Some Basic Economics of Carbon Taxes

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Some Basic Economics of Carbon Taxes*

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Abstract: This paper asks three questions. First, how do carbon taxes drive economic and environmental outcomes? Second, what is the appropriate economic base on which carbon taxes should be levied? Finally, how well does a carbon tax deliver economic-environmental outcomes compared to a comparable emissions trading scheme.

1. Introduction. Carbon taxes and, more generally, taxes on greenhouse gas emissions, are a widely advocated means for reducing such emissions to address anthropogenic climate change. See for example, Metcalf and Weisbach (2009). This paper analyzes the positive and normative properties of a generic 'carbon' tax that covers the various greenhouse gases, with respect to tax incidence and social welfare effects including 'double-dividend' properties. The appropriate choice of a carbon tax base is first considered in a closed and then in an open economy. In an open economy the main issues are the desirable breadth of the tax as well as whether it should be levied on a 'destination' or 'origin' basis. Finally, an evaluation of the case for a carbon tax rather than an emissions trading scheme (ETS) is provided. It is clear that although the analysis focuses on design issues for carbon taxes that many similar issues arise with respect to an ETS. The discussion closes with conclusions and final remarks.

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The advantages of using economic instruments over direct regulations to manage external costs are well-known and are not discussed. The objectives of public environmental policy should not only be to restrict socially damaging carbon emissions but, also, to do this at minimum cost, where cost includes environmental damage cost impacts and costs of abating emissions. The latter cost information is often best assessed by the individual firms in an economy who can make more economically efficient adjustments to priced carbon emissions than can a planner who sought to regulate these firms with direct controls but who lacked knowledge of specific firm costs.

Australian policy thinkers (e.g. Garnaut, 2008) have generally favoured emissions trading schemes (ETS) rather than a carbon tax. With the recent failure of the Senate to approve an ETS a case for using an ETS at least as an interim measure has returned to the agenda. Similarly the US Senate's reluctance to pass the *Energy Security Bill* proposed by Congress has revived calls for a carbon tax. This paper discusses issues that bear on these choices. Indeed the reasons originally advanced by Garnaut for rejecting carbon taxes are similar to those expressed below in Section 4.

2. Tax incidence and welfare consequences. Carbon taxes on the burning of fossil fuels are typically motivated as measures to internalize the climate change externalities associated with carbon emissions. Consider their role in a stylized market where a good - for specificity take the important case of 'electricity' - is produced using a mix of more or less carbon-intensive technologies and then sold to consumers and firms. Suppose, provisionally, that the electricity market is competitive and, initially, for simplicity, suppose the economy is closed to international trade. Section 3 takes up open economy issues.

In **Figure 1** the demand for electricity is D and, given the marginal private production costs (MPC) and the absence of any carbon tax or other restriction on carbon emissions, quantity E_1 of electricity is sold at price P_1. As this electricity is produced, marginal social costs (MSC) arise comprising the marginal private costs (MPC) incurred by resident producers plus the marginal external costs (MEC), borne both by residents of the economy and by those living elsewhere so MSC = MPC + MEC. Carbon emissions associated with electricity production are an externality but they are also a global 'public bad' because the CO_2 released into the atmosphere as a consequence of burning fuels contributes towards damaging climate change. These social costs are difficult to assess accurately because the effect of emissions on climate and the associated damages are uncertain. It is known that the emissions potentially pose the threat of catastrophic, non-marginal social costs (Weitzman, 2009). Yohe et al (2007) provide an estimated average of marginal social cost of carbon at $US43/tC but associate with this estimate the large standard deviation of $US83. These substantial uncertainties

motivate some to seek to determine taxes that meet specific carbon reduction targets but there remain uncertainties about how various tax rates will impact on emissions.

A consequence of these external costs is that, from the viewpoint of optimizing the difference between local private benefits and global costs, electricity production E_1 is socially excessive and is sold at an excessively low price P_1. A measure of the deadweight losses associated with this excessive production is the area of the triangle marked DWL.

The classical Pigovian approach to eliminating these deadweight losses is to levy a tax T on electricity production which raises the MPC experienced by electricity producers to MSC. This increases prices from P_1 to P* = P+T and reduces electricity production to E*. Imposing this tax provides a welfare gain in the sense that the global deadweight losses, DWL, are avoided.

It is not necessary to suppose that different production technologies here have the same carbon emissions intensities so that they therefore face the same emission abatement costs – costs of reducing carbon emissions or of converting such emissions into a non-polluting form. Firms with feasible CO_2 abatement technologies will abate to the point where marginal abatement costs equal the optimal emission tax so that, across firms that do continue to produce, marginal abatement costs will be equated guaranteeing economic efficiency. The socially desired level of output E* is provided at minimum social cost. Firms without abatement technologies will go out of business if their output is redundant to demands met at the tax-inclusive price by lower cost producers.

