and the role of inequality aversion and macroeconomic regimes." *International Tax and Public Finance*, Vol 2, 207-219.

Rose, A. and S. M. Lin (1995). "Regrets or no regrets, that is the question: Is conservation a costless CO2 mitigation strategy?" *Energy Journal*, Vol 16 No 3, 67-87.

Smith, Stephen (1992). "The distributional consequences of taxes on energy and the carbon content of fuels." *European Economy*, Special Edition, No 1, 241-68.

Summers, L.H. (1981). "Taxation and corporate investment: a q-theory approach." *Brookings Papers on Economic Activity*, January, 67-127.

Sutherland, R. J. (1996). "The economics of energy conservation policy." *Energy Policy*, Vol 24 No 4, 361-370.

Teja, Ranjit and Barry Bracewell-Milnes (1991). *The Case for Earmarked Taxes: Government Spending and Public Choice*. London: Institute of Economic Affairs.

Tobin, J. (1969). "A general equilibrium approach to monetary theory." *Journal of Money, Credit and Banking*, 1 (1), 15-29.

Vollebergh, H. R. J., J. L. de Vries and P. R. Koutstaal (1997). "Hybrid carbon incentive mechanisms and political acceptability." *Environmental and Resource Economics*, Vol 9, 43-63.

Wilkinson, Margaret (1994). "Paying for public spending: Is there a role for earmarked taxes?" *Fiscal Studies*, Vol 15 No 4, 119-135.

Williamson, Oliver E. (1996). "The politics and economics of redistribution and efficiency." In *The Mechanisms of Governance*. Oxford: Oxford University Press.

Wirl, F. and W. Orasch (1998). "Analysis of United States' utility conservation programs." *Review of Industrial Organisation*, Vol 13 No 4, 467-486.

Zodrow, G.R. (1985). "Optimal tax reform in the presence of adjustment costs." *Journal of Public Economics*, 27, 211-230.