PART THREE: ECONOMICS AND CARBON PRICING

Part Three investigates the economics of climate change and fossil fuel scarcity; and proposes policy measures to deal with these challenges.

- First, I outline the economics of constraints as applied to climate change and resource constraints: the physical facts of climate change and energy, the concept of a scarcity rent, and the differences between climate change and peak oil.
- Second, the case for a carbon price is outlined from the perspective of political theory.
- Third, I investigate the choice of policy instruments: whether governments should use carbon taxes to control greenhouse gas emissions – or 'cap-and-trade' – or both.

Table of Contents

THE ECONOMICS OF LIMITATIONS [1]

Climate change and the limitation on fossil fuels through geopolitics or inherent resource constraints are often described together[2], both because they are connected in cause (both are associated with the combustion of limited fossil fuels) and both are examples of issues of sustainability, intergenerational equity, and living on a finite planet earth. This article investigates both the economic similarities and differences between the difference cases.

The article consists of three parts:

- The first part explains the science of climate change and fossil fuel depletion.
- The second part describes the similarity between fossil fuel and climate change – both deal with a scarcity. I introduce the elementary economics of scarcity and the associated payment to owners of scarce resources, known as the scarcity rent.
- The third part distinguishes between two different sorts of constraints: 'hard constraints' (which cannot physically be exceeded) and 'soft constraints' (which can be exceeded but at a cost).

The distinction between 'hard' or 'soft' constraint is clearly conceptually different from whether an economic action entails an external spillover effect on another economic agent or ecological system (in economics this is known as an 'externality'). It is argued that externalities are potentially much more serious when they relate to 'soft' rather than 'hard' constraints. In regard to 'hard' constraints,, economic and political questions relate to the efficient and equitable use and distribution of resources – important but second order concerns relative to the constraint itself. 'Soft constraints' share these concerns but also entail the first-order question of whether the constraint itself is breached (and the severe costs that could incur). If a 'Malthusian' is someone who predicts human and environmental disaster unless human behaviour is adjusted to take account of environmental constraints, these arguments explain why it may be possible to be consistently 'Malthusian' with regard to 'soft' constraints such as the emission of greenhouse gases and 'anti-Malthusian' with regard to 'hard' constraints such as the availability of fossil fuels. This reasoning also explains why it is necessary to view the study of human economic behaviour as part of a larger field, which includes the ecological system. Simplified representations of the natural systems involved are encouraged.

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2 See, for example, Mackay (2009)

Economic Features of Climate Change & Fossil Fuel Scarcity

Climate Change

Emissions of carbon dioxide and other well mixed greenhouse gases (such as methane, nitrous oxide and fluorinated gases list of fluorinated gases could go in glossary) are commodities (a tonne of CO_2 emitted at ground level has the same effect, wherever it is emitted). These emissions are often called 'stock externalities' because they add to a long-term global stock, and greenhouse gases are global public 'bads' (by virtue of their negative effects on global climate and ocean acidity) .

Carbon dioxide emissions and consumption of fossil fuels can be measured either in tonnes of carbon or in terms of tonnes of carbon dioxide. The relative molecular mass of carbon is 12 and that of carbon dioxide is 44. Therefore, 1 tonne of Carbon is equal to 3.67 tonnes of CO2; €1 per tonne of Carbon equals €0.27 per tonne of CO_2.

The characteristics of the main well-mixed greenhouse gases are:
a) they are well mixed; that is that their effect is a global one, not a local one.
b) they are relatively long-lived[3]

The economic characteristics of these greenhouse gases are as follows:

a) They are commodities: A tonne of Carbon Dioxide has a similar effect wherever on the surface of the Earth, and however it is emitted[4]
b) They are stock externalities: From a stock externality it is meant that fundamentally it is the concentration of CO_2 that does the damage rather than rate of emissions.

Unlike many other pollutants, Carbon Dioxide does not degrade but continues to reside in the biosphere.[5] [6] The current level of ocean sequestration (7GtCO_2 pa) can be a rough order-of-magnitude estimate of a global carbon budget which would stabilise greenhouse gas concentrations. An outline of the relevant science has been outlined (Stern 2008)[7].

