Some Sectoral and Global Distributional Issues in Greenhouse Gas Policy Design

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Abstract

This paper argues it will be welfare-improving at a national level to auction tradable greenhouse gas permits, and , at an international level, for first-world countries to bribe third-world countries to join a cooperative solution.

Introduction

The design of policies to reduce greenhouse gas emissions requires an appreciation of the distribution of the benefits and costs of policy interventions to reduce these emissions. This paper argues that a high proportion of the economic costs of taxes or tradable permits to reduce greenhouse gas emissions will be passed forward to consumers as higher product prices. As a consequence, much contemporary policy discussion and lobbying to compensate producers is exaggerated. The paper additionally argues that an understanding of the distributional consequences for first-world and third-world countries is important in designing the necessary global policy response to the global externality.

In order that the analysis can focus on the distributional effects of taxes or tradable permits, this paper takes as given many aspects of the debate about climate change and policy interventions to reduce greenhouse gas emissions.[2] The stock of greenhouse gases is assumed to constitute an externality under current industry structures and policies, and the flow of emissions at zero private cost is a significant market failure requiring policy intervention on a global stage. The favoured form of policy intervention to correct the market failure is a system of tradable permits, but with debate about whether the permits should be auctioned, allocated to current polluters (grandfathered), or allocated on some other formula basis. The comparative economic incidence of the different options for distributing tradable greenhouse-gas permits on consumers, producers and government, and on different countries, is the focus of this paper.

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[2] Some references include International Panel on Climate Change (2007), Stern (2006), and Jotzo (2007). Critiques of the IPCC and, in particular, the economic issues raised in Stern, include Carter et al. (2006), Nordhaus (2007), Dasgupta (2007), Toll (2006) and Weitzman (2007). Granted the uncertainty on both the science of climate change and the magnitudes of future economic costs, some policy action to restrict greenhouse gas emissions is argued by many at a minimum to be a good insurance policy investment, and that is the position taken by the author.

The paper is in two parts. The first part presents a range of models and supporting empirical evidence to assess the distribution of the benefits and costs of market based intervention instruments to reduce greenhouse gas emissions on producers, consumers and the polluted, and the aggregate efficiency gain, either for the globe or for a particular economy. We begin with a partial equilibrium model of a competitive industry greenhouse-gas polluter, and then consider a number of partial equilibrium models where firms exercise market power. The results of these models, together with some related quantitative evidence on the economic incidence of taxes, find that most of the economic incidence of tradable permits, or of emissions taxes, to reduce greenhouse gas emissions will be on consumers. A key policy implication is to auction rather than to gift tradable permits, or to use an emissions tax, and to use much of the government revenue gain to provide lump-sum or income tax compensation to consumers.

The second part of the paper considers some of the distributional issues that challenge the reaching of any global policy agreement which includes third-world or developing countries. A simple game-theory model which uses the costs and benefits of the earlier partial equilibrium model is employed. In the absence of a global government to enforce monitoring and compliance across countries in the way that national governments can for their own citizens and resident businesses, individual countries have an incentive to free ride and to ignore the external costs of their own greenhouse gas emissions, even though a cooperative strategy to reduce global emissions would raise global welfare. If first-world countries, for whatever reasons, have decided on a strategy of reducing their own greenhouse gas emissions, it is shown that it is both welfare-improving and viable for the first-world countries to bribe third-world countries to also adopt a strategy of reducing their emissions. A final section brings together the key policy design messages.

A Competitive Partial Equilibrium Model[3]

Consider for example the case of fossil-fuel fired electricity or transport. Under business as usual (BAU), producers consider the private costs of fuel and other materials, labour and capital, but not the external costs of pollution, including