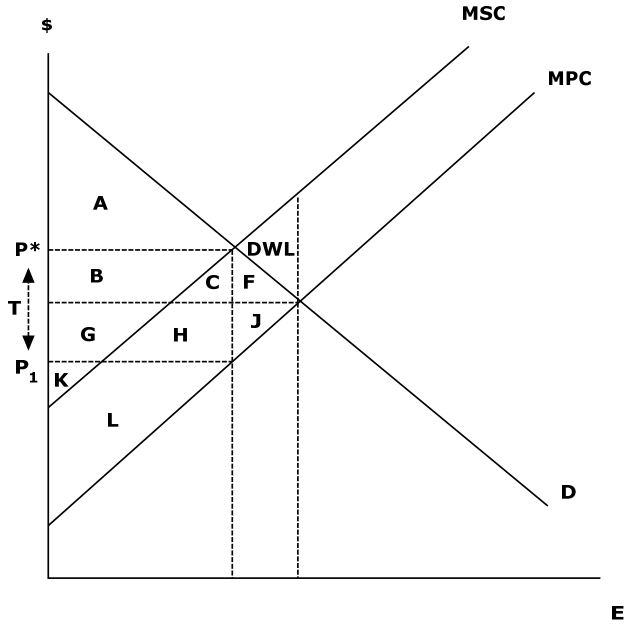

Figure 1: Externalities associated with carbon emissions

Eight comments:

(i) For this analysis to plausibly describe the gains from an activist tax policy, the society considered must value the gains enjoyed by the world as a whole from carbon pollution reduction. Alternatively, it must see net advantages in levying a tax from the strategic effects this has in motivating other countries to mitigate emissions. In short, tax revenue gains from such a policy are not *by themselves* sufficient to compensate for the reduced production and consumption surpluses experienced as a consequence of the tax. Indeed ignoring the environmental gains there is an excess burden from the tax. Thus, in **Figure 1**, producer surplus accruing to electricity producers falls by the area G+H+J with imposition of the tax. Consumer surpluses fall by B+C+F while tax revenues increase by B+C+G+H. If $1 of taxes has social worth $1 then the gain in tax revenues falls short of offsetting the reduced surpluses by F+J. The reduction in unpaid social costs as a consequence of the tax however is DWL+F+J which exceeds the excess of surpluses lost over revenue gained if and only if residents attach positive value to the deadweight losses DWL that are experienced globally or, as mentioned, if they derive net benefits from taking actions that ensure other countries mitigate their emissions.

This analysis recognises that the external costs here accrue both to residents and, for an open economy, to the rest-of-the-world. To include them in a particular country's social welfare function requires first the assumption that the CO_2 emissions are in fact damaging. It also supposes either some degree of altruism towards the world at large or perhaps the objective of achieving comprehensive adherence to a climate change agreement.

Once these external costs or strategic benefits are recognized by citizens, the externality tax itself implies no deadweight losses. Instead, it reduces socially damaging behavior to efficient levels. Tax revenues can be used to cut other distortionary taxes providing what, at first sight, seems to be 'double dividend' benefits as discussed below.

(ii) In a closed economy it makes no difference, from the viewpoint of tax incidence, whether the tax on electricity consumption is levied on consumers or producers. Then the division of the burden of the tax between the economy's producers and consumers depends only on the price elasticities of demand and supply for electricity not on the *nominal* incidence of the tax. The *effective* incidence of the tax is borne primarily by electricity producers if the absolute value of the demand for electricity is much more elastic than supply – this is likely to be the situation in the short-run - whereas it is borne primarily by consumers, in terms of higher prices, if supply elasticities are much greater than the absolute value of demand elasticities as is likely longer-term.

The relative size of these elasticities is an important issue in determining who should receive income or other compensations for the impact of the tax. Again, if demand is relatively inelastic, compensations should be directed to consumers whereas, if supply is relatively inelastic, it is this sector that suffers most from the tax impact and hence it is suppliers who might plausibly be considered for compensation.

The irrelevance of the nominal incidence of a tax breaks down in an open economy where consumption and production of outputs may arise outside an economy. This is discussed below.

(iii) Longer-term supply effects will be more pronounced than short-term effects. Longer-term there will be switches between existing technologies towards those which are less carbon polluting and incentives to innovate low carbon intensity technologies. Indeed the current and future tax-inclusive prices of output delivered using carbon-intensive technologies are important information for establishing the social and commercial viability of alternative long-lived technologies. The competitiveness of renewable technologies and nuclear power as well as carbon capture and storage technologies is easier to assess once carbon taxes are in place.

Longer-term both supply adjustments and demand shifts will help an economy adjust away from carbon-intensive technologies.

