CARBON PRICING & INSTRUMENT CHOICE[1]

Raising the end-user price, or otherwise rationing fossil fuels is a necessary condition for reducing greenhouse gas emissions emissions. This paper will focus on the appropriate mechanism for pricing carbon.

Different options will be assessed according to certain criteria. There are four major aspects of instrument design which are assessed: whether a carbon price should be imposed 'upstream' or 'downstream', what the *coverage* of such a scheme should be, how revenues should be used, and lastly whether policy should primarily deal with *quantity* of emissions or price (carbon taxes). I provide tentative conclusions to these questions.

Two commonly suggested market-based mechanisms for reducing greenhouse gas emissions are a carbon tax and a cap-and-trade scheme. I argue that there are some arguments for preferring a carbon tax over a cap-and-trade scheme, and that the two policies are not mutually exclusive.

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Introduction

What is a carbon price?

A carbon price is a tax or other cost imposed on the emissions of greenhouse gases or, equivalent to carbon dioxide emissions, on the extraction or import of fossil fuels, by carbon content.[2]

Why price carbon?

We should price carbon because emissions of greenhouse gases need to be rationed if we wish to preserve a climate 'similar to that in which civilisation developed'. Imposing a tax (or other form of carbon price) is the most efficient way to ration their use[3]. In rationing them so, we are correcting for an economic external effect: “If the production or consumption of a good creates a negative external effect (i.e. one not reflected in the price of the good) then social welfare can be increased by imposing a tax on the item” (Ekins & T. Barker 2002).

Raising the price of carbon has the following effects (Nordhaus 2009):

- Gives consumers a signal regarding the carbon content
- Gives producers a signal - to move to low carbon technologies
- Gives innovators a signal - to develop long-term technologies
- Economizes on the amount of information required for these actors to make these decisions

At what level should the carbon price be levied?

This question is more straightforwardly answered if we can quantify in financial terms the damage that would result from a given level of greenhouse gas emissions. In this case[4] social welfare will be optimized if a tax is levied on the polluter equal to the marginal damage cost of the pollution generated.

There is a large degree of consensus amongst economists that externalities should be priced at the social cost of carbon; however, beyond this theoretical construction, there is much less consensus over numbers. There have been efforts to approximate the external costs of greenhouse gas emissions (Stern 2006), (Eyre 1998). There is not a high degree of consensus over the level of external costs; and the modelled costs are particularly sensitive to assumptions. Indeed, if, as seems likely, the probability of catastrophic outcomes decays less rapidly than our aversion to such outcomes, the calculation of marginal damage costs is dominated by the willingness to pay to prevent catastrophic outcomes, and this willingness to pay diverges (it is infinite) (Weitzman 2008). It is difficult to estimate the value of 'the social cost of carbon', and difficult to approximate such a cost through trial and error. An alternative approach to justifying the carbon price is called the 'standards and pricing' approach (Baumol & Oates 1971): a target for atmospheric pollutants is determined politically and then a carbon price is used as the primary policy to achieve that target. Note that this could still use a carbon tax (as opposed to cap and trade) so long as the carbon tax was set so as to target a particular level of emissions.

Carbon pricing does not pick one single solution to climate change. It does not choose between technological and behavioural change. Rather, economics recognises that our behaviour is influenced directly and in many indirect and subtle ways by the economic incentives placed on us. A carbon price can indeed be seen as the correction of a previous existing distortion in the real

2 A price on carbon is usually measured in an equivalent amount of Carbon Dioxide; the price in the European ETS is measured in Euros per tonne of Carbon Dioxide.

3 The main part of this paper deals only with the economics; for the wider philosophy please see the appendix.

4 In the absence of the deadweight cost of levying taxation from other sources.

economy, the failure to account for serious externalities. It is not necessarily the whole solution but, in virtue of its powerful effects should be seen as a necessary condition for mitigating climate change.

What Criteria Should We Use to Assess Alternative Instruments?

Three common overall criteria for assessing policies are *effectiveness, efficiency* and *equity (Stern 2008)*. Perman et al. (2003) give a longer list of criteria for pollution control instrument choice:

- Cost effectiveness
- Long run effects
- Dynamic efficiency
- Ancillary benefits
- Equity
- Dependability
- Flexibility
- Costs of use under uncertainty
- Information requirements

To this longer list, I would add the following additional criteria:

- Simplicity
- Susceptibility to adverse regulatory capture
- Compatibility with the incentives of political as well as economic parties
- Modularity

Coverage of Carbon Pricing Schemes

It is important to note that downstream approaches therefore usually include only the large point source emitters. For example, the European[5] Emission Trading Scheme (EU ETS) covers only energy and industrial sectors, collectively responsible for close to half of the EU's emissions of carbon dioxide, or 40% of its total greenhouse gas emissions (European Commission 2008), on a 'production' basis[6].