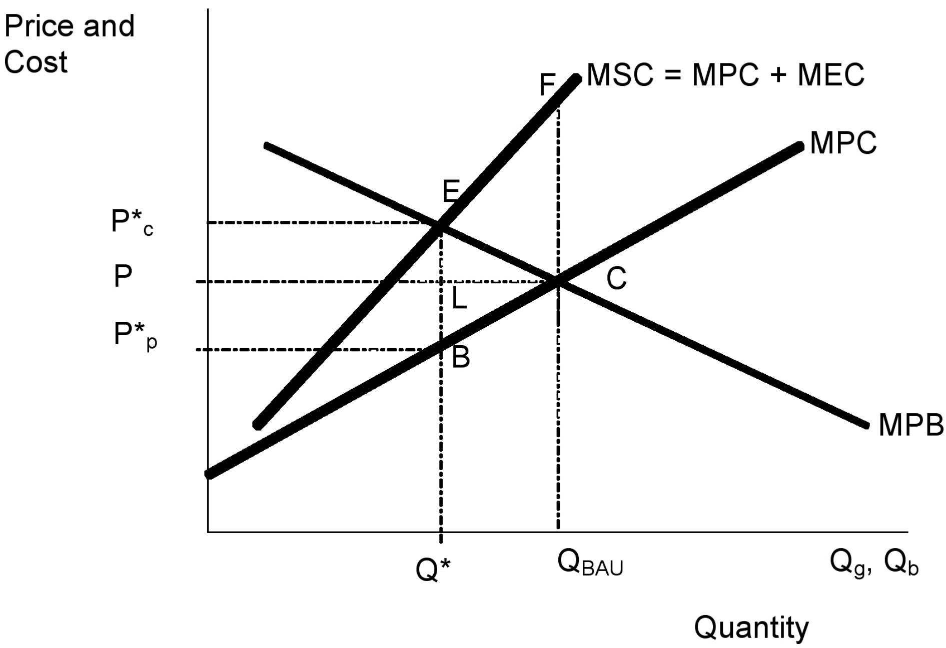
[3] This section uses a standard model of an externality presented in microeconomics textbooks and more specifically for environmental externalities presented in any number of environmental economics textbooks. Figure 1 is most easily understood if the additional simplifying assumption of a constant pollution externality per unit of private good is made. In reality, substitutability in response to changes in the price on the external product good is likely. The more general substitutability assumption changes the magnitudes of the re-distributional effects of a charge on greenhouse gas emissions but not the general pattern of the results. Bovenberg et al. (2005) consider a three-sector general equilibrium model which generalises the partial equilibrium model used here; but, the model and the illustrative numerical example assume a fixed capital stock which gives a short-run rather than a long-run scenario and enforces rising industry supply curves and ensures that some of any tax, including on pollution externalities, reduces producer surplus.

greenhouse gas emissions. Consumers consider the market price of electricity or transport costs, but again not the external costs of pollution. But, the flow of greenhouse gases from each and every country adds to the global stock of these gases, and in time this build-up of the stock induces climate change and adverse effects on future generations. These costs are worldwide, although their relative magnitudes likely will vary from country to country. While some of these costs are likely to fall on the producers and consumers of electricity and transport services, they have much wider impacts.

For simplicity, initially assume a competitive industry so that the supply curve for the good good, electricity or transport, is given by a marginal private cost curve, and the demand curve is given by a marginal private benefit curve. Ignoring the complex issues of time and discount rates, the greenhouse gas pollution adds a marginal external cost. From a global society perspective, the marginal social cost is given by the sum of the marginal private cost and the marginal external cost. Clearly, the BAU solution, or the competitive market solution in which the external costs are ignored, results in too much production and consumption of electricity and transport, and too many greenhouse gases emissions, than is socially optimal.

A more formal representation of the foregoing arguments is presented in Figure 1.

Figure 1: Distributional Effects of a Reduction in Greenhouse Gas Emissions Using a Partial Equilibrium Competitive Product Model



The horizontal axis shows quantities of the good good, Q_g, such as electricity and transport services, and the bad good, Q_b, greenhouse gases, and the vertical axis shows the price or cost per unit of good. Consider first the base case, or BAU outcome under a competitive market. With the supply curve indicating marginal private cost, MPC, and the demand curve indicating marginal private benefit, MPB, the market equilibrium, and BAU solution, is quantity Q_{BAU} and price P.