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3 As defined as the atmosphere plus the oceans plus the land-biosphere (plants and soils on land)

4 If the future is discounted then the damage of a tonne of CO_2 emitted today is greater than that of a tonne of CO2 emitted in the future.

5 About half of the human-caused emissions are taken out of the atmosphere to another part of the biosphere, but these removals are not necessarily permanent, cannot be relied on at the same scale indefinitely. Only atmospheric carbon dioxide causes the greenhouse effect. However, CO_2 stored in the oceans also causes the independent and also serious problem of ocean acidification. The land also contains a carbon sink in the form of forests and trees; this flow is however, very much reversible (from deforestation and from future climate change), and the total carbon stored here is a function both of land use patterns and of temperature. We should therefore not count a flow of carbon to forest and soils as being a permanent removal. The most important sink is the oceans, which sequester 7 Gigatonnes of CO_2 per year. This carbon dioxide is buffered by the presence of carbonate and bicarbonate ions, although the efficiency of this sink is likely to decline over time.

6 The upper oceans are in a rapid chemical equilibrium with the atmosphere. It is beyond this authors competence to know whether global warming itself is likely to cause significant out gassing from the very large natural CO2 sink in the deep oceans. Should CO_2 emissions peak and then decline (a scenario which is, to say the least, politically distant) there is a concern over the .

7 In this paper Stern outlines the following '*key elements of a global deal on climate change'*:
1. In order to Reduce to 20 Gigatonnes by 2050 (2TCO_2eq each) and then less than 10 Gt (1tCO_2eq each). (This can be compared to the Kyoto baseline of 41GtCO2eq/yr and global emissions in 2005 of 45 GtCO2eq/yr.)
2. Developed countries must reduce emissions 80% by 2050. Electricity must be decarbonized

To stabilise greenhouse gas concentrations at levels which would avoid a *high* risk of *dangerous* climate change (2ºCelsius) requires very rapid action. The current warming commitment (the warming that would happen if greenhouse gas concentrations were stabilized) is approximately 2ºCelsius[8] above the pre-industrial level with an additional commitment of 0.4ºCelsius per decade; although there is a credible risk of greater warming (IPCC 2007), (Hansen et al. 2008). In terms of economic theory, greenhouse gas emissions are a global public bad, because they create problems for human likelihood.

Fossil Fuel Scarcity

Of the three main fossil fuels, COAL is the cheapest, the most plentiful and the most environmentally damaging. Although coal prices have risen in recent years they have not gone up as much as oil and gas, and the difference between the cost of energy in the form of gas or oil and coal energy has increased. Coal is now the cheapest method for generating electricity. At current oil prices, coal could yet be used to make liquid fuels too. The return to coal threatens the credibility of any goal to stabilise greenhouse gas concentrations. Without higher carbon prices or taxes on fossil fuels and on coal in particular, the world is likely to return to coal, resulting in a more rapid increase in emissions, and the use of an energy source capable of adding 1000ppm of CO2 to the atmosphere. In short, coal gives the planet enough rope to hang itself.

Energy choices made now will have long term consequences. Coal is found to be both the cheapest fuel and the fuel with the largest climate impact; furthermore it is the most plentiful. In electricity generation in particular, the present costs will lead to a switch from gas to coal. A rush to construct new coal power stations now has significant long term consequences: it makes current and future targets much more expensive to meet.

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3. 500ppvCO2e is key target
4. Reductions in greenhouse gas emissions of 80-90% by 2050 with credible interim targets.
5. Simple arithmetic implies: 'No scope for significant deviation'

8 Long-lived greenhouse gases (Kyoto gases+CFCs) have radiative forcing of of 2.6W-m2 (IPCC 2007a); or equivalent to 450ppm CO2. This corresponds to a warming commitment of 2 .1Celsius (using a best guess estimate of 3 Celsius). However, due to other air pollutants, the short term radiative forcing is 1.6Wm-2 or 1.3Celcius. The difference between this and observed 0.7Celcius warming is explained by the 'prudent' estimate of about 2.6Celsius (Climate sensitivity).

Rent!

Introduction

Scarcity rents are associated with restrictions of various types, for example:

1. a real geographical restriction associated with limited supplies of the good;
2. a cartel arrangement among the producers of a good;
3. a restriction imposed by the governments in the supply of the good.

