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Carbon Taxes vs Carbon Trading

Pros, cons and the case for a hybrid approach

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Contents[1]

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Carbon Taxes vs Carbon Trading: Pros, cons and the case for a hybrid approach

Executive summary

It is now widely recognised that preventing serious adverse consequences from future climate change requires the current upward trend in global greenhouse gas (GHG) emissions, primarily carbon dioxide (CO_2) which we focus on in this paper[2], to be constrained and ultimately reversed. Inter-governmental negotiations are ongoing to agree by the end of 2009 a post-Kyoto deal for addressing this problem. In this paper, we assume that such a global deal is put in place that:

- Agrees binding quantitative targets for significant long-term emission reductions in the major developed economies with broadly equitable 'burden-sharing' between the largest economies in this group, most importantly the US and the EU[3].

- Agrees appropriate mechanisms for China, India, Brazil and other large emerging economies to play their part in addressing the global climate change problem, even if this does not involve binding quantitative limits on emissions (at least in the medium term).

Conditional upon this general assumption that some kind of broadly equitable global deal is agreed, this paper assesses the pros and cons of the two main options for putting an international price on CO_2 emissions: carbon taxes and carbon trading. It also considers the case for a hybrid approach. Our focus here is on the solution for the major developed economies, most particularly the US (or perhaps North America more generally) and the EU. We also consider the (largely separate) issue of whether such schemes should be applied at an upstream or downstream point in the fossil fuel supply chain. First, however, we look briefly at a third policy option: direct regulation.

Direct regulation versus market-based solutions

Direct regulation has its place in circumstances where price incentives may be ineffective in changing consumer behaviour due to myopia and inertia. This may be particularly true in areas like encouraging energy efficiency in vehicles and buildings where setting compulsory minimum standards may be the only way to guarantee adequate change.

More generally, however, direct regulation suffers from the drawback that it puts limits on all sources of emissions, regardless of the cost of abatement. As such, there is general agreement amongst expert commentators that the most cost-effective solution (particularly where the aim is to influence companies that are less likely than households to be myopic or inert in response to price signals) is to put a global price on GHG emissions through market-based policy instruments such as carbon taxes and emissions trading schemes (ETS). This should encourage development of low carbon technologies and enable the world to achieve global emission reductions without undue cost to the wider economy.

[2] Some other greenhouse gases with a relatively manageable number of large, monitorable emitters could also be amenable to the tax or trading approaches that we focus upon in this paper, although others (e.g. methane emissions from ruminants) may not be. But, to avoid overcomplicating what is meant to be primarily a paper about general principles, the discussion generally focuses on carbon emissions unless explicitly stated otherwise.

[3] We assume that other developed economies such as Japan, Canada, South Korea and Australia would also agree binding targets as part of this deal, but in quantitative terms the US and the EU are the two most important players among the developed economies and the ones we focus most attention on in this paper.

Carbon taxes versus carbon trading

Which of these two key market-based policy instruments, tax or trading, should have the primary role in practice is much less clear cut. It is worth noting here that the argument sometimes made that carbon trading is more of a market-based solution than carbon taxes is not correct. Both are mixed government-market solutions: with taxes the government sets the carbon price and the market sets the quantity of emissions; with trading the government sets the quantities of emissions and the market sets the prices. Neither is, *a priori,* preferable on such ideological lines[4]. Indeed, under conditions of certainty, the two approaches would in principle give exactly the same result.

In practice, of course, the uncertainties around both the future costs and the future benefits of CO_2 emission abatement are large. Some commentators have argued that, in these circumstances, neither option is ideal, but a tax may be relatively more attractive due to avoiding the high price volatility seen in many existing ETS schemes, as well as being administratively simpler given that it could make use of existing tax collecting mechanisms and authorities. A tax also raises revenues for governments, which is not the case with many existing ETS schemes, which offered free 'grandfathered' allowances, at least in initial periods, so enabling some large GHG emitters to make significant windfall gains.

But a carbon trading scheme also has potential advantages. Most importantly, it may be easier to get international agreement on a globally-linked trading scheme than on a global carbon tax (or even political agreement on a national carbon tax in many countries such as the US). The trading option therefore tends to be favoured on political grounds, although it remains to be proven that this kind of international agreement on a cap-and-trade scheme can be achieved more easily than a comparable international tax treaty (or set of bilateral tax treaties between key countries/regions).

Some degree of carbon price flexibility within a trading scheme might also be desirable under conditions of uncertainty, so long as it is not excessive. Trading schemes involving auctions can also generate similar (albeit probably less predictable) revenues to taxes and the evolution of the EU ETS shows how a move to auctioning can be introduced gradually once the scheme is up and running. A similar evolution seems likely for any future US carbon trading scheme, although desirably at a somewhat faster rate than with the EU ETS, which was inevitably a learning process being the first such cross-country scheme of its kind.

Could a hybrid scheme be preferable?

Our analysis in this paper suggests, however, that the best practical solution may be a hybrid scheme in which emission allowances are traded internationally, but price volatility is constrained by a ceiling at which governments sell allowances in unlimited quantities and a price floor set by a reserve price in auctions of allowances (and subsequently offering to buy unlimited quantities of allowances at this price).

To raise revenues for governments to use to reduce other distortionary taxes and offset regressive effects of the scheme on poorer households, all or most allowances should eventually be auctioned in such a hybrid scheme, except during an initial introductory period when some grandfathering of allowances is likely to be required to avoid imposing unreasonable costs on incumbents. Banking of unused allowances for future use should also help to limit extreme price fluctuations, particularly before full auctioning is introduced. Indeed it is arguable that, with sufficient scope for banking, you might not need a price floor. The future evolution of the EU ETS carbon price will provide a useful real world test of this view: EU carbon prices have fallen back to low levels since mid-2008 due in particular to the effects of the global recession in reducing energy consumption and so emissions, which some feel is undermining incentives to invest in carbon emission abatement.

As illustrated in the diagram below, this hybrid scheme could be introduced with the price band initially set relatively low and then increasing gradually over time to ramp up the incentive to develop and implement low carbon technologies. If some countries preferred a carbon tax, they could do so

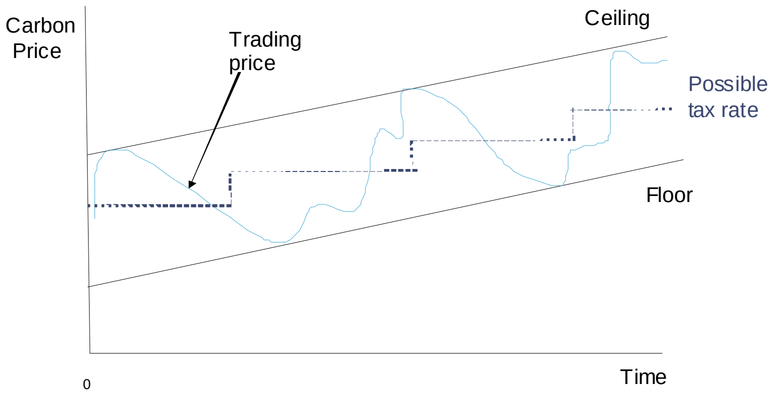
[4] This applies irrespectively of whether your ideology favours market or government solutions.

subject to this being set at levels within this upwardly moving trading price band (see dotted line in diagram). Starting with a low carbon tax rate to 'test the water' on how this affects emissions, with a view to either raising this rate later or perhaps using it as a floor price for a carbon trading scheme, might be an option worth considering for countries that favour a carbon tax initially (although it is not an option for the EU where a trading scheme already exists).

The main potential drawback of such a scheme would be a need for international agreement on the price floors and ceilings (and that carbon tax levels should also fall within these bands) and how these price bands would evolve over time. The US, for example, may favour a scheme with a relatively low price ceiling, while the EU may favour a relatively high floor price, so leaving an undesirably narrow trading band in between. Without agreement across countries on price floors and ceilings (including how countries co-ordinate to buy up excess allowances at such a floor or sell them at the ceiling), however, arbitrage could undermine schemes in some countries or leave them cut off from the rest of the world if they attempt to prevent such arbitrage.