By contrast, the social optimum that recognises the external costs of greenhouse gas pollution would equate marginal social cost, MSC, equal to MPC plus the marginal external cost, MEC, with MPB. This would give a smaller level of production and consumption of both the good and bad goods at Q*, and a higher consumer market price of P^*_c and lower producer return of P^*_p. The social optimum can be achieved with a tax per unit emission of $P^*_c - P^*_p$, or with a system of tradable permits limited to OQ*. Note that the market price of the permits, or their opportunity return, will equal the emissions tax rate of $P^*_c - P^*_p$. Further, in a mature market this socially efficient outcome will occur whether the permits are auctioned or gifted, and then gifted to different identities under different criteria, with only minor differences due to differences in income effects associated with the different options for allocating the initial property rights.[4] From Figure 1 we can assess the re-distributional effects of a tradable permit scheme (or tax emission scheme) relative to the BAU base-case scenario.

Consumers of the polluting electricity and transport products in all cases face a higher market price, P^*_c rather than P, and lose consumer surplus of area PP^*_cEC, equal to a transfer of PP^*_cEL plus ELC. Both the price increase and the consumer surplus loss are greater the less elastic is demand relative to supply. In the extreme case of a perfectly elastic supply associated with constant returns to scale production technology and infinitely elastic factor supplies to the industry, all of the emissions tax or scarcity value of tradable permits will be passed forward onto the consumers of the carbon-intensive products as a higher price equal to the tax or market price of the tradable permit. Such a technology seems a close approximation for most of the manufacturing and service industries which generate greenhouse gas emissions, either directly or indirectly through purchased intermediate inputs.

The re-distributional effects of tax and tradable-permit policy interventions to reduce greenhouse gas emissions on producers depend in part on the way in which the permits are allocated, and in part on the relative elasticities of supply and demand for the electricity, transport and other carbon-intensive products. To the extent that producers face a lower net market return, P^*_p rather than P, producer surplus is reduced by P^*_pPCB, equal to a transfer of P^*_pPLB plus BLC.

[4] This result is an application of the Coase theorem; see, for example, Coase (1960).

If the intervention is an emissions tax, or if the tradable permits are auctioned, and in both cases at a tax rate or fee of $P^*_pP^*_c$, government gains a transfer of revenue from producers and consumers of $P^*_pP^*_c$EB. In this situation, producers lose P^*_pPCB. However, at the other extreme, if the tradable permits are gifted to producers in a grandfather arrangement, producers make a net gain of PP^*_cEL less BLC. Further, if supply is close to perfectly elastic (for the reasons noted above), producers and their shareholder-owners are large net winners and they benefit from the gift of the tradable permits times their market price. Clearly, if some of the permits are gifted and some are auctioned, as seems to be suggested by the Prime Ministerial Task Group on Emissions Trading (2007), the net outcome for producers, and for government, will lie between these two extreme scenario options.

An important result of the foregoing discussion is that the economic incidence of a tradable-permit scheme is bound to be very different from the statutory or first-round incidence. In particular, in the likely case of a highly elastic supply curve for the carbon-intensive products, most of the cost of restraining the production of greenhouse gas emissions will be passed forward to consumers as higher product prices than otherwise. In this case, it is likely that political pressures for compensation for equity will come from households.[5] Compensation might be sought as higher wages than otherwise to maintain real incomes, with the associated threats to igniting a burst of inflation, by gifting the permits to households, or by providing compensating reductions in taxation and increases in social security rates. The latter, of course, require government revenues, and, in turn, this option places a premium on government choosing the options of either an emissions tax or auctioning the permits, rather than gifting them to producers.

The reduction in the production of the greenhouse gas external product, Q_b, in shifting from the BAU output, Q_{BAU}, to the social optimum output, Q^*, in Figure 1 results in a reduction in pollution costs of BEFC. This gain is a type of public good (with properties of non-rival consumption and high costs of exclusion) spread across the globe rather than a gain to the members of a country which introduces the emissions tax or tradable permits. A particular country would gain only a share of BEFC, say α, with $0 \leq \alpha \leq 1$, and other countries free ride on the remaining share $1- \alpha$.