All three of these restrictions could exist in the case of the extraction of oil:

1. governments could restrict the demand for oil;
2. there could (and is) be a geographical restriction on the supply of oil;
3. there could be (and in fact is) a cartel arrangement to restrict the supply of oil.

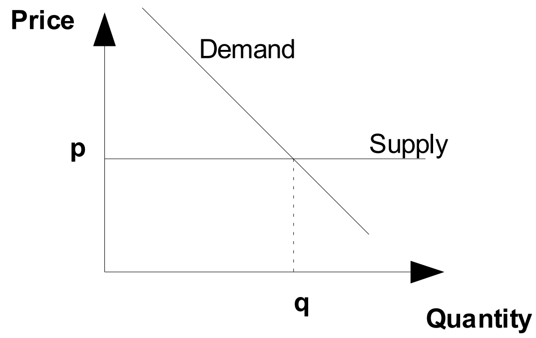
Where this profit goes, depends on how the cap on the good is enforced.

In the case of governmental restrictions on the supply of carbon dioxide emissions (case 1)

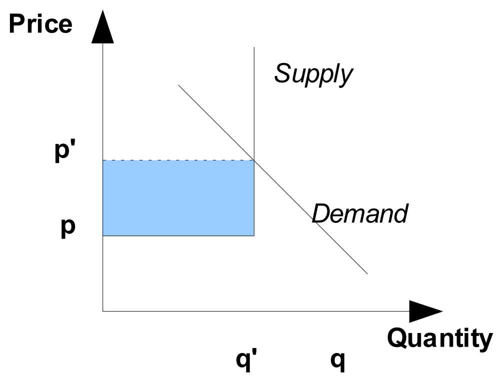
a) If the government is able to *sell* a limited number of permits to companies, the profit will go to the government.
b) If the right to produce the goods is given away (e.g. to the incumbent), the profit will go to the recipient of these rights (e.g. the incumbent companies).

Scarcity Rent for Goods Under Perfectly Competitive Supply

First consider a perfectly competitive market. A good has marginal cost *p* to produce. At any market price greater than c, there are companies willing to supply an infinite amount of that good. At a price below c, no companies will supply the good.



Suppose now we place a restriction on the supply of the good. The following diagram describes the new situation:



The price of the good has risen to p* and the quantity produced has fallen to q*. The revenue taken is now given by q'p' and this is greater than the cost of production which is q'c. The excess revenue is denoted by (p'-p)q' which is the economic rent associated with the restriction in supply.

Scarcity Rent in the General Case

Diagram (i) shows the equilibrium of supply and demand before a restriction is imposed:

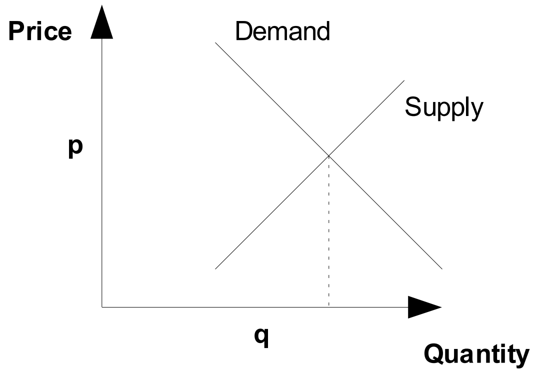


Diagram (i)

Diagram (ii) shows the reduction in quantity from q_0 to q_1 and the price of permits t required. It also shows the revenue generated by the permits, area A.

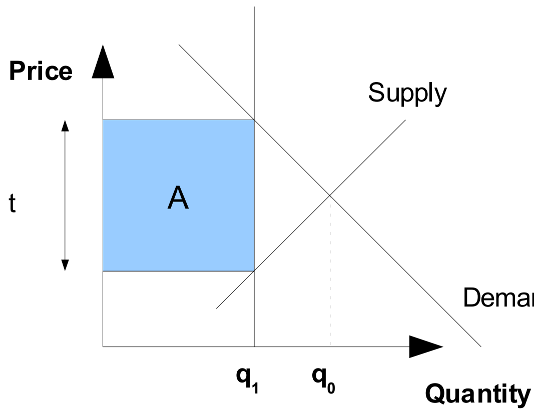


Diagram (ii)

Diagram (iii) shows the required reduction in quantity, instigated by a shift in supplier behaviour (a shift in the supply curve).