(iv) Capital stocks used in activities, such as those used in electricity generation, are long-lived creating a time-consistency issue for those designing carbon taxes in market economies with populist elected politicians. In short, firms using such capital stocks can be subject to 'hold-up' by these politicians who, they will understand, have incentives to initially introduce carbon taxes to drive the commercialization of low-carbon-intensity technologies. Then, once this is done and shifts toward low carbon intensity technologies have been made, these same politicians have incentives to cut such taxes to win public approval and improve their re-election prospects. Firms who understand this may be reluctant to make the substantial new investments required. This difficulty needs to be addressed by setting up independent institutions with the authority to credibly commit to enforcing carbon taxes longer-term. Alternatively, the capital investments required can be publicly-supplied so that the costs of potential 'holdup' are internalised.

Ergas (2010) rejects the case for setting up an independent authority to manage carbon quotas and to devise compensations on the basis that it would be difficult to respond flexibly to new information about the costs of climate change and to changes in the emission policies of other countries and to avoid rent-seeking. This issue is addressed in Garnaut (2008, p. 352). Revising targets needs to be made explicitly dependent on revised climate change damage assessments and international policies. Targets can be

both conditional and unconditional with government only certifying that the conditions for changing a trajectory have been met. Rent-seeking likewise can be reduced by governments setting out clearly in codified rules how assistance would be given.

(v) Carbon taxes will impact on natural resource markets both directly, in markets for carbon-based fuels, and indirectly, through effects on the demand for substitute resources such as nuclear fuels, solar power and complementary capital resources. With a tax demands for carbon-intensive fuels will decline and there will be increased demands for substitute resources and the substantial capital stocks they draw on. There will also be reduced demands for inputs that are complementary to the burning of fossil fuels. These intersectoral effects are important in open economy contexts as will be discussed. Overall, there will be substantial increases in demands for capital in the power generation sector that will, however, have only modest impacts on the global cost of capital. To cut emissions by 25 per cent over 2000 levels by 2030 and to meet climate change adaptation needs requires total investment that is less than 2 per cent of aggregate gross investment over that period (UNFCCC, 2008).

It is also important to understand that goods which are not carbon intensive will face relative price changes favouring them. Adams (2007) provides a general equilibrium analysis of the Australian economy in 2030 given an ETS rather than a carbon tax – the effects of a tax set at equilibrium ETS carbon charges will be close to indentical. Most major effects are, as suggested above, concentrated in the energy sector with renewable technologies gaining and coal-fired power losing market share. Road and particularly air transport services lose. Forestry outputs increase given demands for biosequestration. Indirect effects on such sectors as food and beverages are small.

(vi) A key issue concerns how taxes are initially enacted and how they are subsequently adjusted to reflect tighter emission targets. Taxes must also reflect new economic and science-based information on the costs of carbon emissions and of abatement. Should taxes be gradually introduced at low levels and on a narrow tax base with many producers protected by 'grandfathering' provisions? Or should the economy be immediately exposed to distinctly high taxes on a broad base 'cold turkey'? Once taxes are introduced their value should increase at the rate of return on capital for assets that are comparably risky to the quota assets that would be established under an ETS. Taxes play a role closely related to such quotas and for quota assets to be willingly held their values must increase at the same rate as other capital assets. Metcalf and Weisbach (2009, p17-22) argue for 'cold turkey' policies that motivate firms to begin making adjustments immediately. However with respect to the impacts of new information significant abatement

opportunities involve long-term investments so that tax rate revisions on the basis of new information do not need to occur frequently.

(vii) Carbon taxes are often advanced with unrealistic objectives of revenue neutrality. In fact, public revenue needs may change when such taxes are introduced because of the need to compensate workers displaced from carbon-intensive industries, to set up bureaucracies to monitor adherence to tax regulation and to fund public investments in energy-sector-related R & D.

The detailed impacts of imposing carbon taxes on an economy are complex given spillover effects in both consumer and factor markets. The best way of accounting for such effects is by using computable numerical equilibrium models, such as Adams (2007), which account for the inter-sectoral linkages. Such models can account for the effects of spending the tax revenues received in various ways. For example, an issue is whether using such revenues to cut other distortionary taxes in the economy – such as income or excise taxes – will provide additional gains in the form of 'double dividend' benefits: See Schöeb (2006). The *weak double dividend hypothesis* (WDDH) sees the use of revenues from a revenue-neutral carbon tax as reducing the net distortionary effects of that tax while the *strong double dividend hypothesis* (SDDH) sees the tax as improving the environment and also increasing non-environmental welfare. With the SDDH a carbon tax provides a 'no regret' benefiit even if environmental benefits are in doubt. Most economists accept WDDH but support for SDDH depends on, among other things, how well labour markets function, the extent to which there are immobile factors of production and so on.