Figure 1 can be used to evaluate the net gain for the globe and for particular countries. For the globe there is a net gain of EFC. The global net gain equals

[5] This effect is likely to be non-trivial. The Australian Greenhouse Office estimates Australian annual greenhouse emissions at about 550 million tonnes of CO_2-e. By way of illustration, if three-quarters of these are subjected to a carbon tax or tradable-permit system, as proposed by the Prime Minister's Task Force on Emissions Trading (2007) at a conservative low rate of \$30 per tonne of CO_2-e, and all of this is passed forward to consumers, consumer outlays increase by \$12.4 billion a year, or a little over 2.25 per cent of annual private consumption expenditure.

the reduction in the costs of greenhouse gas-induced climate change, BEFC, less the reduction in economic (producer and consumer) surplus from the reduced production and consumption of electricity and transport, BEC. Note that area $P^*_p P^*_c EB$ is re-distributed between producers, consumers and government depending on the intervention policy instrument and the relative elasticities of supply and demand. The net gain is the efficiency case for a global strategy to reduce, but not to eliminate, the production of greenhouse gases.

In the event that a particular country, or group of countries, introduce policies to reduce greenhouse gas emissions, but others continue with BAU, the innovating country or countries lose EBC and gain only α BEFC, with the other countries free riding with a gain of $(1-\alpha)$ BEFC. Note that the country or countries that in isolation introduce policies to reduce greenhouse gases may actually lose, depending on the relative magnitudes of the aggregate economic surplus loss, the global benefits of the smaller externality cost, and the share of those benefits received by the policy initiator. By contrast, the free-riding countries unambiguously gain. As will be shown later, these cross-country distributional effects are important considerations for the development of a global policy strategy to reduce greenhouse gas emissions.

Models with Market Power

In reality, because of the importance of economies of scale, product differentiation and other considerations, producers in particular industries may have market power and use this power in determining decisions. This section considers potential qualifications to the distributional effects of policy interventions to reduce greenhouse gas emissions reported in the preceding section for a competitive model if producers use their market power in setting prices and quantities, and in particular in changing price and quantity decisions in response to the additional production costs of an emissions tax or a tradable-permit scheme.

While there are many different models of monopoly, oligopoly and monopolistic competition, they have some common properties which are germane to our questions. On the assumption that firms seek to maximise profits, they choose quantities and prices to equate marginal revenue, MR, with marginal private costs, MPC.

Assume initially that the firm demand curve has a constant elasticity of demand. A typical firm i has a MR_i function

$MR_i = P_i\,(1 - 1/E_i)$ (1)

where, P_i is price on the firm's perceived demand curve, and E_i is the absolute value of the elasticity of demand perceived by the individual firm i taking into account such considerations as the quantity and price-decision reactions of other firms in the industry. Note that profit-maximising firms choose an output where demand is elastic, that is $E_i > 1$, so that $MR_i > 0$. Equating (1) to the firm marginal cost, MC_i, the firm sets price as a mark-up over marginal cost, with the mark-up given by $E_i/(E_i - 1) > 1$, at

$$P_i = (E_i/(E_i - 1))\, MC_i \quad (2)$$

Note from (2) that the competitive model of the previous section is a special case of (2), since as the perceived firm demand elasticity becomes more elastic, and in the extreme perfect competition case $E_i =$, the mark-up approaches unity.

More generally, when the perceived firm level demand elasticity E_i is very large, the competitive model assessment of the distributional effects of market measures to reduce greenhouse gas emissions will provide a good approximation. In these cases, P MC, and the industry supply curve is also approximately the MPC shown in Figure 1. In the case of monopolies, often the price is regulated to be close to MC. In most cases of monopolistic competition there are many firms with fairly similar or close substitute product options. In the case of oligopoly industries, for Cournot (or quantity setting) firms the perceived firm elasticity of demand increases with the number of firms, and for Bertrand (or price-setting) firms the price set approaches MC the closer are the firm product substitutes, and for perfect substitutes P = MC as under perfect competition. For many of the major greenhouse gas-emitting industries, there are similar quality products; for example, electricity is electricity. There are a large number of firms with differentiated products, but where some of the different products are close substitutes — for example, motor vehicles — this suggests the competitive model results will be a reasonable approximation of the distributional effects of market-based policy interventions to reduce greenhouse gas emissions.

Suppose instead that greenhouse gas-emitting firms are able to, and in practice do, exercise market power and set prices according to (2); that is the perceived firm demand elasticity E_i is, say, 5 or less elastic. Then, BAU output, including greenhouse gases, will be less than the competitive model, and the initial market price for the good goods will be above the competitive market price. More importantly, using (2) and assuming a constant marginal cost,[6] the effect of a carbon tax or the opportunity cost of a tradable permit, T, to reduce greenhouse gas emissions on the consumer or market price P_c will be

$$dP_c/dT = E_i/(E_i - 1) > 1 \quad (3)$$

That is, unlike the competitive model in which 100 per cent of the tax or permit price is passed forward to consumers, here more than 100 per cent of the additional cost is moved forward to consumers.