Policy Solutions

There have been attempts to ration the other sectors, such as transport and domestic fossil fuel with, for example, Domestic Tradeable Quotas (DTQs) (Starkey et al. 2005). Nevertheless, the advantages of these schemes over upstream approaches appear to reside mostly in the realm of psychology – individuals would be directly managing their own carbon footprint, which would be visible. In comparison with this potential psychological benefit, the administrative burden and cost of implementation might be relatively high.

The most obvious alternative solution for these sectors that minimizes the transaction cost is an upstream carbon tax or emissions trading scheme. To some extent, there are taxes already imposed upon oil products used in road transportation. However, these can be seen as a road payment for the rental and maintenance of the road network which also account for the other externalities involved in road transport. In addition it can be argued (Stoft 2008) that oil should be taxed in addition to its impact on climate change, for energy security reasons, so as to minimize transfers of scarcity rent to the oil producer cartel.

'Production' or 'Consumption' Basis?

It is also important to note that emissions on a 'production' basis are not the only emissions associated with domestic consumption. There are further emissions that need to be accounted for: those from imports, overseas tourism and international aviation and shipping. Emissions according to a 'consumption' basis include all these further emissions from the choices of domestic consumers. These emissions can make a big difference to the overall size of emissions and to their growth trajectory; for example the diagram below shows the trajectory of UK emissions on a consumption basis, split into Kyoto (production); net emissions from tourism, net imports of ('embodied[7]) carbon, and the emissions from international shipping and aviation. Note that UK emissions are both much higher (72% greater that UNFCCC guidelines, at about 1,100MtCO2e) and rising rather than falling (increase in emissions of 19% over 1990-2003, as opposed to a reported fall of 15% according to UNFCCC guidelines).

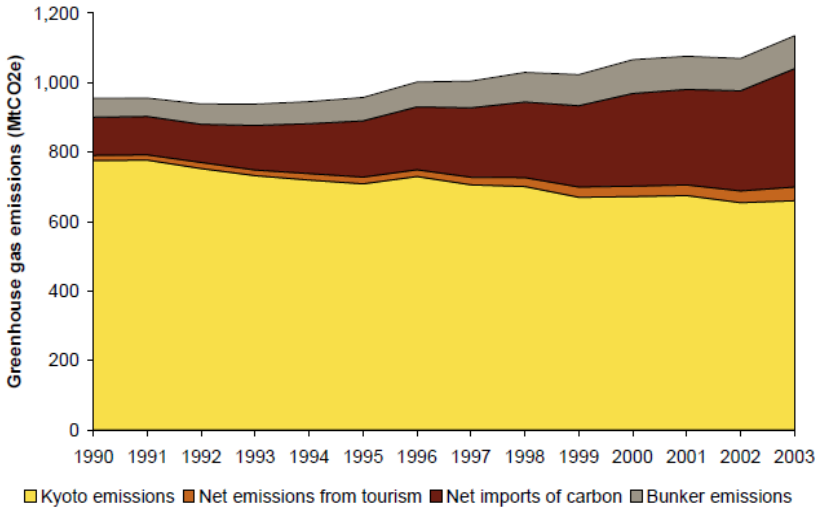
5 The EU ETS contains: “27 EU Member States but also the other three members of the European Economic Area – Norway, Iceland and Liechtenstein” (European Commission 2008)

6 The existing 'Kyoto' convention is to allocate emissions generated when producing goods which are exported to the producing country rather than the importing (consuming) country. The proportion of total emissions covered by the EU ETS on a 'consumption' basis, would be even smaller than 40%. For more details and approximate numbers for the UK see next section.

7 Carbon combusted in the manufacture of goods and services.

UK Emissions when Embodied Carbon Imports and International Transport are Included:

Figure 11 Greenhouse gas emissions on a consumption basis, 1990–2003



Source: (Helm et al. 2007)

Conclusion

The current EU ETS covers little more than one third of emissions in, for example, the UK when emissions are measured on a consumption basis. Such a scheme is likely to produce inefficient or perverse results. Serious attention must be paid to the sectors not covered by the ETS: household consumption of fossil fuels, transport, including international transport and carbon embodied in imports. In regard to household fossil fuel use and transport, it is likely that markets work less efficiently than in the traded sector; nevertheless, to avoid inefficiencies, carbon leakage and rebound effects, all sectors should show a minimum price of carbon.