On the other hand, there would always be scope to adjust price limits over time if the width of the band was initially set at what was later agreed to be too narrow a level. Furthermore, international agreement on the 'rules of the game' would be required for any approach based either on inter-linked trading schemes or on some form of broadly comparable international carbon tax regime. So the need for difficult negotiations is by no means unique to a hybrid scheme even if the latter does add some additional parameters on which such agreement is required. For the US, which is starting from scratch at the federal level, there appears to be no obvious practical problem in implementing a hybrid scheme. For the EU, it would just require a relatively small change to the planned rules for the regime to operate from 2013 onwards (even if this was feasible, it would not seem desirable to change the Phase II regime up to 2012, given the need to provide as much regulatory certainty as possible to investors in low carbon technologies).

Carbon prices in a hybrid scheme



This kind of hybrid scheme potentially allows better handling of uncertainty as it prevents extreme price spikes and crashes while minimising the social losses created by errors in predicting trends in abatement technologies and levels of environmental and economic damage from increased carbon emissions. In so doing, it would provide the right balance of flexibility and predictability to maximise the incentives for investors in low carbon technologies (and other forms of abatement).

Upstream versus downstream schemes

Irrespective of whether tax, trading or a hybrid of the kind described above is adopted, a secondary issue arises as to whether the preferred option should be applied upstream or downstream along the fossil fuel supply chain.

For countries such as the US (at federal level) and other developed economies without an established method of setting a carbon price, the preferred type of scheme, whether tax or trading, could be applied upstream to all supplies of oil, natural gas and coal in the economy (including imports). This would make a market-based policy easier to implement because of the reduced number of participants, although some credits would be needed to encourage downstream initiatives like carbon capture and storage (CCS) within such a scheme. However, this would fit less well with the EU ETS and other existing schemes that trade allowances for emissions at a downstream level. It is important that the US and other countries take this into account in designing their schemes, because without a broad measure of international consistency, the benefits of such policies at global level would be significantly reduced. It may be, for example, that the US could initially introduce a downstream scheme for major emitters such as power plants and large industrial plants on similar lines to the EU ETS, with an upstream carbon tax or hybrid trading scheme then being introduced for other sectors of the economy.

Within the EU, the existing ETS appears likely to remain a centrepiece of policy for some years to come (i.e. at least until 2020) and it would be very damaging to low carbon investment incentives to make more than very minor changes[5] to this scheme before 2020 at the earliest. But there may be a case for considering alternative upstream approaches for European industry sectors not already covered by the EU ETS, such as road transport fuels (and perhaps even to rethink plans for the aviation sector along these lines). Here, however, there would also be a need to consider interactions with existing road fuel tax regimes, as well as with alternative future policies such as road pricing, in order to avoid politically unsustainable double taxation of the motorist.

Conclusions

There are many detailed points to be considered before adopting the kind of a hybrid scheme described above, most particularly in terms of establishing effective inter-linkages between national/regional trading schemes (and achieving a degree of harmonisation with countries preferring the carbon tax route). The feasibility of moving the EU ETS in this direction without undue disruption to investment decisions on low carbon technologies also needs further consideration.

Nonetheless, our analysis suggests that a hybrid scheme applied across the EU, the US and other major developed economies could provide a reasonable combination of economic cost-effectiveness, administration practicality and political viability. We therefore believe it merits serious consideration as one of the options for putting a price on carbon/GHG emissions. In the longer term, such a scheme could also be rolled out to China, India, Brazil and other major emerging economies.

If adopted, this kind of hybrid scheme could be supplemented as required through other policy instruments such as direct regulation to encourage energy efficiency in areas where price incentives are likely to be ineffective due to consumer myopia and inertia, and through support for basic scientific research and early stage development of low carbon technologies such as renewable energy and carbon capture and storage. This latter technology-driven approach is likely to be an important part of any package that will be acceptable to the US, which will also seek to focus on solutions that can be seen both as combating climate change and as promoting energy security. By encouraging energy efficiency and diversification away from dependence on imported fossil fuels, a hybrid trading scheme could meet these criteria, with the price ceiling avoiding undue costs to US business in the process.

[5] As noted above, price ceilings and floors might be added to the intended design of the EU ETS from 2013 onwards to reduce market volatility, supported by existing procedures to allow banking of unused allowances and plans already announced for increased auctioning. But anything more radical than this kind of incremental change should be avoided.

1 Introduction

"Climate Change is the greatest market failure the world has ever seen".

-The Stern Review: The Economics of Climate Change (2006)

The 'tragedy of the commons' is a conflict over finite resources between private interests and the common good. It arises because there are no property rights for these resources, so creating conflicts of interest. The earth's atmosphere can be seen as a global commons. There has been no incentive for private individuals or organisations to limit their pollution of the atmosphere since there has been no market price put on this pollution.

In this general context, it is now widely recognised[6] that preventing serious adverse consequences from future climate change requires the current upward trend in global greenhouse gas (GHG) emissions, primarily carbon dioxide (CO_2) which we focus on in this paper[7], to be constrained and ultimately reversed. Inter-governmental negotiations are ongoing to agree by the end of 2009 a post-Kyoto deal for addressing this problem. In this paper, we assume that such a global deal is put in place that:

- Agrees binding quantitative targets for significant long-term emission reductions in the major developed economies with broadly equitable 'burden-sharing' between the largest economies in this group, most importantly the US and the EU[8].

- Agrees appropriate mechanisms for China, India, Brazil and other large emerging economies to play their part in addressing the global climate change problem, even if this does not involve binding quantitative limits on emissions (at least in the medium term).

Conditional upon this general assumption that some kind of broadly equitable global deal is agreed, this paper assesses the pros and cons of the two main options for putting an international price on CO_2 emissions: carbon taxes and carbon trading. It also considers the case for a hybrid approach. Our focus here is on the solution for the major developed economies, most particularly the US (or perhaps North America more generally) and the EU. We also consider the (largely separate) issue of whether such schemes should be applied at an upstream or downstream point in the fossil fuel supply chain. First, however, we look briefly at a third policy option: direct regulation of emissions through 'command-and-control' schemes.

The structure of the paper is therefore as follows:

- Section 2 looks at the potential advantages of market-based policies relative to command-and-control regimes;

- Section 3 looks at how emissions trading schemes can be designed to reduce carbon emissions;

- Section 4 discusses the merits of carbon taxes;

- Section 5 looks further at the relative merits of both instruments;

[6] As documented in the latest round of IPCC reports published during 2007 and in the agreement by all the leading world governments at the Bali conference in December 2007 to a roadmap for reaching an international deal to be pursued over the following two years, culminating it is hoped in a global post-Kyoto deal by the Copenhagen conference in 2009.

[7] Some other greenhouse gases with a relatively manageable number of large, monitorable emitters could also be amenable to the tax or trading approaches that we focus upon in this paper, although others (e.g. methane emissions from ruminants) may not be. But, to avoid overcomplicating what is meant to be primarily a paper about general principles, the discussion generally focuses on carbon dioxide emissions unless explicitly stated otherwise.

[8] We assume that other developed economies such as Japan, Canada, South Korea and Australia would also agree binding targets as part of this deal, but in quantitative terms the US and the EU are the two most important players among the developed economies and the ones we focus most attention on in this paper.

- Section 6 considers the attractions of a hybrid scheme;
- Section 7 considers whether, independent of which type of scheme is preferred, this should be applied at upstream or downstream level in the fossil fuel supply chain; and
- Section 8 summarises the key conclusions from the analysis.

More technical supporting analysis is included in an Annex, which is followed by a list of references to other studies quoted in the paper.

2 Command and Control vs Market-based Instruments

Command and control (CAC) policies (or 'direct regulation') set a uniform standard across an industry that each firm must meet, so that the industry in total meets an overall cap on emissions. The problem with this approach, however, is that each firm must limit its emissions to a uniform level rather than most of the abatement being undertaken by those firms that can do it most cost effectively. Hence, the inflexibility of the regime makes it unduly costly.

Market-based policies avoid this problem and, at least in theory, allow emissions reductions to be achieved at least cost because they allow firms to respond optimally to a price signal. If it is cheaper for a firm to reduce emissions than pay a tax or a allowance fee, then a firm will cut emissions. Conversely, if paying the price of emitting is cheaper than making use of the cheapest form of abatement to the firm, then it will continue to produce a given volume of emissions and will pay the price to have the right to do so.