[6] An upward- (or downward-) sloping MC can be included in the model. In the case of an upward-sloping MC curve, some of the tax burden will be borne by the producer.

Now, rather than assuming, as was done above, that the firm demand curve has a constant elasticity at all price–quantity combinations, suppose instead that we assume a linear demand curve (with demand becoming more elastic at higher prices). In the special case of a monopoly, only a half of any marginal cost increase, including that associated with a greenhouse gas emission-reduction policy, would be passed on to consumers. With a Cournot oligopoly, the price increase enlarges with the number of firms and approaches 100 per cent for many firms (Smale, et al., 2006). In the case of monopolistic competition, Ng (1986) shows that more than 100 per cent of any cost increase will be passed forward to consumers as higher prices. Here, the emissions tax or the opportunity cost of the tradable permit increases both the average and the marginal cost, and the reduction in firm numbers (because of the higher price and less aggregate industry demand), combines to reduce the slope of the firm demand curve at which the new higher equilibrium price is established.

In principle, we can point to a wide range of different models of firm conduct with the use of market power, to differences in the shape of the demand curve facing each firm, and to differences with the shape of firm cost curves. Different combinations result in less than 100 per cent, about 100 per cent and more than 100 per cent of the increased costs to firms of policy interventions to reduce greenhouse gas emissions been passed forward to consumers as higher prices. But, in most cases, with the monopoly with a linear demand curve being the main exception, a cost pass-through of 100 per cent or more is the behavioural response. We now turn to some empirical evidence on the rate of pass-through of higher taxes or tradable-permit costs on greenhouse gas emissions on consumer prices for carbon-intensive products.

Some Empirical Evidence

A study of the EU Emissions Trading Scheme by Sijm et al. (2006) estimated that for the German and Dutch power industries between 60 and 100 per cent of the market price of the permits was passed forward to consumers as higher electricity prices. The cases of less than 100 per cent pass-through were associated with situations where the additional cost reversed the low-cost ranking of different production technologies; in particular, where the former higher-cost gas-fired units, which are less carbon-intensive than coal-fired generators, became the lower-cost and hence the marginal price-setting option, under the additional emissions permit cost.

There are two related sets of empirical evidence for Australia which give insights into the likely economic incidence, and the distributional effects, of a tax on emissions or a tradable-permit system to reduce greenhouse gas emissions. These are studies of tax incidence, and the experience of the GST package of reforms introduced in 2000.

Studies of the distributional effects of Australian indirect taxes, including the petroleum products excise which can be considered in part a selective carbon tax (and also in part a tax to fund road construction and maintenance and perhaps a tax on congestion) and on motor vehicles, assume 100 per cent pass-through to the consumer for both the direct effects and the indirect effects through intermediary inputs. These include studies by ABS (2007), and by Warren and NATSEM (for example, in Warren et al., 2005).

A related practical experience with several messages for the conduct of policy on emission taxes or tradable permits to reduce greenhouse gas emissions is the GST package of reforms introduced in 2000. The reform package involved using revenue from eight of the 10 percentage points of the GST to replace other indirect taxes, including the wholesale sales tax and several state stamp duties, with revenue from the remaining two percentage points, plus some budget surplus, to fund lower income taxation and an increase in social security payment rates. The net incidence of the reform package of indirect taxes on product prices was modelled on the assumption of 100 per cent pass-through to consumers, and the Australian Competition and Consumer Commission (ACCC) used these numbers with effect to monitor business pricing, and that is how the actual numbers evolved.[7] In the spirit of the competitive industry model of Figure 1, the ACCC modelling and monitoring of price changes assumed constant returns to scale production technology and competitive passing forward of net tax (and cost) changes. The actual numbers revealed corresponded almost one to one with the model estimates.