There are no simple analytical answers here and empirical investigation is essential (Fraser and Waschik, 2010). Using carbon tax revenues to cut other excises can have indirect effects in increasing the demands for polluting goods. Imposing carbon taxes reduces the real income of workers thereby, by itself, increasing distortionary effects of income taxes on labour (Sandmo, 2009, 17-18). If carbon taxes are levied on goods where long-term supply is highly elastic and demand less so – an example is electricity consumption – then most of the tax will be passed onto consumers. This reduces purchasing power and distorts work and savings decisions. Using revenues to offset such changes by cutting income taxes or GST can reverse this.

(viii) The analysis has assumed that the sector subject to a carbon tax is competitive. The more realistic assumption for actual electricity sectors is that the substantial capital costs of a power station assign monopoly power that can be more or less regulated. An unregulated monopolist produces less than the socially desired output and charges a socially excessive price. A Pigovian tax seeking to internalise an emission externality will be positive if and only if social damages from

emissions are sufficiently high so optimal output and price is less than the monopoly price. Then the broad implications of the preceding analysis go through. If firm profits are taxed away then the same distributional outcomes hold as well. If the firm is regulated to price at average cost or at a markup on average costs then the core issue, again, is whether the regulated price is less than the socially desired price. If pricing occurs at short-run marginal cost then the competitive conclusions cited above go through. As an anonymous referee points out, if the electricity sector is reasonably competitive with pricing at short-run marginal cost enforced, the earlier analysis applies.

3. Choice of a tax base. The choice of a tax base involves choosing the optimal breadth and coverage of the tax as well as whether to levy it on producers or consumers. The breadth issue involves trading off benefits of increased inclusiveness against administrative and collection costs. In countries, such as the US, it is estimated that, by collecting carbon taxes upstream, 80 per cent of total emissions can be covered by taxing fewer than 3000 taxpayers so that 90 per cent of emissions can be covered at moderate cost (Metcalf and Weisbach, 2009). This concentration is due to the 80 per cent contribution of energy use in US emissions. Similarly in Australia the planned carbon pollution reduction scheme and its implied carbon charges would provide mandatory emission restrictions on around 1000 entities providing 75 per cent coverage of carbon emissions (Australian Government, 2008, xxviii). Globally energy use is a smaller percentage contributer to total emissions because of the more significant role for land use changes, especially deforestation and agriculture, in stimulating emissions particularly in developing countries. Ways of including forestry and agriculture in the tax base are therefore of particular significance for developing countries.

The benefits from a broader tax base include the greater revenues yielded which reduce the costs on individual firms taxed under a narrower base. The offset is the greater political opposition that a broadly-based tax is likely to generate despite lower average tax impacts.

In a closed economy setting the choice between taxing producers and consumers is largely irrelevant but, in an open economy where a country can buy or sell outputs from other countries and where capital resources are mobile and so can relocate internationally, it matters profoundly. The analysis to follow makes particular sense for industries other than electricity that produce a non-internationally traded good. It applies, for example, to steel, cement or alumina production. Take the case of steel.

Steel exports from a country which taxes its carbon emissions on a production or origin basis will face higher costs, on this account alone, compared to production from countries which do not mitigate emissions. Such exports face a competitive disadvantage in international markets simply

because globally desirable carbon mitigation objectives are being pursued. Similarly, the competitiveness of locally-produced steel in a local market will suffer if carbon emissions are taxed locally but not in countries supplying import-competing steel outputs. In each case the products of countries taxing emissions will experience a competitive disadvantage as a consequence of the tax compared to the products of countries which do not. In addition, firms in a country subject to carbon taxes may have incentives to relocate in countries without such a tax by relocating to 'pollution havens'.

As a referee points out these trade effects will be partly offset by exchange rate depreciations that stem from the loss of competitiveness locally and from the increased competitiveness of non-mitigating countries. This will somewhat cushion the effects of origin-based accounting.

These phenomena are instances of 'carbon leakages' since the output diversions and the relocations mean that carbon pollutions shift towards countries which do not tax emissions. The resulting carbon pollution shifts from a point where it is taxed to where it isn't. The countries which do mitigate lose industrial employment and output as well as facing costly structural readjustments without any global environmental improvement occurring.

The empirical extent of such leakages is controversial. For many industries the cost increases from a carbon tax are small because energy costs are a small fraction of total costs. In other cases, such as transportation and electricity, which are energy intensive, carbon leakages are irrelevant because the goods or services are not internationally traded. In a few key sectors (e.g. steel, aluminum and cement) leakages are likely to be important. Babiker (2005) argues that, leakages may then lead to post-mitigation emissions which are greater than 100 per cent of their original levels.

Daley and Edis (2010) argue that the likely extent of carbon leakages in Australia is limited to steel and cement which are very exposed to relocation pressures. More limited leakage issues arise with respect to aluminium and oil refining.

It cannot be denied that the notion of significant leakages does discourage some developed countries from actively moving towards carbon pricing. For example, the United States refused to ratify the Kyoto Protocol largely because under it Annex 2 developing countries were not obliged to mitigate their emissions. The US saw loss of competitiveness and leakages as important threats.