Although market-based policies are more efficient than command and control policies in principle, they could not initially be developed because the technology was not available to monitor emissions. The development of this technology has allowed increasing use of these policies. The lead-in-gasoline program implemented in the US in the 1980s was one of the world's first emissions trading environmental policies, which aimed to remove lead from petrol. Stavins (2003) estimates that cost savings of $250m a year were made compared to the alternative of command and control regulation. The Acid Rain Program was implemented in 1995 to reduce the sulphur dioxide emissions of the US electricity generating sector. Carlson et al (2000) estimate that cost savings of $1 billion a year were made compared to a CAC regime, while emissions of sulphur dioxide from the US electricity generation sector fell from 15.7 million tons in 1990 to 10.2 million tonnes in 2005 (EPA, 2005).

A caveat to the efficiency of these policies is that the arguments above assume, as is standard in economic theory, that all participants are rational profit-maximisers. This may be a reasonable simplifying assumption for businesses, but if these instruments were applied to individuals then the expected outcome may not emerge due to myopia (short sighted views about the cost effectiveness of reducing emissions) or inertia. In this case, a CAC regime forcing individuals to reduce emissions (e.g. by setting standards for energy-efficiency of home appliances) may have a better outcome by obliging them to take action rather than relying on them responding optimally to price signals.

If, however, the problem is not myopia or inertia but rather just that households (or businesses) are not well-informed about the potential benefits of, say, energy efficiency programmes, then a market-based instrument plus an informational campaign may be the best approach to adopt.

3 The Theory and Practice of 'Cap and Trade' Emissions Trading Schemes

3.1 Design

An emissions trading scheme (ETS) attempts to put a price on the emissions of a targeted gas, so as to make firms internalise environmental resources in their business decisions. A cap is set for aggregate emissions in the system. Allowances are then issued (either for free based on past emissions, which is known as 'grandfathering', and/or through auctioning) that allow their holders to emit a certain quantity of the targeted gas. The sum of all allowances issued is equal to the overall cap. Firms are then allowed to trade these allowances. If it is cheaper to reduce emissions than buy an allowance, then a firm will become a net seller; conversely, if it is cheaper for a firm to buy allowances than reduce its emissions, then it becomes a net buyer. Trading occurs until all gains from trade have been exploited and the price of an allowance is equal to the (marginal) cost of cutting emissions. The cap sets the environmental effectiveness of the ETS while market forces guarantee allocative efficiency (WWF, 2005).

The control of carbon dioxide should lend itself to an ETS because it is a stock pollutant; it does not have spatial or temporal considerations due to it being a uniform externality (Ellerman, 2005). This is unlike the emissions of sulphur dioxide, which have larger negative implications if their emissions in one particular area are increased, causing 'hot spots'. The impact of carbon emissions therefore does not depend upon emissions in a single year, but rather the accumulated stock over a long time horizon (Newell & Pizer, 2003).

As set out by Butzengeiger, Betz and Bode (2001), there are two main conditions that must hold in order for an ETS to be feasible. The first is that participants must be sufficiently varied for there to be potential gains from trading allowances. If instead all firms were the same, then they would all face the same abatement costs and so they would all be either net buyers or net sellers. Hence no trade would occur. In practice, however, this should not normally be a problem.

Secondly, there should be a sufficient number of polluters included in the scheme in order to ensure a reasonably liquid market. This increases the amount of trades that occur, hence allowing a clear price signal to emerge. In turn, this reduces the uncertainty that participants face when making long term investment decisions because the expected gains from investing to abate are much clearer. Furthermore, the risk of any one participant holding extensive market power, which would restrict trading, is reduced (Boemare and Quirion, 2002).

3.2 Allocation of allowances: grandfathering vs auctioning

How to allocate the initial endowment of allowances has generally been the most controversial aspect of emissions trading schemes in practice (e.g. Ellerman, Joskow and Harrison, 2003). Theoretically, auctioning is preferable to grandfathering, which allocates allowances for free based on historical emissions data. In practice, however, grandfathering has often been the allocation method of choice, particularly when schemes are first set up. The amount of allowances allocated is crucial for the credibility of the ETS as stringent caps are needed to create scarcity (Neuhoff et al., 2006).

Auctioning has many desirable properties. The first is that it sends out a price signal for allowances, which promotes price transparency (Neuhoff et al., 2006). This increases information and certainty within a scheme, and hence facilitates long term investment decisions on whether to abate or purchase allowances. Secondly, revenue is raised for the policy maker in the form of scarcity rent which can be used to cut distortionary taxation in an economy (e.g. Fullerton & Metcalf, 2001, Grubb 2006) or to fund research and development into green technology. Furthermore, as noted for example by Ellerman, Buchner and Carraro (2006), cutting distortionary taxation on capital and labour in Europe appears particularly desirable because of the persistence of relatively high unemployment within the EU. Finally, auctioning reduces distortions within an ETS as it allows new entrants to be treated the same way as incumbents i.e. all participants must buy their allocation of allowances.

3.3 Banking and borrowing

One period trading of allowances allows participants to find the least cost form of abatement at a given point in time. A key feature of an optimal ETS in theory, however, is the inclusion of banking and borrowing[9], which allow firms to find the least cost compliance method over time (Burtraw, 1998). In a world of perfect certainty, an ETS and a tax on a targeted emission are equivalent, but they diverge in practice due to uncertainty (see Section 5 below and the Annex for more detailed discussion of this point). A tax gives a stable price, but an ETS is more certain of achieving its environmental goal due the cap it imposes on emissions.

Banking and borrowing allow an ETS to display both of these properties because they act to stabilise the price of an allowance. If the price begins to rise, then borrowing for future allowances increases supply to prevent a price spike. Likewise, if the price falls then firms can bank allowances to use in the future. This reduces supply and creates a price rise. These attributes therefore reduce price volatility by converting uncertainty in demand into fluctuations in quantities, rather than prices, so allowing the imposition of a fixed cap in the presence of uncertainty (Ellerman, Joskow and Harrison, 2003).

While some form of banking and borrowing is therefore desirable in principle, however, you would not want this to be unlimited. This is because, if unlimited banking of unused allowances was permitted in the current period, this might lead to a loss of momentum in abatement efforts in future periods as companies take the easy option of using up banked allowances rather than making serious efforts at further abatement. Conversely, allowing too much borrowing might lead to abatement efforts being forever put off into the future, which is clearly not desirable. Some banking and borrowing should therefore be permitted, but fine judgements are required on what limits should be imposed on this in practice. These limits will, however, in turn restrict to some degree the extent to which price instability in an ETS can be smoothed out through banking and borrowing. There are, however, other options here involving setting price ceilings and floors in a hybrid scheme, as discussed in Section 6 below.

3.4 Credibility

The credibility of the system is also of the utmost importance in order to ensure that expectations are in line with desirable policy outcomes. Firstly, the time horizon of the policy must be long enough to allow long term investment decisions to come to fruition. If this is not the case, then insufficient investment in abatement will occur (Stavins, 2007). This does, of course, raise difficulties in practice since it requires successive governments to stick to the policies of their predecessors. This is particularly problematic for climate change where a global approach is required, with policy shifts by a future government in any of the major economies potentially causing the whole international agreement to unwind. This is a particular risk at the point where new treaties need to be negotiated, although there is also the possibility, of course, that the global policy consensus could move in a direction more favourable to tackling climate change at these key renegotiation points.

Secondly, the must be strict and accurate monitoring of emissions in order to preserve the environmental integrity of the ETS and send a credible signal to participants that the emissions constraints are binding. Finally, penalties for emitting more than the allowances held must be sufficiently high to be material for the participants and related to average market prices to discourage non-compliance (Butzengeiger, Betz and Bode, 2001).