Another important message from the GST reform package is that it included a net increase in indirect taxes, much as would a carbon tax or tradable-permit scheme. This was projected to increase the overall CPI index, by about three per cent. Compensation of households (in fact over-compensation because of the draw on additional budget funds), through a combination of lower income taxation and higher social security payments was argued by the Coalition government to avoid the need for any compensating wage increase, and for an increase in nominal interest rates. In practice, this is what happened. There was a one-quarter blip in the CPI, with no flow-on effects to wages, interest rates and other macroeconomic variables (see, for example, The Treasury, 2003).

Some General Equilibrium Effects

So far, the paper has focused on the partial equilibrium assessment of a single product, and with a key result that the introduction of an emissions tax or a system of tradable permits pushes up the consumer price and reduces the level

[7] Dixon and Rimmer (2000) provide a brief description of the application of the MONASH model used by the ACCC, with references to more details of this model, and also to the PRISMOD and MURPHY models which also were consulted.

of production and consumption of the greenhouse gas-emitting product. In a multi-product or general equilibrium model assessment, consideration of the distributional effects of the policy initiatives should look also at the effects of changes in relative prices. In a multi-product and multiple production methods context, some products and production methods gain and others lose, whereas the partial equilibrium model focuses only on the losers.

For consumers, the relative prices of carbon-extensive products will fall relative to the prices of carbon-intensive products. Then, some of the reduction in consumption of electricity, transport and other carbon-intensive products will be offset by increases in consumption and, in turn, increases in production of such carbon-extensive products as clothing, insulated buildings, public transport, and smaller and more fuel-efficient vehicles and household appliances. Businesses similarly will redirect their choice of production methods to expand on the now relatively cheaper lower carbon-intensive methods such as better-designed and better-insulated buildings, renewable rather than fossil-fuel-based energy, and energy-conservation measures. In a dynamic context, the changed relative prices provide larger incentives and rewards for a new set of innovations based on R&D and investment that economise on the now relatively more expensive carbon-intensive products and production processes. Popp (2006) provides a compelling survey of studies showing a significant and quantitatively important response of induced business R&D and innovation towards energy efficiency and less carbon-intensive energy production methods in response to higher energy prices.

From a general equilibrium perspective, market-based policy interventions to reduce greenhouse gas emissions change the mix of production and consumption in what Schumpeter called 'creative destruction' with a much smaller, and perhaps even indeterminate, net effect on aggregate employment, investment and output, although one with fewer greenhouse gas emissions.

A Global Policy Strategy

There are at least four sets of reasons why it is desirable, if not necessary, for global cooperation in developing a first-best policy strategy to reduce greenhouse gas emissions. Clearly, understanding the distributional effects across different countries of alternative policy intervention options to reduce greenhouse gas emissions is important. First, the pollution externality is of a global nature, and the benefits of reduced pollution have classic public-good characteristics. Second, this public-good characteristic of the pollution-reduction good means that there are incentives for individual countries to free ride with a likely non-cooperative game equilibrium of BAU and excessive global pollution relative to the global first-best solution. Third, many of the carbon-intensive industries are globally footloose. Restricting their activity level in one country induces migration offshore of the pollution-intensive industries, with the result of a very much smaller net reduction in the global stock of greenhouse gases. Fourth, cost-effectiveness in reducing the stock of global greenhouse gases, and the associated future costs of adverse climate change, are favoured if tradable permits and credit offsets have an integrated global market rather than just a series of autarkic national markets. Given the obvious advantages of global cooperation, this section considers some of the distributional effects, and especially between first-world (or developed) countries and third-world (or developing) countries, that affect the barriers to, and the opportunities for, global cooperation.

Consider first a simple game theoretic model for two countries, or country groupings such as first-world countries, F, and third-world countries, T, with two possible individual-country strategies of business as usual, BAU, and invest in reducing greenhouse gas emissions, ABATE. Table 1 sets out the game and with the pay-off matrix using the BAU-BAU strategy as the base-case strategy with a net payoff for each country of zero. For simplicity, further assume the two sets of countries are similar, since this does not alter the points to be made. If both countries invest in reducing greenhouse gas emissions, each makes a positive gain, roughly area EFC of Figure 1, of, say, +20 for each country. But if one country chooses ABATE while the other chooses BAU, the abating country incurs the costs, roughly area BEC of Figure 1, and receives only a portion α of the reduction in the external costs of reduced climate change,[8] area BEFC, and so makes a net loss of, say, –20, and the BAU player incurs no costs but free rides and receives $1 - \alpha$ of the benefits of reduced global pollution for a net gain of, say, +30. Note that because the ABATE–ABATE strategy maximises global welfare, the ABATE–BAU strategy mix provides a lower aggregate net gain, and in our illustration +10 versus +40. Also, the ABATE–BAU strategy by moving towards the global optimum provides larger aggregate gains than the BAU–BAU strategy mix.