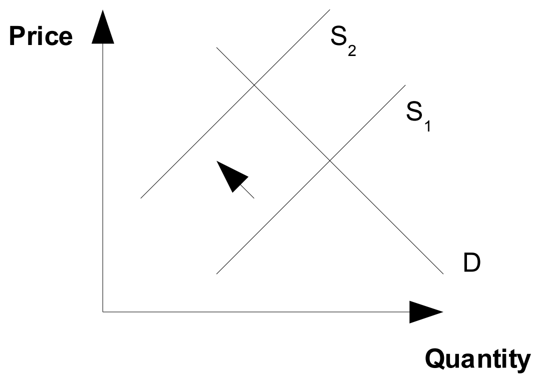


Diagram (iii)

Diagram (iv) shows the same reduction, induced by a reduction in demand from D1 to D2.

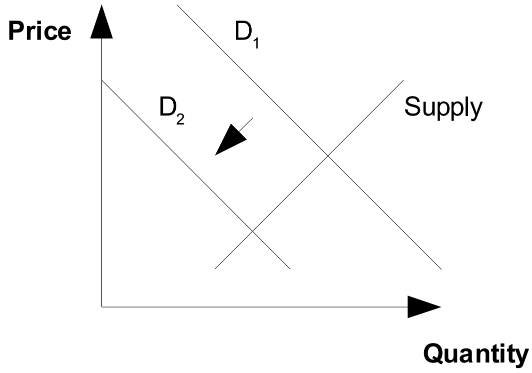


Diagram (iv)

The following diagrams describe the changes in welfare for the different participants. CS denotes the consumer surplus; PS denotes the producer surplus.

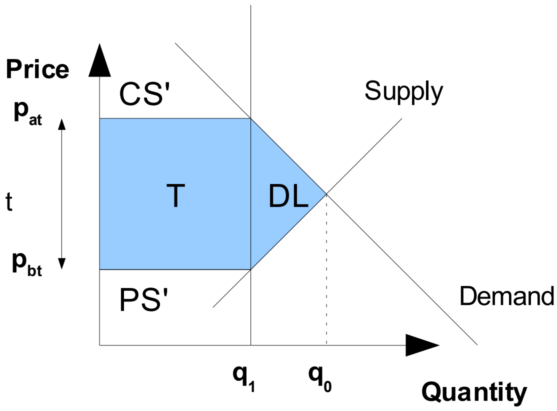


Diagram (v) describes the situation before the restrictions are put into force.

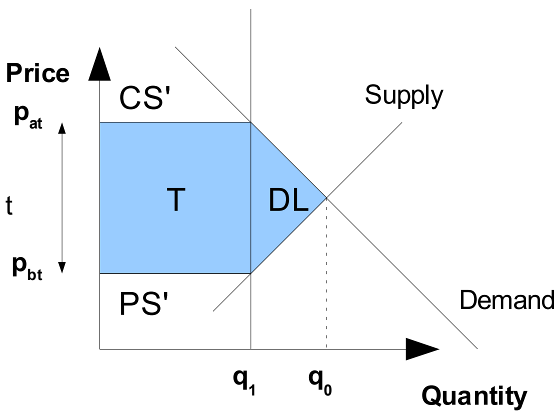


Diagram (vi)

Diagram (vi) describes the situation after the restrictions are put into force. Both consumer surplus and producer surplus are reduced. This loss in surplus takes two forms: revenue (T) and deadweight loss (DL). The scarcity rent T is appropriated either by whoever imposes the restriction: producer or the supplier, or the tax-raising power. The deadweight loss is value lost from the economy as a whole. The customer does not tend to benefit from restrictions.

Discussion

As has been demonstrated, the restriction of supply of a commodity (either by externally-imposed law, by geography or by cartel) leads to an excess profit or 'economic rent'. This rent can be claimed by producer, consumer or by tax-raising authority. There therefore exists a game as to who is to captures the rents. The players are

- On one side the oil consumers, principally the EU, Japan, China.
- On another side, the oil producers, principally OPEC and Russia.