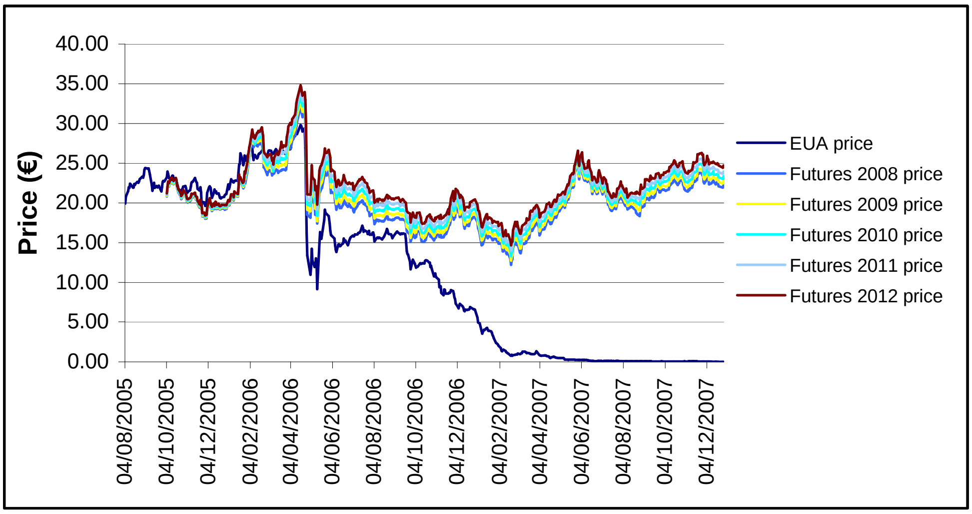
3.5 Trading in practice: the EU ETS

The EU ETS is the first international scheme that uses allowance trading to control the output of carbon dioxide. It came into force at the beginning of 2005 and was originally split into two trading phases: the first ending in 2007 and the second extending from 2008 to 2012. Originally a relatively stable price emerged for carbon allowances. However, as Figure 1 below illustrates, the price

[9] As discussed in Section 6 below, price floors and ceilings with a hybrid ETS scheme might avoid the need for banking and borrowing, although the latter might still be allowed to some degree to smooth prices within the price band in a hybrid scheme.

crashed in April 2006 as it became apparent that there had been an over-allocation of allowances in the system. Allocation of allowances was decided by the member states of the EU. This gave an incentive to the member states to over-allocate allowances in order to protect their national economic interests, of which France, Germany and Italy were particularly guilty[10]. With no ability to bank allowances into the second phase, the price of a Phase I allowance trended towards zero during 2007 as the 'use-by' date made them virtually worthless towards the end of Phase I (see chart below).

Figure 1: EU Allowance (EUA) and Futures Price Trends during ETS Phase I



The futures prices of Phase II allowances remained steadier during 2007 and rose to a peak of just under €30 per tonne of CO2 in July 2008. Thereafter, however, carbon prices fell sharply, standing at only around €10 per tonne of CO2 in early February 2009. This sharp decline mirrors trends in the price of oil and other commodities since mid-2008, reflecting the impact of the global recession in reducing energy consumption and so carbon emissions. Phase II allowances are therefore in less short supply than previously expected and are therefore less valuable, despite some banking of allowances being allowed in Phase II. There may also have been some unwinding of earlier speculative activity that pushed carbon prices up to their mid-2008 peak levels.

The European Commission has already announced plans for Phase III, which attempts to address some of the issues that arose in the trial period. Amongst the plans are: a centralisation of the way that allowances are allocated; an auctioning of 60% of the total allowances initially, which will increase from 2014 onwards; an end to grandfathering of allowances to the power generation sector; increased coverage of emissions sources and gases totalling half of the EU's total greenhouse gas emissions; and the allowance of banking Phase II allowances into Phase III. The overall target is for EU emissions to be cut to 20% below 1990 levels by 2020 (equivalent to around 21% below 2005 levels, which illustrates the lack of progress between 1990 and 2005 in reducing EU emissions). Figure 2 summarises some of the key features of the three phases of the EU ETS.

[10] The Economist, 18th November, 2006.

Figure 2: Architecture of the EU ETS

Phase I (2005)

CO_2 targeted only

No auctioning

40% of the EU's greenhouse gas emissions covered

National Allocation Plans used to allocate allowances

Banking in but not between phases

Phase II (2008)

CO_2 targeted only

Up to 10% auctioning

40% of the EU's greenhouse gas emissions covered

National Allocation Plans used to allocate allowances

Banking between phases

Phase III (2013)

CO_2, nitrous oxide and perfluorocarbons targeted

60% auctioning, increasing from 2014

50% of the EU's greenhouse gas emissions covered

EU-wide Allocation Plans from Brussels used to allocate allowances

Banking between phases

The ETS should be much improved by Phase III as an effective tool to reduce carbon emissions, but some important issues remain. In particular, partial coverage of the EU ETS creates a potential need either to extend the scheme or to introduce other policies to reduce carbon dioxide emissions of activities not included by the scheme.

The most important such area in terms of the scale of emissions is road transport, which is not within the EU ETS but could be addressed through some combination of a carbon tax, road pricing and/or regulation to require that all new vehicles must emit no more than a given amount of carbon dioxide. However, the latter policy would give perverse incentives as it would increase the cost of purchasing a new vehicle. Therefore, older vehicles would become economically more viable to drive, and hence the higher emitting sources would remain in use for longer in preference to new cars. This suggest that market-based mechanisms may be preferable for transport, whether through a carbon tax or an upstream ETS that, as described below, could be expanded to cover transport emissions at an earlier stage in the supply chain (e.g. at oil refineries). But this would need to be properly integrated both with existing fuel duties[11] and with other potential future initiatives such as road pricing in order to avoid politically unsustainable double taxation of the motorist.

[11] Since existing fuel duties were introduced long before awareness of carbon emissions as a serious problem, they are most naturally interpreted as being aimed at other objectives (simple revenue raising, congestion reduction, noise and other air pollutant reduction etc). As such, some additional carbon tax might be justified in response to the negative externality of carbon emissions. More governments may have begun to use carbon reductions as a (more or less plausible) rationale for fuel taxation (or other motor taxes such as vehicle excise duty in the UK), so this picture has become rather less clear-cut. Some pragmatic judgements would therefore be needed as to what proportion of existing fuel taxes, if any, already represented an implicit carbon tax, so reducing the necessary level of additional explicit carbon tax.

4 The Theory and Practice of a Carbon Tax

4.1 The theory of carbon taxes

A carbon tax sets the price of a unit of CO_2 and allows the quantity of CO_2 emissions to fluctuate instead of the price. The advantage of this is that a clear fixed price signal is created, which adds certainty to investment decisions. The disadvantage is that total emissions are not capped, so creating environmental uncertainty.

The difference between a carbon tax and general taxation is that the former is a tax on a 'bad' rather than a 'good' (such as labour or entrepreneurship) and hence should not have the adverse distortionary effects that are typically associated with other taxes. On the contrary, a carbon tax aims to reduce the marginal benefit that a firm receives from polluting so that firms will freely choose to emit the socially optimal amount of carbon dioxide.

A carbon tax regime may be less exposed than an ETS to the influence of market power, since in a trading scheme with few participants there could be more potential for one firm to withhold allowances and attempt to manipulate the market. In practice, however, this should not be such a problem if emitters of all types trade with each other, as opposed to having separate types of allowances for different industry sectors, some of which (e.g. electricity generation) may be highly concentrated.

4.2 Scandinavian carbon taxes

Carbon taxes have been implemented since the early 1990s in some Scandinavian countries. For example, such a carbon tax in Norway is estimated to have reduced carbon dioxide emissions by 2.3% between 1990 and 1999, but this reduction could have been larger if it wasn't for exemptions granted from the tax (Bruvoll and Larsen 2002). The Norwegian economy grew by 23% over the same period, but carbon emissions grew by only 4%, which is interpreted by the authors as evidence that growth of the economy and carbon emissions were decoupled.

However, the Norwegian carbon tax did have its problems. Firstly, all fuels were levied with the same charge despite the different carbon content of these fuels. Secondly, many firms were excluded from the tax. Finally, carbon taxes differ in structure across Scandinavia, raising possible competitiveness effects. A patchwork approach to emissions reductions may lead to schemes in different countries undermining each other due to exclusion of different industries and other inconsistencies. These differences have not as yet been able to be reconciled within Scandinavia and this kind of consistency problem would only increase if you tried to apply this approach on a broader international scale (Ekins and Barker, 2001).

5 Taxes vs Trading

Whether to use a carbon tax or an ETS as the primary weapon to address global warming is a question that divides expert opinion. The arguments for and against each instrument are set out more systematically below, with additional supporting information in the Annex (although some of the key arguments have already been mentioned in the discussion above). One argument to dispose of up front, however, is that carbon trading is more of a market-based solution than carbon taxes. In fact, both are mixed government-market solutions: with taxes the government sets the carbon price and the market sets the quantity of emissions; with trading the government sets the quantities of emissions and the market sets the prices. Neither is, *a priori,* preferable on such ideological lines[12].

Instead the two options need to be assessed on their respective merits in relation to factors such as, in particular:

- ability to deal with **uncertainty** about technology (and so the costs of abatement) and the environmental and economic benefits of abatement;
- avoidance of undue **carbon price volatility**, which might weaken low carbon investment incentives;
- **revenue-raising** capabilities for government (including predictability of revenues as well as their expected levels);
- **simplicity** and, related to this, administrative and set-up costs; and
- **political acceptability**, both nationally and internationally.