'Downstream' or 'Upstream'?

The main greenhouse gas is carbon dioxide (CO_2) and the main source of anthropogenic emissions of this gas is from the combustion of fossil fuels. In the process of extraction, refining and combustion of fossil fuels, carbon is conserved: one atom in carbon in the original fossil fuels will be transformed into a molecule of CO_2 in the atmosphere (unless it is used to make other products, or is sequestered underground).

There are in principle two ways to charge for carbon dioxide emissions from the combustion of fossil fuels: 'downstream' or 'upstream'. They relate to the stages in the extraction and combustion of coal, oil and gas. Charging 'upstream' means charging for the carbon content of fossil fuels on extraction or import. Charging 'downstream' means charging for the final emissions of carbon dioxide.

Economic theory suggests that the two methods are completely equivalent. Although the two options would usually be levied on different entities – a downstream emissions tax is levied on electricity producers and industrial users of electricity; whereas an upstream carbon tax would be levied on the importation or extraction of fossil fuels – the *economic incidence* of the taxes would not differ.

Often carbon taxes are associated with an upstream carbon price, and emissions trading with a downstream price. Charging for carbon upstream or downstream is consistent with either price (tax) or quantity (emissions trading) approaches: So, there are examples of upstream carbon tax (Stoft 2008) and upstream cap and trade (Tickell 2008), as well as downstream cap and trade (European Commission 2008)

	Price (Tax)	**Quantity (Emissions trading)**
Upstream	Upstream Carbon Tax (e.g. Stoft)	Upstream Emissions Trading (e.g. Tickell)
Downstream	Downstream Emissions Tax	Emissions Trading (e.g. *Kyoto Protocol / EU ETS*)

Administrative Burden of Two Approaches

Here there is a clear distinction between approaches that charge upstream and downstream. Upstream approaches require far less administration than downstream approaches, because an upstream approach has to charge for carbon only at the sites where fossil fuels are imported or extracted (at the port or pipeline entry point; mine or well-head), whereas 'downstream' approaches have to charge for the carbon wherever the greenhouse gases are emitted. There are relatively few of these 'entry points', whereas there are as many legal persons responsible for greenhouse gas emission as there are citizens.

Use of Revenue

An important question concerns the use of the revenues from carbon pricing. When permits are sold or a tax is levied, large revenues are made for the government. The equity and efficiency of the revenue measures depends partly on how these revenues are used. In the case of emissions trading, the permits are often given away free to the existing polluters.

The efficiency, equity, and political acceptability of a carbon levy depends as much on the *use of the revenues* as the characteristics of the levy itself. Assuming a levy that accrues to a national government, the levy can be used in various ways.

1. Revenue can be raised by government, increasing the total tax take used:
   a) To reduce government borrowing (the national debt) by purchasing government bonds or reducing the issuance of new bonds[8]
   b) To increase government spending, either in general or on specific projects (e.g. those related to developing technology to mitigate climate change)

2. Revenue can be transferred back to individuals or companies:
   a) by reducing or eliminating other taxes
   b) by returning money directly to individuals in the form of a cash payment or citizen's income
   c) by offering free permits or cash payments to companies

In principle, a tax system and cap and trade scheme are completely equivalent from the point of view of the use of revenues.

	Revenue Raised By Government	Revenue Given To Individuals	Revenue Given To Companies[9]
Carbon Tax	Carbon Tax alone	'Tax and Rebate'	'Tax and Refund'
Cap and Trade	Cap-and-trade with auctioned permits	e.g. 'Cap and Dividend', TEQs	Cap-and-trade with 'grandfathering'

Tax Collection and Tax Incidence

It is important to note that the economic burden of a tax (who suffers economic loss as a result of a tax) in no way depends on the nominal incidence of the tax (who is charged the tax)[10]. The economic incidence instead depends on the relative elasticities of supply and demand for the good taxed. If demand is perfectly inelastic (e.g. in the case of insulin injections), then the entire burden of a tax on this good will fall on the consumer of the good. Likewise, if demand is perfectly elastic (say for example for pink highlighter pens where green highlighters are a complete substitute), then the entire burden will fall on the suppliers of that good. If supply is perfectly inelastic (e.g. in the case of land for which there is no substitute), then the full burden of taxation will fall on the suppliers of that good. It doesn't matter where in the chain of extraction, refinery and energy transformation revenues are collected (Levinson 2009).