Either side can restrict the amount produced by, in effect, adding a tax to the oil sold.

Producers and consumers are in a game. Essentially, there is a choice between different parties as to who receives the gains from trade. Carbon taxation will cause a change in the terms of trade. Economic rent (i.e. profit) that would have been captured by countries exporting energy, would instead be taken by the richer countries. For more information see Stoft (2008).

Resource Versus Environmental Constraints

Introduction

There are in general two sorts of constraints that may face us, which I will term 'hard' and 'soft'. Hard constraints are inviolable, whereas soft constraints can be exceeded, at the cost either of significant reduction in the capacity to produce the good or service, or of damage to other environmental or human systems. Either type of constraint may or may not be included in the economic decision made by agents: these constraints can be part of the economic decision, or they may be 'externalities' which are not properly priced.

'Hard constraints are that that are physically impossible to exceed - there is no choice over the matter. Examples of 'hard' constraints might include the total amount of oil remaining in a particular oil field. Resources subject only to hard constraints can be underused, but they cannot (by definition) be overused - there is simply a limited amount of them to go around.

'Soft' constraints are those that can be breached – but at some cost. For example there may be a maximum sustainable yield that is consistent with maintaining a certain stock of fish. It is possible to fish above this rate, but if one does so the total breeding stock would decline. Breaching soft constraints may cause hard constraints to become more onerous.

Externalities

The examples of constraints expressed earlier may relate to the idea of an externality. An externality or 'spillover' is an effect of an economic transaction on parties not involved in the transaction. Externalities can be positive, such as the benefits of technological advances, or negative, such as the effects of pollution. Negative externalities can be controlled in various ways, including criminalization, tort law, taxes or permits.

Note that behaviour involving hard or soft constraints may or may not entail externality; the two concepts are in principle independent and all four logical options are possible. An example of a hard constraint which *does* entail an externality is the following: if I take a space on the bus; someone else may be too late in the queue to be physically able to get on the bus. Similarly, it is possible to have a soft constraint that *does not* involve an externality: the construction time of a major piece of infrastructure usually takes a certain amount of calendar time to build; however it is possible to 'hurry up' construction by paying people overtime, and recruiting workers that are willing and able to work faster.

From an environmental perspective whether constraints are or are not exceeded may be more important than the distribution. This implies that problems of externalities involving a 'soft' constraint are different in kind and potentially much more serious than those that involve a 'hard' constraint. In the case of 'hard' constraints, it is not physically possible to exceed the constraint, so that the economic issues are 'second order'; involving the efficient and equitable distribution of resources between people and in time, and not, in general, the overall constraint. In the case of 'soft' constraints the *very constraint* is in question. There is no natural or decentralized reason why a 'soft' constraint would be respected, without central government or some other moral, social or political process to impose a constraint. Severe damage is therefore possible in regard to situations when agents act and are not constrained.

Economics of Hard Constraints

Hard constraints cannot (by definition) be exceeded. We argue that, as a general rule, any economic system deals quite well with hard constraints. In addition, a free market system will ration the constraint efficiently. We will consider whether this initial judgement is true in more detail below.

Economics of Soft Constraints

Soft constraints are less easy to deal with than hard constraints. Because soft constraints can be exceeded, it is very important that they are priced correctly. If soft constraints are not taken account of in economic pricing arrangements, then the violation of soft constraints can be extremely costly. The lack of pricing of soft constraints is therefore a particular example of the general problem of externalities; where the violation of soft constraints causes severe damage, this mispricing may be extremely significant.

A soft constraint might be the number of seats on the bus. Above this number, some passengers must travel in discomfort, with discomfort increasing significantly as capacity is reached. It is not clear what the efficient solution is in this situation: Can a free market determine whether buses should travel with standing people or not?

Where the damage cost of soft constraints is severe, it may be that the damage of exceeding the soft constraint is greater than the price needed to cut off demand. In this case, it seems that the additional price needed to ration the good is the greater of the damage cost and the cost needed to ration demand to the natural limit.

The question of the overall constraint relates only to soft constraints – and must be imposed by social processes, such as taxes or cap.