Clarke (2010a) suggested taxing carbon emissions on a consumption (or carbon *destination*) basis rather than taxing on a production (or carbon-*origin*) basis. In short, one should tax goods that involve carbon emissions in their production on the basis of where they end up being consumed –

their *destination* – rather than where they are produced – their *origin*. This means that carbon-intensive exported goods should be exempt from taxes while imports of carbon-intensive goods should be subject to border tax adjustments making their tax treatment consistent with that of locally-produced goods. G. Carmody in CEDA (2009) argues, among other things for a consumption-based tax.

The issue of designing an open economy tax base involves difficult compromises. Metcalf and Weisbach (2009) argue for a modified destination base but without tax exemptions for exports (ibid, p24) because such exemptions will lead to a diversion of output towards exports creating leakages (ibid, p53). The standard way of providing such compensations is, however, to make them lump-sum which protects the incomes of exporters without creating marginal incentives to divert output. In addition, Metcalf and Weisbach argue that taxes on imports from countries which do not mitigate would punish countries that did mitigate by leaving them disadvantaged. That is not self-evident since countries which 'hold out' in the face of mitigation efforts by others may gain residual leakage benefits by being 'shorter on the list' of possible 'pollution havens' (Clarke, 2010b).

There are advantages of using a *pure* destination-based scheme to a *pure* origin-based scheme:

(i) The use of border tax adjustments levied on imports of untaxed carbon-intensive goods seems consistent with the rules of the GATT-WTO which generally disapprove of environmental taxes on traded goods. These arguments draw on analogous arguments for WTO approval of VAT and GST consumption taxes (Tamiotti et al., 2009).

(ii) Adverse competitiveness effects due to carbon leakages, from countries which tax emissions to those which do not, are eliminated. Exports are exempt from taxes, the competitiveness of local taxed carbon-intensive goods are secured by the border tax adjustments and firms have no incentive to relocate from countries which mitigate to non-taxing countries in order to export to the countries which do mitigate. Thus 'pollution havens' become less relevant.

(iii) Incentives for non-mitigating countries to mitigate are enhanced at least to the extent that carbon tax revenues now accrue to the exporters themselves rather than to countries which impose destination-based carbon accounting on these same exports.

(iv) With border taxes and export exemptions there are improved incentives for countries, such as the United States, to unilaterally move to mitigate their emissions since they now face reduced prospects of carbon leakages. Paradoxically, while features such as border tax adjustments are viewed negatively by developing countries, such as China and India, they provide some offsetting advantages to these countries which would, in the absence of decisive action from countries such as

the US, otherwise experience great harm from climate change. These countries gain advantage because developed countries, such as the United States, are now *induced* to mitigate.

The major disadvantage of selecting a consumption tax base is that it leaves untaxed carbon-intensive exports from mitigating to non-mitigating countries. Since these products will then face reduced demands in their country of export – petroleum and coal exporters which tax on a consumption basis will demand less of such fuels themselves – the net outcome will be an improvement in the terms of trade of carbon importers given induced price falls of such commodities. This is a type of global, macroeconomic carbon leakage that reflects the fact that concerted action to mitigate by fuel exporters will reduce the price of such fuels in countries which do not mitigate emissions.

This might not be a decisively adverse implication of destination accounting. The use of this accounting can be viewed as a precursor to fully-fledged, origin-based accounting which remains a long-term ideal. If it is fully implemented, origin accounting removes the need for costly border tax adjustments and high transaction cost, export-rebate exemptions. This is advantageous since computing border tax adjustments is non-trivial because adjustments are country and technology specific. For example, it would not make sense to impose a border tax on imported alumina that was produced using non-polluting hydro-power. Similarly exempting exports is complex since such exemptions cannot be *ad valorem* without inducing a switch from production for domestic to production for export again creating a basis for leakages. Provisional use of a destination-based system might encourage imitative mitigation efforts and ultimately a switch to a global origin-based system.

There is some evidence that destination accounting principles can be distorted. In Australia, for example, policy has sought to protect the profitability of trade-exposed, carbon intensive industries under its proposed *Carbon Pollution Reduction Scheme* by distributing free emission permits. This is analogous to granting tax exemptions of rebates under destination accounting. This was a poor approximation to the ideal tax exemption policies however. The initial planned allocation of permits, in December 2008, went beyond the range of industries that needed protection and the allocations were further increased again in May, 2009 and December 2009. In addition, although permits reduce by 1 per cent per year many firms could cut their emissions faster than this. In addition free permits were to be provided to industries that would protect them from competition from lower emission substitutes which would not receive free permits. Moreover, the free permits were to be issued irrespective of the emissions intensities of overseas producers. This would

discourage firms from moving overseas even when this would reduce global emissions. This is not the intention of the destination accounting framework.