8 Or in principle to reduce the money supply – the opposite of 'printing money'.

9 Permits have often been given to historical polluters. It is hard to understand the *economic* justification for this approach.

10 The naïve view that whoever is charged the tax, will suffer the burden, is known disparagingly as the '*flypaper theory of tax';* like a fly on flypaper, this theory assumes that on whatever entity the tax is initially imposed, the burden sticks too.

Price or Quantity Control?

Taxonomy of government measures to deal with climate change

The following measures are commonly suggested to deal with greenhouse gas emissions, and may constitute the usual set of measures to deal with the problem:

- Regulations[11]
- Carbon Taxation
- Cap-and-Trade

Equivalence of Cap and Trade and Carbon Tax (Under Static Conditions and Perfect Information)

The issuance of a fixed number of permits to emit CO_2, and a tax set at a rate intended to limit CO_2 emissions to the same level, are essentially equivalent under fixed market conditions and complete information. Both regulate the supply of CO_2 by price; if an economic agent wishes to emit any CO2 then they will have to pay for a permit or the equivalent tax price. They can both be expected to achieve the same objective under conditions of perfect information about the abatement cost curve, and the absence of market shocks.

Under these conditions, both cap and trade and carbon tax can be expected to reach a certain economic objective at the lowest cost. Either can therefore be considered a 'market solution' in the sense that they use the economic system to allocate resources and make decisions over carbon abatement. Regulation is not in general as efficient a solution, because in general different technologies may be outlawed than qre economically optimal.[12]

Efficiency in the Presence of Uncertain Knowledge

The first argument over the relative advantages of taxes and quotas is their relative efficiency in the event of imperfect information. We will formulate it in terms of damage costs and marginal net private benefit of emissions.

As is argued (Ekins & T. Barker 2002) “It is preferable to fix the price, where there is uncertainty over the control cost function and a possibility that it is highly sensitive to greater than optimal emissions reductions, and it is preferable to fix the quantity where there is uncertainty over the damage function and a possibility that it may be highly sensitive to greater than optimal emissions.”

It is furthermore argued (Hepburn 2006) that it is precisely and only the relative slopes (elasticities) that matter. What are the curves like in reality? Since CO_2 is a stock-commodity externality (each tonne of CO_2 is basically equivalent and accumulates in the same way over time), the truth appears to be that the damage cost curve is flat but highly uncertain in magnitude; the marginal abatement cost curve is flat in the long run and sharp in the short.

A usual assumption of economists is that the curves will be close to one another; however, this assumption is challenged by the structural uncertainty over the damage cost of carbon. Two flat curves may hardly intersect at all; this perhaps explains some of the polarity in global warming discourse.

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11 For example mandating the energy efficiency of appliances

12 If we operate under conditions of perfect information we would presumably know which are the technologies that would not be justified at all; but we might be able to regulate marginal behaviour change between driving and taking a bus for example.

Dynamic Consistency

Economists tend to suggest that there are two decisions made by companies: long term decisions over investment and short term decisions over fuel mix. This leads to a steepening of the marginal abatement cost curve over time. In the limit, the marginal abatement cost curve becomes vertical.

It has sometimes been alleged that the crash of the carbon price was caused by *over-allocation* of permits, but instability is a fundamental part of a carbon quota scheme, due to a) the changing nature of the marginal abatement curve and b) its horizontal volatility.

The Implication of Volatility for Investment

It is well known (Dixit & Pindyck 1994) that uncertainty tends to delay investment. There remain serious concerns as to how much a low and volatile carbon price can drive low carbon investment, in particular decarbonization of energy systems. Financial Contracts can guarantee the carbon and/or electricity price for low-carbon electricity investors, promoting large scale investment. Rapid decarbonization can be promoted by higher-price contracts going to the first to build. Given that climate change is a 'critical path' sort of problem, this is an important concern. A further paper will deal with these issues.

The Political Dynamics of Rent Seeking

Climate policy architectures need to make stringent emissions reductions compatible with the incentives of participating nations. A second paper will deal with the game theoretic implications of rent seeking in international policy.

Legal Structures & Clubs

The European Union demonstrates an important legal precedent it is a *club* and has a *legal structure*. A further paper will deal with a proposal for a climate club on similar grounds.

Is Cap-and-trade preferable to a carbon tax as a 'market solution'?