Rationing Between People and In Time

Whereas the question of the overall constraint relates only to 'soft' constraints, questions as to how limited resources constraint are rationed among people and over time relate to both hard and soft constraints.

We can imagine more than one method of rationing the *use* of resources among people.

1. by price (most goods and services in a market economy)
2. equally per capita (e.g. in wartime)
3. by merit (e.g. in applying to university)
4. by queue (e.g. when waiting for bus)
5. by whoever is stronger - 'rule of the jungle'

Economists tend to argue that rationing by price is the most *efficient* measure; however, other considerations may entail a different rationing scheme. For example, the rationing of scarce resources entails important consequences as regards distribution of income..

In the case of rationing by price, the additional price needed to bring demand below supply (the *rent*) constitutes a permanent additional charge over and above the costs of production. Given that rationing takes place by price, there remains the question as to who will charge the additional rent needed to keep supply below the fixed constraint. Those who charge the rent, get to keep it. Therefore, the way that the rents are distributed from the limited amount of hard constraints is an important question.

Price rationing can take place by the owner of the resource or service (the seller), by the *buyer* of the resource, or by an intermediary such as the government. If buyers ration their behaviour then they can reduce the price paid for the scarce item. In effect, the scarcity rent required is taken by the buyers. Otherwise, the goods will be rationed by the *sellers, who will take the profit.* A third option, proposed by, among others, Confucius and Henry George, is for the government to impose a tax, so rationing demand.

The 'default' position, in the absence of specific interventions, is for the sellers or owners of the resources to impose the rent. These rents can be very significant; they are a permanent 'supernormal' profit. The economics of poor but resource-rich countries is often dominated by so-called 'rent seeking behaviour', which can lead to conflict: a situation known as the 'resource curse'.

The inter-temporal rationing of resource-use is also an important question. If a non-renewable resource is extracted too fast, it may not leave enough for future generations. If there are agents that have long time perspectives and can store the resource, then it's likely that the outcome will not be a major economic failure. Because of its scarcity value, those who invest in the resource could make money by speculating on future price rises. Therefore we expect that inter temporal rationing should be taken care of by the market; but the distribution of rents is an important question that needs careful consideration.

Conclusion

Constraints in environmental and resource economic problems are generally of two types

1) a physical limit on something (e.g. resources) that it is physically impossible to exceed or
2) environmental limits that we can cross but at the cost of severe damage.

Economic issues in relation to physical limits are a matter of *distribution (*of resources between individuals at a particular time, and *between* generations). A free-market economic system works to allocate scarce resources amongst competing needs – even across generations; but the distribution between agents may still be a matter of concern. In regard to environmental limits, humanity must limit itself: a free market system will cross economic limits unless some constraint (such as a tax or cap) is imposed. In regard to the satiation of human needs through limited *resources*, there is little prospect of a Malthusian crisis, famine is more likely to be caused by the distribution of resources, than by a lack of food. In regard to *environmental* problems by contrast, however, the limitation on our behaviour is not enforced by nature – society must enforce the constraints itself, or face irreversible damage.

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POLITICAL THEORY AND CARBON PRICING[9]

Policies and strategies to reduce carbon emissions, such as a carbon price, are evaluated in a wider context of political norms and philosophy. In this context, a price on carbon is found to be a viable and reasonable approach to mitigate climate change.

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Introduction

Putting a price on carbon will reduce our emissions of greenhouse gases. However, there are other options for dealing with carbon emissions other than a price on carbon. These might include 1) *no government action* (what we might call non-interventionist minimalism), 2) education and moral suasion and 3) regulation. To assess these options will sometimes take us out of the realm of economics and into the realm of political philosophy.

Assessment of Strategies

Non-interventionist minimalism argues that it is not the government's responsibility to minimize carbon emissions. Rather, it is the responsibility of individuals to decide what emissions they emit. Just as we treat the consumer as sovereign when deciding whether to buy a McDonald's hamburger or visit a locally owned restaurant, so it is the responsibility of individuals to regulate their own carbon emissions. There are two concerns with non-interventionist minimalism.