We review these five factors in turn below.

5.1 Uncertainty

In a world of perfect certainty and perfect rationality, both an optimal ETS and a tax would have exactly the same outcome. However, the introduction of uncertainty creates a potential divergence between the two policies. Following the argument first set out by Weitzman (1974) and elaborated by Hepburn (2006), two types of uncertainty have implications for the outcome of each instrument; uncertainty about future technological developments affecting abatement costs and uncertainty about the environmental benefits of abatement (see Annex for a more technical analysis of these issues, which are discussed more intuitively below).

Uncertainty about future technological developments affecting abatement costs

Uncertainty about future technology equates to uncertainty over the costs to firms of investing in abatement. The policymaker must estimate these costs ‘ex ante’, but the actual costs will not be revealed until after the policy has been put in place. If these costs are not estimated accurately, then the policy (whether tax or trading) will not cause firms to emit at the most socially efficient point (i.e. where marginal benefits of abatement equal its marginal costs), so leading to social welfare losses.

Past experience, for example with the US SO2 (acid rain) trading scheme, tends to be that introducing market prices for pollutants may itself stimulate significant development of new low cost abatement ideas. These are difficult to foresee in advance, however, so leading to an initial overestimate of likely abatement costs. Within a trading scheme, this could lead to emission permit prices falling to lower than expected levels, given that the quantity of abatement would be fixed by the number of permits issued. With a tax, by contrast, it would lead to a greater quantity of abatement

[12] This applies irrespectively of whether your ideology favours market or government solutions.

being undertaken, which would be socially optimal if the tax accurately reflected the marginal benefits of abatement.

Uncertainty about environmental benefits of abatement

Uncertainty over the environmental benefits of abatement further complicates this picture. If variations in carbon emission levels have relatively minor implications for the expected environmental damage caused by climate change, which is likely to be the case in the short term, then a tax will tend to give a smaller social loss than an ETS because the divergence between the actual tax levied and the optimal tax will be small.

However, if the environmental problem displays threshold effects, so that pollution beyond a certain point will lead to catastrophic consequences, then it is the divergence of the actual aggregate pollution level over the period during which the policy is set from the optimal aggregate pollution level that becomes important, rather than the divergence of price. An ETS will cap emissions, so preventing a threshold from being crossed. A tax, however, would not set a limit to emissions and greenhouse gas concentrations and consequent global warming effects might cross the threshold at some point, causing a huge social loss.

In practice, there clearly are threshold effects from global warming, but the exact points at which these key thresholds are reached are subject to significant scientific uncertainties. Much depends on the time period for which the policy needs to be set: the longer this is, the better in terms of certainty for investors, but also the greater would be the chance that possible deviations in cumulative emissions from target in a tax-based scheme could have serious damaging environmental effects relative to an ETS scheme that fixes emission quantities. It is therefore not obvious, a priori, whether a tax or a trading scheme would be most socially efficient in practice. As discussed in Section 6 below (and in more technical terms in the Annex), this may point to the merits of a hybrid scheme. Before discussing this option, however, we review other possible pros and cons of carbon taxes and trading schemes.

5.2 Price Stability

The biggest argument in favour of a carbon tax (see, for example, the discussion in Nordhaus (2007) and CBO (2008)) is the potentially much greater price stability that this brings relative to an ETS. A tax therefore produces greater certainty about returns to abatement investment. Experiences with emissions trading schemes to date appear to add some weight to this argument, with the large price fall in April 2006 and the subsequent convergence towards zero of the Phase I allowance price in the EU ETS being a key case in point. Similar episodes of extreme price volatility have also been seen in earlier US SOx and NOx[13] emissions trading schemes relating to acid rain reduction (Stavins, 2007).

However, this argument is pitched against an ETS without banking and borrowing (or price floors and ceilings). As described in Section 3.3 above, the options of banking and borrowing allow firms to smooth emissions over time, which in turn smoothes the price of allowances and increases certainty and thus investment. On the other hand, although a carbon tax will never give less certainty over price than an ETS in the short term (bearing in mind also the point made above about needing to put some limits on banking and borrowing), tax regimes can easily be changed in the medium term, which can also introduce instability. This links to the political economy arguments considered further below.

[13] In particular, the NOx RECLAIM trading scheme in Los Angeles ran into serious problems in 2000-1 when prices spiked very dramatically, leading to the effective suspension of participation in the scheme by electricity generators. This was related to a wider crisis in the post-deregulation electricity market in California, however, and was exacerbated by the very limited banking and borrowing allowed in the NOx RECLAIM scheme. So one should not over-generalise from this experience, but it does nonetheless provide useful lessons on the need for some mechanism to deal with (or ideally mitigate in advance) periods of exceptional price volatility.

5.3 Revenue-raising capabilities

A carbon tax has obvious revenue-raising benefits as well as direct environmental impacts, and this is often used as an argument for taxes as the revenue can be used to cut distortionary taxation elsewhere in the economy, and/or be reinvested in zero/low carbon technology, and/or be used to offset the potential regressive effects of carbon taxes on poorer households for whom domestic energy bills may make up a relatively high proportion of their incomes[14]. However, this argument assumes that allowances are grandfathered in an ETS. As discussed above, the preferable solution (at least after the initial phase of a scheme during which some form of grandfathering is likely to be needed to avoid undue transitional losses to incumbents) is for allowances to be auctioned, potentially generating the same revenue as a tax.

However, as we saw with the auctioning of the 3G mobile telecommunications licences in different countries across Europe, the proceeds of auctions can be very difficult to predict, particularly initially, which may make a carbon ETS much less reliable as a revenue source for government than a carbon tax.

One should also note that revenues from either a carbon tax or an ETS allowance auction will be offset to some extent by reductions in other receipts (e.g. from corporation tax due to the knock-on effects on business costs and profits). Nonetheless, there should still be some net increase in government revenues, even if not as large as the gross receipts from the carbon tax or auction.

5.4 Simplicity and administration and compliance costs

A carbon tax will generally be simpler and cheaper to administer than a trading scheme because of the complex nature of an ETS. The tax instrument does not require the architecture to mimic a market and the administrative costs that are attached to this, nor does it require the set up and monitoring of banking and borrowing in order to achieve a stable price signal. Furthermore, a tax could be collected through the current tax infrastructure.

Compliance costs for companies will also generally be lower for a tax than an ETS scheme, since the former could be incorporated within the activities of a company's existing tax department, whereas dealing with a trading scheme may involve a whole new department. This potential compliance cost burden has been recognised in excluding smaller installations from the EU ETS for which this burden would be disproportionate, given that it is estimated that the largest 7% of installations account for around 60% of total emissions covered by the scheme.

Estimates of corporate compliance costs related to the EU ETS vary significantly, but research by the UK Emissions Trading Group (ETG)[15] based on a survey of its members suggests that these costs could be material, potentially totalling up to £68 million for UK companies participating in Phase 1 and over £100 million for Phase II over the respective lifetimes of these schemes. UK government estimates were much lower at less than £1 million for both phases combined, although these official estimates only covered direct administrative costs, not all possible compliance costs.

5.5 Political acceptability

Finally, and arguably most importantly in practical terms, an ETS currently appears more politically feasible than a carbon tax, particularly when considered at international level. This reflects the fact that a carbon tax is often seen by the public as a revenue raising instrument with potential environmental benefits. However, due to the cap that is imposed by an ETS, the emphasis of this instrument is very much on its environmental benefits and it only acts implicitly rather than explicitly as a tax. The failure to get pan-EU political agreement on a European carbon tax in the 1990s is

[14] This is less clear for petrol, where it may be middle income households who would be worst hit if a carbon tax was applied to petroleum products, over and above existing fuel taxes.

[15] N. Riddell, ETG Briefing Note on 'Administrative Cost of the Emissions Trading Scheme to Participants', A Working Group 5/6 Study, September 2008.

evidence of this, although this also reflects the particular voting arrangements within the EU, which require unanimity for tax measures but only qualified majority voting for an ETS.

Lobbying by key industries may also result in the exemption of some industries from a carbon tax, but this could also apply to the coverage of a trading scheme or the extent of grandfathered rather than auctioned allowances for particular sectors. Therefore, there is no clear advantage either way on this score.