It is often suggested that carbon trading is a 'market' solution to the problem of climate change, in contrast not only to regulation, but also to a carbon tax, which is viewed as a 'state' solution. There are two sides to this argument; the first regarding the formal structure, the second regarding the institutional structures which make the emissions reductions.

According to the first structure, we define a policy goal (which, we would assume, is informed by scientific concerns); we want to reach this emissions reduction commitment in the most efficient way. However, this argument gives undue weight to the original goal. In reality, the original goal is often driven not only by scientific concerns but rather the expected ability of the economy, and particularly the energy system, to respond to these goals.[13] But we may not know the ability of the economic system to respond to carbon pricing and other policies Presumably our goal regarding climate change could be expressed more honestly to 'decarbonize the economy as quickly as possible, without excessive costs'.[14] In that case, a fixed price would be, in a sense, more of a 'market' solution than an emissions trading scheme, simply because, if our goal is driven in part by considerations of economic viability, it would be better if the market provided this information rather than it being presupposed that we can determine how fast the economy should be decarbonized.

A different ethical cost-benefit analysis, rather than comparing the estimated costs of tackling

13 Sometimes environmental goals are explicit, but one is suspicious that those criteria appear to be a compromise between the science and the economic practicalities.

14 Barker (2008)

climate change to the estimated benefits, might instead consider the *risks* of climate change, compared to the *risks* of a carbon tax.[15]

One issue with a carbon tax is the word 'tax' which appears to be political suicide. There is no need for this to be final, however: it is possible to have a tax and yet not using the word 'tax'. For example, one could talk about “Price” or “Quantity” Permits.

Further Arguments

William Nordhaus argues in favour of a system of harmonized domestic taxes on CO_2 emissions (Nordhaus 2007; Nordhaus 2009). Countries would agree to penalize carbon fuel. Revenues would be collected and retained domestically. From a conceptual point of view, the tax should be harmonized in all sectors and countries. Nordhaus points out the following advantages for Taxes over Cap-and-trade:

1. The price based approach can be more easily integrated into an international trading system
2. Emissions taxes are more efficient; because of the linearity of the damage cost curve and the sharp convexity of the abatement cost curve
3. Emissions trading schemes have produced severe volatility. It is inherent in the system, because of the constraint and the relative elasticities.
4. Tax approaches captures revenues more easily and can show long-term benefits
5. Tax approach is less distorting to economic behaviour.
6. No artificial scarcities to encourage rent-seeking behaviour
7. Taxes are a proven instrument. We need to use tried and true instruments.
8. Carbon Tax model is a friendly approach for countries wishing to agree on a climate treaty.

Under the internationally harmonized carbon tax model, they would only have to agree on that minimum price.

It is further argued (Stoft 2008) there are the following more political disadvantages from Cap-And-Trade:

1. Caps Take Control. They control emissions—completely.
2. Caps Kill Initiative. Reducing your emissions doesn’t help the climate, because the overall emissions are capped anyway.
3. Kyoto-Style Caps Will Fail Again. China still rejects caps.
4. Cap & Trade = Cap & Pay. If we cap first, China will just sell us offsets.
5. They’ll Charge You for What’s Free. Companies pass on the “cost.”
6. A Cap Is a Tax. Paying for permits is just like paying a tax.
7. A Cap Is Regressive. The poor pay the highest cap-tax rate.

Nevertheless, there are some arguments in favour of cap-and-trade. Here are some commonly argued:

1. There is a certainty of outcome (in theory at least) But see Nordhaus (3) above
2. International emissions trading promotes international flows and investment
3. Flexibility is enhanced in various ways (some people see the option of grandfathering permits as being a political advantage; others as a disadvantage).

However, these advantages appear slight relative to the disadvantages. It is possible that elements of both might be combined.

Practicalities

The cap and trade system, and it's cousin, international targets, appears to have won out. The

15 See later section.

arguments in favour of tax are strong. The arguments for cap-and-trade are weaker. Most importantly, there are serious questions over the structural soundness and perverse incentives associated with the current international (Kyoto) process. Therefore, alternatives to cap-and-trade and targets should be urgently considered.

Hybrid Systems

Adjustable Taxes

It is customary to compare a fixed tax with a fixed quota. But taxes can be flexible too. In the same way that the (e.g. Carbon central bank). With learning and readjustment of policy the difference in effects between carbon taxes and carbon trading can be reduced. However, continual policy readjustment creates further uncertainty for firms that increases the cost of capital for low-carbon investments.

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