Under most theories of liberty (e.g. Mill 1986) the right to do harm to others is restricted, even if liberty in general is supported. Carbon emissions are likely to change the world's climate system in ways that makes it more difficult to live in parts of the world without severe consequences to life and limb; this arguably involves harm to future generations. A man who poisons the water supply is committing a crime, and society punishes such activities. The liberal contention is that one should be free to behave how one likes unless it involves harm to others. Freedom to act does not involve freedom to harm, and if carbon emissions involve harm to others, then they should be restricted; the exact restriction (whether it should be banned outright or just penalized with a cost) is yet to be determined. In contrast, , we might consider that harmful activities should be banned outright and not just restricted or charged. In the case of natural systems we sometimes can define a threshold for harm, for example, the level of fishing at which fisheries collapse.

In the case that carbon emissions might be inconvenient to others but not harmful, it is less clear that they should be regulated, and to a large extent it might depend on how such regulation takes place. Libertarians argue that a lack of government interference in peoples lives in not so much a question of optimality but rather about good procedure. Whether a solution is sympathetic to libertarian or Austrian concerns will rather depend on the details as to whether an overall policy proposal constitutes an increase or a reduction in government interference. Replacing transaction taxes with upstream carbon taxes might in fact reduce the level of state interference.

Carbon emissions might,however, be considered by some to be inconvenient to others but not harmful. There are things we do to one another, which while not harmful are not pleasant. For example, playing loud music does not actively harm one's neighbours but it does inconvenience them. If I drive to work alone rather than taking the bus, then my actions will not only cause more carbon emissions, but also use up more scarce traffic space and therefore indirectly cause other people inconvenience. These actions are not harmful in a strong sense, but yet they do diminish our neighbours' interests, happiness or convenience. Economists often argue that such activities should be regulated. Collectively, our lives might be better if we were charged for road congestion; the total welfare is increased because we each pay the social costs of our behaviour; rather than our share of the social cost of everyone else's.

Liberals are often involved in local programmes to reduce emissions; they often emphasize moral suasion, awareness raising and giving information as methods to reduce emissions. We might look on such efforts sympathetically, since they presumably increase the level of information available to make both individual and political choices. Nevertheless, moral suasion appears to be a difficult strategy to implement effectively as Hardin (1968) argues. There is always an incentive to defect in social choices. It could be argued that some of our social 'peer pressure' functions have been given over to the state, especially in large societies where our social interactions are with others we do not know personally. not what ? Hardin's argument for 'mutual coercion mutually agreed upon' appears solid.

Thus, we fail as self-regulators. This is not a pleasant message to give but it is an important one to argue. We fail because we have other priorities. As individual agents, we cannot be expected to take care of the future of all of humanity in our behaviour: we take care of ourselves, of our family and friends and our neighbours; but not everyone on earth to an equal degree. If we were all perfect utilitarian agents there would be no need for a tax. The reasons for our failure of self-regulation are partly the unrealistic requirements that pure altruism would entail; not only in terms of our desire to help those we are not connected to; but also in the information needed to do so. Finally, actions that are for the sake of those around us are often implicitly regulated by those around us by multiple methods of social interaction. It is between humans that presumably the full panoply of human interactions can be fulfilled. Such interactions have little chance of being mediated on a global scale and between generations. Ethical behaviour is, arguably, mediated and supported by human interactions; human interactions which are not available at a planetary scale, since the number of people is too large to be known personally. The argument for government intervention thus comes from both the scale of climate change and it's newness as an issue to be dealt with.
An important sociological criterion is therefore whether or not a certain activity is intended to be self-regulated or other-regulated. Hardin (*ibid.*) argues against 'soft' (non-coercive) interactions and in favour of 'hard' (coercive) interventions on a number of grounds. Soft interactions may tend to promote guilt and harm those who are swayed by such reasoning; leaving those who are not swayed to go free. The perception of many people is that environmentalists wish them to give up their car or foreign holidays and this causes rejection of the whole message.