4. Carbon taxes versus emission trading schemes. There are distinctive and complex issues that affect the choice between carbon taxes and an ETS in open economies. Hence the issue is first discussed in an idealized closed economy not involved in international trade. This is followed by the case of open economies.

In a closed economy control of the flow of carbon emissions can be realized by a tax on carbon emissions or by a quota on total emissions per period which can be freely traded. As **Figure 2** shows it is always possible to select a carbon emissions quota which, assuming market conditions remain stable, will realize the level of emissions realized with any carbon tax. Here the level of emissions is graphed on the horizontal axis and the marginal damages that accrue globally are represented as MDF. The MDF is drawn quite flat since, for many economies, the scale of these marginal damages will not vary greatly with variations in the scale of their national emission mitigation policies. MAC describes the marginal abatement costs of local producers. The initial emissions flow is e_0. These are optimally abated by e_0-e* if the country in question abates efficiently at minimum cost. This can be achieved by setting a carbon tax T or by targeting aggregate emissions e* and then employing an ETS.

An ETS involves initially allocating the aggregate quota in some way to carbon emitters and then allowing it to be freely traded in an emissions market. Those who value the quota most will pay most for allocations so it should end in its highest value use thereby realizing economic efficiency. If the carbon quotas are initially auctioned and purchased by the highest-bidding emitters then, again abstracting from uncertainty, the fiscal implications of an ETS are identical to the corresponding carbon tax. Ignoring differential collection and administrative costs both policies yield identical revenue. Under these conditions the choice between a carbon tax and an ETS is of second-order importance. The important issue is to control emissions and each of these approaches yields the same outcome.

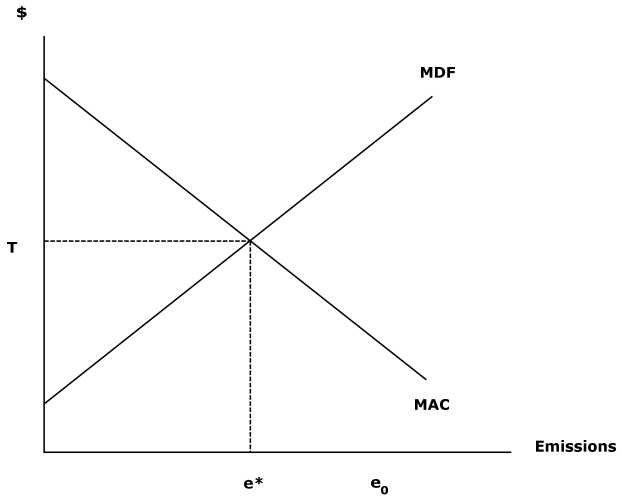

Figure 2: Carbon taxes and an equivalent carbon quota

The analysis changes if policy-makers are uncertain about demands for carbon emissions because of uncertainty over production costs or the demand for carbon-intensive outputs. If a carbon tax is set with uncertain demands or costs, the resulting extent of emission control becomes random and the achievement of exact emission targets unlikely. If, alternatively, a particular quota is set but the demand for output is uncertain then the equilibrium carbon price is random. The question then becomes which type of uncertainty is socially preferable. This was discussed in Weitzman (1974) and pursued in a climate change setting by Pizer (1997), Aldy et al. (2009). There are strong assumptions in Weitzman – linear costs and additive shocks - but it is a starting point. Analysis centres on the respective slopes of emission costs and benefits schedules. If the marginal benefits schedule is relatively flatter than the marginal cost schedule – Pizer shows that if this is the case - then fixing a tax leads to outcomes relatively closer than setting quotas to what would be selected once uncertainty is resolved. Freebairn (2009) argues, to the contrary, that it is 'Taking a longer run and time consistency perspective it is not obvious whether the MAC will be more or less elastic than the MEC' so that it is impossible to asssess on the basis of the Weitzman analysis whether price vor quantity instruments will minimise efficiency losses.

Some claim that a randomly varying and highly uncertain carbon price makes it difficult for those seeking to commit to long-lived and irreversible capital investment decisions. It might also promote increased short-term volatility in energy prices creating the potential for poor decisions and suggesting a case for a fixed carbon tax. This claim can be overstated since, provided markets are reasonably efficient, there are opportunities to hedge carbon price uncertainty in futures markets. Moreover, the viability of long-lived investment projects depends on long-term carbon price trends not short-term fluctuations. In addition, if the price variability reflects the health of the macro-

economy, with carbon prices being lower in recessions and higher in booms, then such variability has the desirable feature of acting as an automatic economic stabilizer with charges rising in boom periods and – as has happened during recent European experience - falling back during recessions.

In addition it can be reasionably argued that, since social damages are related to the stock of emissions rather than rates of flow, that variability in flows imposes low social costs (Freebairn, 2009).