Table 1: Greenhouse Gas Emissions as a Prisoner's Dilemma Problem

Third World First World	ABATE	BAU
ABATE	20 20	30 −20
BAU	−20 30	0 0

From Table 1, the global cooperative strategy to maximise welfare involves both sets of countries investing in policies to abate or reduce greenhouse gas emissions, the ABATE–ABATE strategy mix. However, for each individual country, their dominant strategy is to free ride, or to choose BAU, with a Nash

[8] Note that in a many-country model, α can be quite small. For example, for Australia we contribute only 1.4 per cent of annual global CO_2-e emissions.

equilibrium of BAU–BAU. This is no more than a variant of the textbook Prisoners' Dilemma game.

The policy challenge becomes one of establishing a binding global agreement for the ABATE–ABATE strategy.[9] This is an extremely difficult challenge. Unlike national and regional pollution problems where there are national and regional governments with the power to coerce all players to accept the cooperative agreement, there is no such international government. Certainly international agreements, usually under the auspices of such bodies as the UN or the WTO, can be negotiated for such purposes. However, while some regard the Kyoto Protocol of 1997 to have made some progress for the specific case of greenhouse gas emissions, the fact that third-world countries do not have binding agreements, that the US and Australia decided not to join, and that some of the signatory countries seem likely to exceed their targets, and with no effective sanctions, casts doubt on this approach as developed so far. Further, there is no robust global governance structure to ensure the accuracy of monitoring by national governments, or to impose and enforce the payment of penalties on non-conforming nations.[10] At the heart of reaching a cooperative agreement is establishing a mutually agreed sense of fairness, or distributional equity, necessary to induce the majority of countries to sign up, and then to meet commitments.

Different proposals for the initial allocation of tradable permits between first-world and third-world countries highlight the challenges to reaching a global consensus. With considerable merit, third-world countries object to the option of grandfathering permit allocations to countries based on their current pollution levels, a strategy at the heart of the Kyoto Protocol and now of the European tradable-permit scheme. Third-world countries argue that the first-world countries have been the principal contributors to the stock of greenhouse gases. This has been a key part of the industrialisation process over the past two centuries which lies behind the much higher per-capita incomes of the first-world countries. They, the third-word countries, have legitimate equity claims to proceed with industrialisation to raise their own incomes, and therefore the first-world countries should bear most of the cost of reducing the further build-up of global greenhouse stocks. Arguably, a fairer allocation of tradable permits would be one based on equal per-capita allocations as argued, for example, by Parikh (2007). The first-world countries look at this option, and its

[9] For a much broader and more comprehensive discussion of experiences and options for achieving a cooperative solution for a wider range of global public goods, including global peace, suppression of pandemics, CFCs and the ozone zone, as well as climate-change mitigation, see, for example, Barrett (2007) and references therein.

[10] While some argue that conforming countries could impose trade restrictions against cheating countries, the history of trade restrictions against particular countries is not an impressive one.

associated cost of buying permits from the third-world countries, with much concern.

Suppose that for whatever reason(s), and as is beginning to be the case, that the first-world countries choose to implement policies to reduce their own greenhouse gas emissions (the ABATE strategy of Table 1), what are the minimum and maximum bribes they would offer the third-world countries to induce them to voluntarily also adopt the ABATE strategy, and so achieve the global welfare-maximising ABATE–ABATE outcome? In the first row of Table 1 we can evaluate the minimum subsidy or bribe that the third-world countries require to chose strategy ABATE over BAU, and the maximum subsidy or bribe that the first-world countries would be willing to pay to have the third-world countries choose ABATE over BAU without either set of countries being worse off than the ABATE–BAU outcomes. Represent the benefit to country k, with k = F or first-world and T for third-world, for the choice of strategy i by F and strategy j by T, with i,j = ABATE or BAU, as $G^k(i,j)$. So as not to be worse off, the minimum bribe required by the third-world countries, $Bribe_{min}$, is