This argument against self-regulation also applies to the economic formalism of Coase (1960). Coase's theorem implies that state imposition of taxes is not necessary, so long as property rights are well formed. Those who pollute and those who receive pollution will come to a legal agreement, which although not necessarily equitable, will be efficient. The argument that legal rights of those who have an externality inflicted upon them will lead to an efficient outcome without government intervention is largely appropriate to smaller scale problems involving only two parties. It does not begin to address the collective action problems which are arguably at the core of the climate problem. Similarly, it is the economy of information (that is, that economic incentives are passed to individuals, in increased prices, without the individual having to assess individually the carbon cost of each transaction – rather than in a complex set of messages that may be ignored) that is the key to the advantages of the carbon tax approach.

If, therefore, a method of persuasion that is to some degree coercive, exists, there remains the question as to what method of coercion is required and whether such coercion is possible. Taxes, permit schemes, regulation of goods and activities and direct control of people's lives are to a larger or smaller extent coercive activities. Taxes and quota schemes have arguably a similar level of coercion – they allow an activity but only at a price. Regulation, however, outlaws some activities entirely. The argument in favour of market mechanisms is largely one of efficiency at achieving a given goal. Taxes or quotas do not pre-judge the best way to achieve a certain goal.

In any case, it can be expected that the aggregate result of individual action is a certain level of emissions – either this level is acceptable or it is not. If it is not acceptable, then further more coercive activities may be required and there may be a trade-off between the political and economic costs and the environmental benefits. I therefore investigate in particular that situation, where additional mitigation, in addition to that which is voluntary, is required.

Welfare economics sometimes seems to assume that individuals are perfectly selfish in regard to collective goods and that the state is capable of being perfectly altruistic, in the presence of good economic advice! Neither assumption is fully justified, but it appears that individual's altruism is at the very least non-complete. An alternative way of putting this is that economics often deals with the allocation of scarce goods. In most cases the price mechanism is used to ensure the rationing of these goods, so in principle the same should be applied to public bads. The assumption of perfect altruism on the part of the nation-state is itself questionable but in principle a question of political theory and not of economics.

Conclusion

In conclusion a price on carbon is a viable and reasonable approach to mitigate climate change from the point of view of political theory.

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CARBON PRICING & INSTRUMENT CHOICE[10]

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.[11]

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[12]. 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[13] 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

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11 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.

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

13 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[14] 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[15].

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[16]) 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).

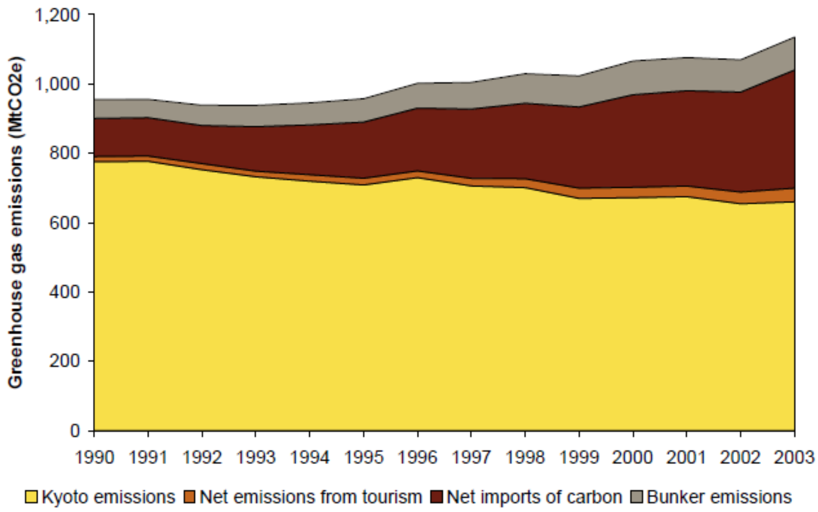
14 The EU ETS contains: "27 EU Member States but also the other three members of the European Economic Area – Norway, Iceland and Liechtenstein" (European Commission 2008)

15 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.

16 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[17]
   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[18]
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)[19]. 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).

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

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

19 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[20]
- 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.[21]

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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20 For example mandating the energy efficiency of appliances

21 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.[22] 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'.[23] 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

22 Sometimes environmental goals are explicit, but one is suspicious that those criteria appear to be a compromise between the science and the economic practicalities.
23 Barker (2008)

climate change to the estimated benefits, might instead consider the *risks* of climate change, compared to the *risks* of a carbon tax.[24]

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

24 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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