Attitudes may, however, be changing towards a carbon tax despite its difficult history in Europe[16]. A recent survey by PricewaterhouseCoopers (2007) found that UK businesses view carbon taxes as environmentally more effective than an ETS, with 23% seeing a tax as ‘very effective’ compared to just 9% holding the same opinion about an ETS. Meanwhile British Columbia implemented a carbon tax from July 2008, while the states of Jersey have been considering the imposition of a carbon tax after public consultation found that there was broad support for it as long as the revenues were earmarked for environmental purposes. There are also indications that a carbon tax may be a possible option in India. Elsewhere, however, emissions trading schemes appear to remain the favoured political solution (e.g. Australia and some US states are planning such schemes at present and the new Obama administration in the US also appears to favour this option).

5.6 Summary: carbon tax vs trading assessment

In summary, a well-designed ETS has some potential political advantages over a carbon tax, but may also have some drawbacks given that banking and borrowing may need to be limited and so will not totally smooth out price volatility, while political acceptability may prevent 100% auctioning of allowances. Taxes also have potential disadvantages in not directly constraining emissions and so risking serious social welfare losses where this leads to threshold effects being triggered in some scenarios.

Overall, however, both options have pros and cons and neither emerges as a clear cut winner from the analysis above. Given this conclusion, an obvious question arises as to whether some kind of tax/trading hybrid could be optimal, combining the merits of both policies.

[16] The Clinton/Gore administration also failed to get their proposed energy (‘Btu’) tax through Congress in the mid-1990s, showing the strength of US political opposition to any such broadly-based tax at the time. The election of President Obama, with his campaign commitment to a long-term reduction of 80% in US carbon emissions, is hoped to herald a more positive approach to international climate change negotiations, but this seems more likely to involve carbon trading than a carbon tax, although it is too early to know the details of the new administration’s policy at the time of writing.

6 Hybrid schemes

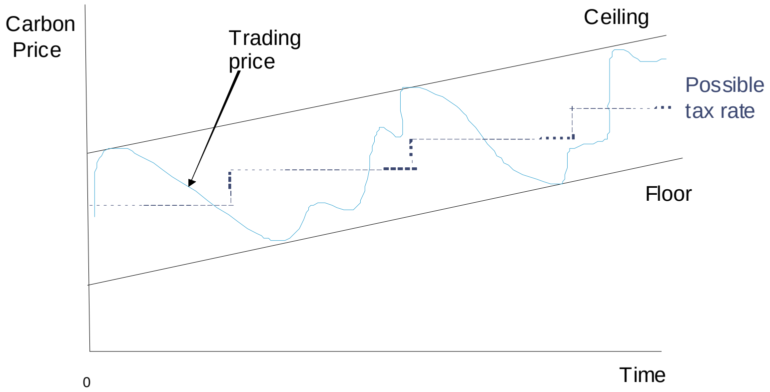
As illustrated by Roberts and Spence (1976) in a general theoretical context and developed further by McKibbin and Wilcoxen (2002) in relation specifically to carbon taxes and trading, a hybrid of the two policies results in an ETS that has 'safety valves' built into it. This contains the social cost imposed by a market-based policy if uncertainty over technology and environmental impact leads to ex-ante misjudgement (see Annex for more technical analysis of this point). Under this system, firms would trade allowances at prices moving within a band between a pre-set ceiling and floor (see Figure 3 below). This price band might rise gradually over time as described further below.

The **price ceiling** could be determined by the government. If the allowance price rises above the ceiling, then firms would switch to paying the cheaper government price. Within a trading scheme, this ceiling could be imposed by governments offering to sell as many allowances as possible at this price, so setting an effective ceiling on market prices. The ceiling would be very similar to a carbon tax in its effects, but would have the political advantage of not needing to go by this name. It could either replace borrowing or be supplemented by some limited borrowing to smooth carbon prices below the ceiling level. Such a ceiling would protect energy users from extreme price spikes, particularly towards the end of trading periods when allowances may be in short supply, or following major unanticipated shocks that push up prices. Although some would argue that price spikes are valuable in signalling the need for additional investment in abatement technologies, the experience of US SOx and NOx trading schemes (such as RECLAIM in California) does suggest that some moderation of price spikes is desirable for the stability and sustainability of trading schemes.

The **price floor** could be set initially by a reserve price where auctions are used and then subsequently in secondary trading by a subsidy that would be paid by the government to participants to purchase their allowances (i.e. the government would effectively offer to buy any amount of allowances at this subsidy price). If the price falls below the subsidy price, participants would choose to sell their allowances to the government rather than on the open market for a lower price. This creates a price floor for secondary trading. The subsidy still encourages abatement if there has been an over-allocation of allowances (which is a clear risk for political reasons as seen in the early stages of the EU ETS) by artificially supporting the allowance price. Abatement will still take place if it costs less than the subsidy that can be received from holding an allowance. Banking could also help to prevent allowance prices from falling below this price floor, or perhaps even from approaching this floor in normal trading conditions. But the recent experience of the EU ETS since mid-2008 has shown that prices can still fall to low levels in the face of unexpected shocks even with banking, which tends to reinforce the case for a price floor if an ETS is to provide credible and reliable signals to potential investors in carbon abatement technologies.

The carbon price ceilings and floors could be revised upwards over time as the overall emissions cap would be tightened to reduce carbon emissions. The amount of emissions reductions required could be relatively small to begin with, which would allow participants to become comfortable with the system. The cap could then become more restrictive through time as participants become able to adapt more easily and at lower cost (e.g. because renewable energy technologies and CCS become cheaper over time due to 'learning by doing' effects). Price ceilings and floors would therefore be expected to trend upwards over time as shown in Figure 3 below.

Figure 3: Carbon prices in a hybrid scheme



Some countries may prefer to opt for a carbon tax where this is politically acceptable. This could still be consistent with a hybrid scheme operating in other countries so long as the tax rate fell within the carbon price band, as illustrated by the dotted line in the chart above. There might be a broad analogy here with indirect tax regimes within the EU, where total harmonisation is not required but VAT rates, for example, are required to fall within a limited band with certain agreed exceptions.

A hybrid scheme represents a combination of the pros and cons of pure tax and trading schemes[17]: the narrower the price band, the closer it resembles a pure carbon tax, while the wider the band, the closer it comes to a pure trading scheme. By avoiding excessive price volatility, it avoids the main disadvantage of a pure trading scheme. At the same time, it retains the political advantage of not actually involving a tax, although its revenue effects may be similar so long as the majority of allowances are auctioned, which seems to be the best approach (at least after an initial transition period with limited grandfathering of allowances to existing emitters).

In practical terms, the price ceilings and floors in a hybrid option should be easy to implement within an auction-based trading system in a single country or region, supported by banking in the case of the price floors. Borrowing may be less essential with a price ceiling in place as a safety valve.

Much more complex are the issues relating to international linkages of such hybrid schemes, which would require harmonisation of price ceilings and floors if such schemes are not to be undermined by cross-country arbitrage (or to leave some schemes stranded if they set their price bands at the wrong level, as happened in Canada in the past). However, price bands could be adjusted over time to address such issues and harmonisation of rules would also be an issue with a pure tax or trading scheme if this is to be applied at international level, so this is not a problem specific to hybrid schemes. However, the latter do imply the need for such broad harmonisation for two additional scheme parameters – namely the price floors and ceilings – and getting a common position even between the US and EU on this will not be easy.

There also need to be agreements on international co-ordination to defend price floors in particular against speculative attack, which might (for example) require part of the proceeds from allowance

[17] Past studies suggesting support for a hybrid scheme relative to either pure trading or a pure carbon tax include Pizer (2002) and a series of papers by McKibbin and Wilcoxen (1997, 2002). Some kind of hybrid option is also reviewed favourable in a recent paper by the IMF (2008), although it ranks second to a pure carbon tax in the assessment by CBO (2008). The latter assessment, however, does not take into account the potential political advantages of the hybrid option over a pure carbon tax.

auctions to be held in reserve to fund possible government purchases of allowances at the price floor if required. Short-selling might also be prohibited in carbon trading markets if this was found to encourage speculative attacks on price floors that required costly allowance purchases by governments to defend against.

There are also a number of other complicated issues that need to be addressed with any such international scheme, relating to matters such as border adjustments, exchange rate translations and carbon offsets. But discussing these in detail is beyond the scope of this paper. For the moment, our conclusion is just that a hybrid scheme is an option worthy of further serious consideration.