$$Bribe_{min} = G^T\,(ABATE,\,BAU) - G^T\,(ABATE,\,ABATE) \quad (4)$$

and the maximum bribe willing to be paid by the first-world countries, $Bribe_{max}$, is

$$Bribe_{max} = G^F\,(ABATE,\,ABATE) - G^F\,(ABATE,\,BAU) \quad (5)$$

For the illustrative numerical payoffs in Table 1, $Bribe_{min} = 10$ and $Bribe_{max} = 40$. In general, using (4) and (5), together with the fact that the ABATE–ABATE strategy maximises global welfare, and therefore that the ABATE–BAU strategy generates less global welfare, we can conclude that

$$Bribe_{max} > Bribe_{min} \quad (6)$$

This means that it is possible to reach a global Pareto agreement involving a subsidy from the first-world to the third-world countries, and that (4) and (5) set the bands for negotiating the subsidy level to the third-world countries to seek their agreement to invest in reducing greenhouse gas emissions.

In practice, the subsidy to gain third-world country acceptance to participate in a global agreement could take several forms. Direct grants are the simplest and most transparent. Another option is in the initial country-by-country allocation of greenhouse gas emission-permits to provide third-world countries with surplus permits to current pollution (and in effect to move part way towards the per-capita allocation idea). Until their economy and pollution output expands, the third-world countries would gain from the sale of their surplus permits to first-world countries, but a positive price for carbon signals the need for both producers and consumers to reduce carbon use and consumption. The proposal by some first-world countries for them to invest in R&D to reduce the costs of reducing greenhouse gas emissions, and then to share the results for free or at a subsidised rate with third-world countries — for example, as a key component of the AP6 proposals — will help, but it is unlikely to go far enough to win agreement from many third-world countries.

Policy Implications

Most of the final or economic incidence of a system of emission taxes or tradable permits to reduce greenhouse gas emissions will be on consumers, and not producers. This follows from the high elasticity of long-run supply of most products intensive in carbon, and it is supported by studies of the incidence of indirect taxes and the experience of the GST tax reform package of 2000. If we allow for the exercise of firm market power, even more than 100 per cent of the tax or permit price could be passed forward.

The passing forward of most to all of the cost of carbon taxes or tradable permits to consumers as higher prices has at least two key messages for the design of a tradable-permits scheme. First, gifting the permits to producers, including under grandfathering principles, represents a redistribution of national income. A status-quo equity system would auction the permits or turn to a tax on emissions systems, and then return the initial government revenue gains to consumers. Second, because of the consumer price increase and associated increase in the cost of living, there is a compelling case for using the government revenues gained to compensate households via cuts in income taxes and increases in social security payments in an aggregate revenue-neutral package to minimise the prospects of compensating increases in wages and an impetus to inflation.[11] This form of compensation would not alter the necessary change in relative prices against carbon-intensive products.

A complete picture of the distributional effects of a tradable emissions or emissions tax scheme to reduce greenhouse gas emissions requires a general equilibrium model assessment. These policy interventions change relative prices. While the production and consumption of carbon-intensive products facing higher relative consumer prices decline, other products facing lower relative consumer prices expand and in the process create new investment and employment opportunities.

In the global context there are incentives for individual countries to free ride and not to invest in policy actions to reduce greenhouse emissions and achieve a cooperative global social optimum. Third-world countries argue, with considerable merit, that they should bear less of the cost burden of reducing global greenhouse gas emissions than first-world countries and, in particular,

[11] A detailed study of the likely incidence of a carbon tax in New Zealand across different households (by demographic type and income level) by Creedy and Sleeman (2006) finds that the vertical and family-type incidence of the carbon tax is close to proportional to expenditure.

they object to a system of grandfathered allocations of tradable permits of the form proposed under the Kyoto Protocol. Clearly, global cooperation from the developing countries requires innovative options on an equitable distribution of global permits.

Interestingly, the paper shows that if first-world countries choose to invest in policies to reduce their greenhouse emissions and the third-world countries decline to participate, there is a sizeable win-win opportunity for the first-world countries to subsidise or bribe the third-world countries to join a cooperative global welfare-maximising agreement.

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