Protection against very sharp carbon price hikes following unexpected surges in fuel demands, for example those that might occur as a consequence of a cold northern hemisphere winter, can be addressed using dual tax-cum-emission trading schemes. Here an ETS operates under normal conditions but a price-ceiling is set for emission permits with a government agency being prepared to stand in the market to deliver unlimited emission quotas at the ceiling price.

Hybrid ETS-tax schemes can incorporate price floors as well as 'safety-valve' price ceilings (McKibbin et al. 2002, 2009; Wood and Jotzo, 2010). These floors help provide certainty to investors in low-carbon technologies and thereby offset some of the credibility issues that may impact on such investments. Price floors provide insurance against low prices for such investors. An alternative to this is to set lower emissions targets or for the government to buy back quotas at the floor price. This latter suggestion might impose unlimited liabilities on a government if quotas were internationally traded. Wood and Jotzo (2010) suggest a dual tax-cum-ETS scheme where carbon is subject to an extra tax on carbon emitted even when a quota has been purchased.

A crucial difficulty with these types of suggestions is that the existence of very low carbon prices in an ETS market suggests, given it is known that carbon emissions are very socially costly, that quotas have been set too liberally. The first-best response is to tighten the excessive quotas.

Another claim is that setting carbon taxes offers lower potential for special interest groups in market economies to make claims for special treatment in terms of free or generous quota allocations under an ETS that would not occur with a tax. This seems unproven since the same interest groups can equally well argue for tax exemptions. Generous free quota allocations transfer benefits between firms and other firms and from consumers to firms. They undermine the potential for the scheme to be revenue neutral by offering compensations, but it is not clear that similar costly defects will arise from selective tax exemptions.

There is also a fear, induced by evidence of ethical misbehavior in financial markets during the recent global financial crisis, that futures markets in carbon prices might be subject to manipulation via insider trading by those employed in the power generation sector. Taxes are also seen as a more

flexible policy instrument that is less vulnerable to evasion and corruption. These are policy design issues and call for specific regulatory side-measures.

An argument sometimes advanced for an ETS rather than carbon taxes is that carbon quotas sold have value as assets in the hands of their owners. These owners would defend such a scheme in order to preserve such value thereby improving the longer-term credibility of an emissions control scheme. This seems unproven since governments have shown themselves in the past to be reluctant to abandon lucrative tax bases such as fuel excises.

The case for targeting emission levels via an ETS is mainly that it assures a certain level of emissions control. This is of concern in an international setting where countries agree to target a certain emissions cut as part of a comprehensive agreement. Climate scientists know the level of global cuts necessary to offer high confidence of achieving certain desired climate targets. For example, the widely-advocated target of restricting warming to $2^{o}C$ means that a global climate agreement must provide an arithmetic framework for achieving such reductions by aggregating agreed-on cuts by individual nations.

In an integrated world economy there are distinctive arguments for an ETS rather than a carbon tax alternative:

(i) **An ETS assists in the achievement of global distributional fairness**. With an ETS there is the important advantage of being able to allocate carbon emission quotas internationally to reflect the different development needs of nations while retaining efficiency in emissions reduction (Clarke, 2010c). A major concern of developing and emerging countries is that they currently have low levels of energy consumption per capita compared to developed countries. A claim by countries, such as China and India, is that, although they agree to substantially reduce their energy intensities (their energy use per dollar of output), they should be entitled to increase their aggregate emissions to a point where their per capita emissions and energy consumption levels are comparable with those of developed countries. As noted by Garnaut (garnaut, 2008, p. 196) this objective is consistent with an ETS provided large emission quotas are assigned to developing countries for a transitional period while their energy consumption 'catches up' to developed countries levels. An ETS provides a mechanisnm for inducing cooperation in an international agreement to cut emissions.

Differential carbon taxes can achieve distributional fairness but only at the expense of efficiency since, with such tax differentials, prices will differ and there will be deadweight losses.

Because emission quotas are valuable assets use of quotas as a redistributive tool is essentially a resource transfer from developed to developing countries. Substitutes for such a resource transfer

could, alternatively, be income transfers or low cost access to new low carbon intensity production technologies from developed countries.

The desired size of the transfers here is bounded by the requirement that all countries should enjoy welfare gains from jointly mitigating emissions after paying or receiving transfers. This rejects the approach of Bhagwati (2010) and others who claim that compensations must be paid to developing countries on the grounds that the cumulative emissions of the developed countries are large and now it is the turn of the developing countries to enjoy the same entitlement. This argument is factually questionable. When changes in land use are also taken into account, the developing regions of the world have actually been responsible for some 45 per cent of total carbon dioxide emissions since 1850 (Houghton, 2008). Moreover, even was this not so, past emissions imply no culpability when the potential for damages was not even recognized when the emissions occurred. In addition, most of the polluters who caused these damages are now deceased. The issue is not compensation for past misdeeds but the need to devise a comprehensive, collective, international agreement where all participants gain.