We should not conclude, however, that a hybrid ETS/tax scheme (or other options for carbon pricing) is all that is required to regulate carbon emissions; further policy intervention may be required where there are additional market failures. These market failures may arise if consumers do not fully understand the life-cycle energy efficiency of a new car, say, to use the earlier example. This could be corrected by forcing dealerships to display how much money a vehicle would cost to fuel over, say, a 10 year period. The ETS (or a tax for that matter) will not address this asymmetric information problem, and further initiatives to correct this problem may be required. Vattenfall (2007) have published a global cost curve for abatement, based on research by McKinsey, which shows that there are many potential negative cost abatement opportunities that currently are not being exploited, such as insulation and other energy efficiency improvements that would actually save money over a number of years. This suggests that, as noted in Section 2 above, consumer myopia and inertia may often prevent some forms of apparently cost-saving abatement taking place, so justifying some degree of direct regulation. But providing better information could also help in such cases when combined with appropriate market instruments.

As always though, care would need to be taken to co-ordinate different policies and avoid either gaps or duplication. In particular, if an ETS has set a limit on emissions by a particular industry sector, then additional policies such as taxes or energy efficiency schemes in that sector will not affect emission levels but instead just put downward pressure on the carbon price in the ETS.

7 Upstream vs downstream options

Aside from the choice of carbon tax, trading or hybrid scheme, there is also the logically separate question as to whether it should be imposed upstream on original fossil fuel producers or importers within a country/region, or downstream at the point of emissions (as for the EU ETS). Once again there are pros and cons here and theoretical arguments need to be qualified in the light of practical arguments of feasibility, consistency with existing regimes (particularly in the EU) and political acceptability.

7.1 Upstream targeting of emissions

A carbon tax or ETS imposed upstream in the fossil fuel supply chain has theoretical attractions. If the policy was applied to the carbon content of fossil fuels (i.e. coal, oil and natural gas) at the point of their extraction, import, processing or distribution, then almost all of the carbon entering the economy would be accounted for while keeping the system as simple as possible. Including all sectors of the economy should allow all abatement opportunities within an economy to be exploited, giving economy-wide incentives to innovate (Stavins, 2007).

Bluestein (2005) finds that almost all of the US's CO_2 emissions could be covered by an emissions trading scheme or carbon tax covering only around 2,000 upstream entities. An economy-wide cap would potentially render command and control regulation unnecessary as all emissions would already be bound by this upstream cap. Price signals would filter through the economy in order to create incentives to abate all the way down the supply chain, and this incentive effect for consumers of fossil fuels would be analogous to a carbon tax, whether it was introduced in this form or via either a pure or hybrid carbon trading scheme. Stavins (2007) makes similar arguments of broad coverage and administrative simplicity and cost-effectiveness in the case of an upstream trading scheme, but his main points would apply similarly to an upstream carbon tax.

There are, however, also some practical arguments that may militate against such a solution, not least that in the EU there is already a downstream ETS in place that cannot be significantly changed (at least before around 2020) without destroying the regulatory certainty needed by potential investors in low carbon technologies. Even in other countries such as the US, there can be practical difficulties with an ETS scheme in cases where fossil fuel supplies do not lead to significant carbon emissions downstream (e.g. for power plants or factories with carbon capture and storage, or where crude oil is used to make petrochemicals that are not used as fuel). A pure upstream solution would therefore not work in practice without a complex system of credits or exemptions to cover such circumstances, as well as an appropriate audit trail to monitor such effects. This point applies whether the upstream solution involves a carbon tax or an ETS and qualifies the simplicity argument that authors such as Stavins and Bluestein put (in a US context) for favouring an upstream solution.

7.2 Downstream targeting of emissions

Downstream targeting of emissions is more difficult to apply widely outside sectors like power generation and heavy industry with a relatively small number of fixed point emitters that can be monitored under a downstream tax or ETS regime. This explains with the EU ETS, in common with earlier US NOx and SOx ETs schemes, tend to operate at a downstream level and focus on these kinds of sectors. But this leaves the problem of how to cover the rest of the economy.

The Centre for Sustainable Energy (CSE, 2006) has looked into the feasibility of individual carbon trading in the UK, an additional downstream policy that could cover many of the gaps left by the EU ETS. It is estimated in this study that UK carbon emissions directly attributable to individuals could be reduced by around 40-50% if such a scheme were to be implemented. The current UK banking system could be used to manage carbon transactions and accounts, which would aid familiarity with the system.

The CSE authors model this policy and conclude that it is potentially less regressive than a carbon tax. However, such a system is likely to be much more complicated than an upstream policy because of the number of participants in such a scheme, which will increase the administration and compliance costs. Furthermore, the scheme would not cover as much carbon dioxide output as an upstream policy, hence rendering it potentially more expensive and less effective.

Sorrell (2006) looks at the relative merits of individual (downstream) carbon trading and upstream targeting of emissions as a way to cover emissions that are outside of the scope of the EU ETS. He concludes that an upstream approach to this issue would be significantly more cost-effective because the scheme would be much easier to administer due to the smaller number of participants are involved. Both schemes involve the issue of double counting, but keeping an audit trail using an upstream policy to overcome this problem would be much easier than using an individual carbon trading scheme where the number of participants would be much greater.

7.3 Summary: upstream vs downstream options

In practice, just as a hybrid scheme has some attractions as a compromise between a pure carbon tax and a pure ETS, so a mixed upstream-downstream solution may have attractions as a practical solution. This is particularly true in the EU, where any solution needs to be consistent with the existing downstream ETS, but this could be linked to an upstream carbon tax or trading scheme covering the other major parts of the economy such as road transport. This kind of two-tier model may also, in practice, be a likely option for any federal-level US scheme.

8 Summary and conclusions

- In this paper we have explored the pros and cons of alternative policy instruments for delivering significant carbon emissions reductions across the major developed economies, particularly the EU and the US, on the assumption that broad political agreement is reached within the next few years on the need for binding targets for these reductions.

- In most cases market-based policies (i.e. carbon taxes or trading schemes) are more efficient than command and control regimes, although the latter might be preferable in areas where consumer inertia and myopia prevent an efficient response to market signals, even if backed up by information campaigns (e.g. as regards certain energy efficiency issues relating to buildings or household appliances).

- The choice between carbon taxes and carbon trading is much less clear-cut, since both have pros and cons under conditions of uncertainty. In particular, trading schemes have certain political attractions as well as guaranteeing certain emission reductions, while carbon taxes avoid the risk of excessive short-term carbon price volatility that might discourage potential investors in low carbon technologies.

- The addition of banking and borrowing into an ETS should reduce the volatility of prices, so reconciling price stability with environmental effectiveness and mitigating one of the key disadvantages of a pure ETS relative to a carbon tax. However, banking and borrowing cannot be unlimited, so this does not entirely avoid the risk of greater price volatility in an ETS than with a tax. Carbon price floors and ceilings might therefore be considered so as to constrain price volatility further within pre-determined bands.

- Auctioning of allowances is probably preferable in an ETS in the long run, after the initial stages when grandfathering of allowances (as in the first two phases of the EU ETS) is generally necessary to avoid excessive costs being imposed on incumbent companies and indeed to gain political support from energy-intensive industry groups. In principle, an ETS with auctioning can raise just as much revenue as a carbon tax with the same expected environmental impact, although the proceeds from an auction will generally be less predictable and hence less reliable than those from a tax.

- Rather than a pure tax or trading scheme, another option worth serious consideration would be a hybrid of the two instruments in which trading is subject to price caps and floors set by the government, with this whole price band moving upwards over time to give increased incentives to invest in low carbon solutions as technology advances over time and so makes these solutions more economically viable. This kind of hybrid scheme potentially allows better handling of uncertainty as it prevents price spikes and crashes while minimising the social losses created by errors in predicting technological trends and levels of environmental and economic damage from increased carbon emissions. Banking may be useful to supplement the price floor, particularly during the transition to full auctioning, but borrowing may not be needed in addition to a price ceiling unless further price smoothing is considered desirable.

- Hybrid schemes would require international co-ordination on the level and operation of price floors and ceilings if they are to be linked up internationally, as is clearly desirable in order to move as close as possible to a global carbon price. But pure tax or trading schemes also require international agreement on the 'rules of the game' so this problem should not be overstated as a specific argument against hybrid schemes, even though the latter would require agreement on two additional parameters. Nonetheless, in practice there will be difficult negotiations between, for example, a US government favouring a relatively low ceiling to protect energy users from the extreme price spikes seen in some previous US emissions trading schemes for SOx and NOx, and the EU, which may tend to favour a relatively high price floor given recent experiences of price collapses in the EU ETS.