(ii) **Traded international carbon quotas can drive cost efficiency.** If quotas are internationally tradable then developing countries have incentives to rely on low carbon technologies and to sell unused quotas in international markets. This can yield further efficiency gains. With enough trade in such quotas their price will be driven to equality internationally suggesting that emissions reductions will be occurring in areas where they can be achieved at lowest cost. Such trade has been estimated to reduce the costs of emissions reductions by 20 per cent (Tony Blair and Associates, 2009). Emissions reductions would then be achieved with greater global economic efficiency.

A carbon tax can be set differently in different countries to accommodate distinct national circumstances but, if this is done, global emissions reductions efforts are necessarily inefficient since different carbon prices will prevail in different countries. That carbon emissions are being valued differently in different countries implies foregone opportunities to trade and hence economic inefficiency. Nordhaus (2006) proposes harmonized taxes across countries with initial exemption periods for poor countries, with complete exemptions for very low income countries and with compensatory income or technology transfers from wealthy to poor countries. However this proposal offers no mechanism determining the requisite scale of the transfers. Harmonised taxes can be set but then the transfers must be computed indirectly in terms of economic impacts on relatively high though uniform taxes on poor countries.

Freebairn (2009) develops arguments suggesting that tax regimes have relatively favourable implications over quotas in the *long-run*. But longer-term there is little to choose between the alternative approaches given that each will need to be tweaked to reflect new knowledge and changed economic status. That quota can be designed to achieve *global distributive justice* and that international trade in quotas can reduce the costs of global emissions control are decisive advantages.

The advantages of international trade in carbon emission quotas to reduce the global costs of emissions reduction have been questioned. An *additionality* requirement for such trade to improve efficiency is that when a quota is purchased a corresponding emissions reduction must occur on the part of the vendor and that this reduction would not have occurred in the absence of an ETS.

The issue of verification of emissions reductions proved to be a stumbling block in the recent Copenhagen negotiations. In particular, neither China nor India agreed with the United States on verification procedures. The notion that emissions reductions are not reductions that would have occurred without free trade and an ETS is a well-recognized difficulty of the Kyoto Protocol-approved *Clean Development Mechanism*.

5. Conclusions and final remarks. Carbon taxes are Pigovian taxes which seek to address the global costs associated with carbon emissions. They have significant effects on markets for goods which utilize carbon-intensive inputs and on markets for these inputs themselves as well as for substitute and complement inputs.

The choice of a carbon tax base is of importance in an open economy where carbon leakages can arise. Leakages associated with loss of competitiveness of a mitigating country's exports and its import-replacement sectors as a consequence of carbon taxes can be offset by using a consumption or destination basis for taxing, by exempting exports from taxation and by imposing border tax adjustments on untaxed imports. This also reduces the incentive of firms to relocate to pollution havens compared to the case where origin accounting is used. A difficulty with using a consumption basis is that, by reducing mitigating country demands for carbon-intensive outputs, it reduces their price thereby inducing general macroeconomic carbon leakages in non-mitigating countries.

The case for using a carbon tax is often contemplated with an ETS alternative in mind. There are various arguments for each policy approach but an advantage of an ETS over a carbon tax is that it facilitates the compensations that developing countries require to be equitably dealt with in a global climate agreement while still promoting economic efficiency. A further advantage of an ETS is that it permits the resolution of the arithmetical task of specifying individual national targets to hit desired

aggregate global emission targets. If carbon quotas are internationally tradeable the global costs of mitigating emissions are reduced. A difficulty of trading global carbon quotas lies in verifying the *bona fides* of actual deals. Quota sales do need to reflect a genuine diversion of mitigation effort

To many the key issues of concern in the climate change debate are those of securing a workable global environmental agreement rather than specific concerns over design of a carbon tax or use of an alternative policy such as an ETS. There has been a neglect of such strategic issues in the preceding discussion. However there are important implications of carbon charging design for broader issues of negotiating such an agreement.

The strategic implications of appropriately selecting a carbon tax base seem to be particularly important. A key issue is the additional incentives a consumption-based tax offers *developed* countries to unilaterally mitigate emissions. In addition, an integrated international carbon emissions market offers cost savings which can be shared among all participants and also can be designed to protect the legitimate development objectives of emerging economies.

The analysis has considered the case for utilizing a carbon tax rather than an ETS. Various arguments for and against each approach have been considered.

As a parting remark it should be emphasized that the policy choice here between taxes and quotas is of second-order compared to the choice between doing something and doing nothing. The debate over choice of approach between an ETS and a carbon tax should not be used as an excuse to delay action. Indeed, even though market-based economic instruments are preferable to direct regulation incurring the efficiency losses of heavy-handed regulation and direct controls will yield better expected outcomes than not taking any action to address the climate change problem.

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