- Whether such a hybrid scheme (or indeed any pure carbon tax or trading scheme) should be applied upstream or downstream in the fossil fuel supply chain is also a complex question without a clear answer in practice. Upstream schemes have theoretical advantages in terms of broad coverage across the whole economy and administrative cost-effectiveness in terms of targeting a relatively small number of fossil fuel producers or importers. But, in practice, they also run into problems in cases such as carbon capture and storage and the use of oil to produce petrochemical products not used as fuels, which require some more complex system of tax credits and/or exemptions from needing ETS allowances at the upstream level. A downstream ETS scheme may also have political attractions.

- There is more flexibility here in the US than Europe, where the EU ETS needs to be regarded as a largely fixed point, subject to incremental reform of detailed aspects of it (potentially including price floors and ceilings). But any system adopted in the US also needs to bear in mind the desirability of being capable of being linked up to the EU ETS in future in order to promote the evolution of a common carbon price across the developed world.

- In the longer term, major emerging economies would also need to be linked into this system, but the first priority would be to get the US and Europe linked up and then to extend this incrementally over time to a global level as and when this is politically feasible. Meanwhile, other priorities such as encouraging low carbon technology transfer should remain a key focus of policy in relation to emerging economies.

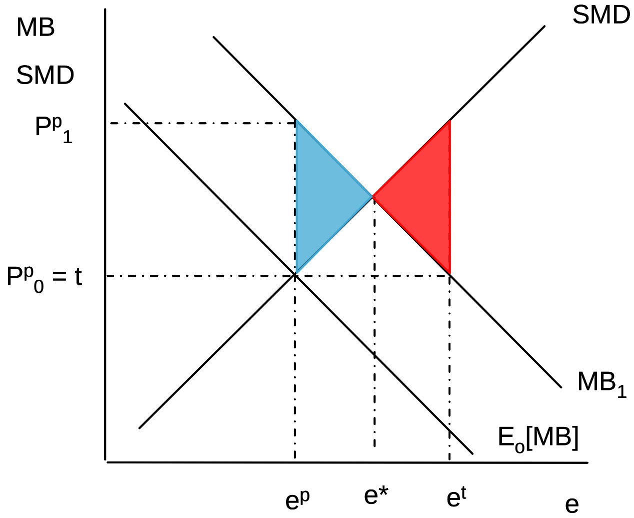
- Such a growing global network of schemes might also be broadly consistent with some countries preferring the carbon tax option where this is politically feasible, subject to these tax rates falling within the price band from the major inter-linked hybrid trading schemes around the world. Full harmonisation of the global carbon price may not be possible, but approximate equalisation of this price should bring most of the benefits of low cost carbon abatement, subject perhaps to additional measures such as border tax adjustments in certain cases (where these were consistent with WTO rules).

- Moving towards international carbon pricing, whether through a hybrid scheme or other options, is a key priority for a post-Kyoto deal, but it should be supported where appropriate by other policies such as direct regulation to improve vehicle fuel efficiency and building energy efficiency standards in areas not covered by trading schemes. There is also a potential role for well-targeted government support (at national and international level) for basic scientific research and early stage development of low carbon technologies such as renewable energy and carbon capture and storage.

Technical Annex

A.1 Uncertainty and environmental policy

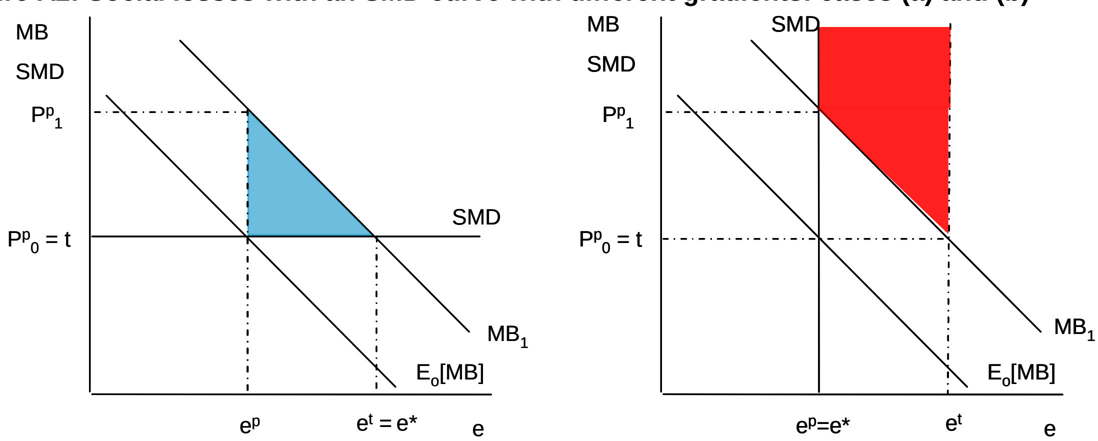
Figure A1: Market-based policies and uncertainty



In Figure A1, ex-ante policy is set using the social marginal damage (SMD) curve and the expected marginal benefit (E_0[MB]) curve. However, the marginal benefit curve may ex-post be MB_1. If an ETS is implemented, emissions are capped at e^p and the permit price rises to $P^p{}_1$, causing a social loss represented by the blue triangle. If a tax is implemented, then firms pollute to where the marginal cost (the tax) equals the marginal benefit of doing so. This is past the optimal pollution point of e*, causing a social loss represented by the red triangle.

If there is also uncertainty over the environmental damage that climate change will have or the speed that it is affecting the planet, then the slope of the SMD curve is also unknown. In the extremes, if the SMD curve is horizontal, then implementing a tax is always optimal as it always gives the optimal amount of pollution at the efficient price. An ETS would create large social losses. Conversely, if the SMD curve is vertical, so that the environmental problem displays threshold effects such that pollution past a certain point would have huge implications, then an ETS would always give the optimal outcome, provided that the emissions cap is not set beyond this threshold.

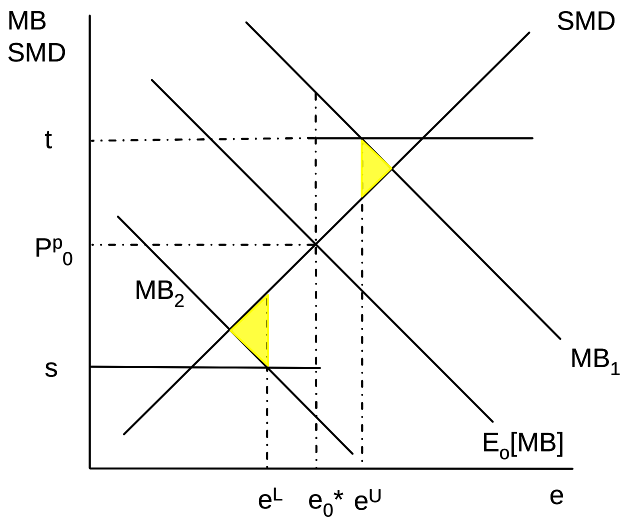
Figure A2: Social losses with an SMD curve with different gradients: cases (a) and (b)



The left hand panel of Figure A2, case (a), shows the social loss of an ETS when the SMD curve is horizontal (represented by the blue triangle), while the right hand panel shows the environmental implications of levying a tax on an environmental impact with threshold effects, as shown by the red area. This shows that a tax is potentially very damaging in the latter case, but optimal in the former case. In practice, the slope of the SMD will not be known for carbon emissions, however, so the theory does not give a clear-cut answer as to which scheme is preferable in practice.

A.2 Hybrid schemes

Figure A3: A Hybrid Policy can mitigate social losses relative to a pure tax or pure ETS



The yellow triangles in Figure A3 represent the social loss from the use of this instrument, which is never more than the social loss under either of the pure instruments. This policy is like a non-linear tax. The optimal hybrid tax schedule would be one where the SMD curve is traced out exactly. The position of the MB curve then becomes trivial becomes the optimal tax rate would be levied wherever the MB curve cut the MSD curve. All possible MB curves would be accounted for. In practice, such a scheme may be too complex to implement, but the general point remains that a hybrid scheme with caps and floors on prices may reduce expected social losses compared to either a pure tax or a pure ETS. Further details are contained in McKibben and Wilcoxen (1997) and Pizer (2002).

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Economics

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