Draft
Comments Invited

Carbon Taxes vs. Cap and Trade

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January 2009

I am grateful to Ken Judd, Suzi Kerr, Charles McLure, Gib Metcalf, Richard Newell, Paul Schwartz, Robert Stavins, and Michael Wara for helpful suggestions, and to Anuradha Sivaram and Xiaoling Zhou for research assistance.

1. Introduction

In response to mounting scientific evidence that human activities are contributing significantly to global climate change[1], decision makers are giving growing attention to public policies to reduce greenhouse gas emissions and thereby prevent or reduce such change.

Increasingly, policy makers are employing or contemplating the use of market-based instruments for climate policy. The two market-based instruments receiving the greatest attention are a carbon tax and "cap and trade" (a system of tradable emissions allowances). A main theoretical attraction of these two instruments is their potential to achieve emissions reductions at lower cost than conventional, direct regulations such as mandated technologies or performance standards.

While there is wide agreement among economists as to the potential advantages of market-based instruments, there is much debate as to which particular market-based instrument – carbon tax or cap and trade – is the better climate policy option. In recent years, cap and trade has commanded most of the attention in discussions relating to the Kyoto Protocol or connected with state-level climate policy efforts in the U.S. Thirteen of the fifteen climate bills introduced in the last (110^{th}) U.S. Congress called for cap and trade, with the other two supporting a carbon tax (Resources for the Future, 2008). The Obama Administration also expresses support for cap and trade. However, a significant chorus of economists and other policy analysts favors carbon taxes[2]. Potentially, disagreements as to the relative merits of the two options could hamper efforts to introduce a market-based climate policy in the U.S.

This paper examines the relative attractions and disadvantages of these policy alternatives. It shows that the relative performance depends importantly on how each option is designed. Several analyses have claimed that a carbon tax is superior to cap and trade in

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[1] For a compilation of current scientific evidence, see Intergovernmental Panel on Climate Change (2007).

[2] For example, the Pigou Club, formed by Harvard's Greg Mankiw and named after the renowned early 20^{th} century tax and welfare economist, favors carbon taxes and includes as members a large number of eminent economists, including three Nobel prize winners. See www.pigouclub.com.

terms of the ability to achieve low administrative costs; others have argued that cap and trade is more capable than a carbon tax of achieving a fair distribution of the policy burden or preserving international competitiveness. This paper indicates that if properly designed, the policies have equivalent potential along each of these dimensions. The design of the instrument may be as important as the choice between instruments.

Along other dimensions, however, there are very different potential impacts, even if each alternative is designed equivalently. In comparing alternative (well-designed) policies, this paper finds that a hybrid extension of cap and trade – that is, a cap-and-trade system that includes an allowance price ceiling – is superior to a pure cap-and-trade program along nearly all critical evaluation dimensions.

The relative attractiveness of the hybrid to a carbon tax is more difficult to assess. A key finding of this paper is that the ranking depends on whether one takes a "constrained" or "unconstrained" approach to policy evaluation. The difference parallels the difference between second-best and first-best analysis. As discussed below, the constrained approach gives considerable weight to current political considerations and existing climate programs, as well as implementation-related political efforts such as rent-seeking. The unconstrained approach gives much less weight to these factors. Analysts that take this approach may assume that these factors are transient or malleable and need not constrain *prospective* policy decisions.[3] This paper finds that under the constrained approach, there are strong grounds for favoring the hybrid over the carbon tax. On the other hand, under the unconstrained approach, the carbon tax seems to emerge as most attractive.

The rest of this paper is organized as follows. The next section lays out the basic functioning and general attractions of carbon taxes and cap-and-trade systems, and analyzes connections between these instruments and existing conventional forms of regulation. Section 3 then focuses on dimensions along which carbon taxes and cap-and-trade systems, if well designed, are equivalent. Section 4 concentrates on dimensions along which the two options perform differently. The final section integrates the information from sections 3 and

[3] The potential malleability of constraints lies behind this paper's focus on the terms "unconstrained" and "constrained" rather than "first best" and "second best." The first best is often viewed as signifying an unattainable ideal. In contrast, when an analyst adopts the "unconstrained" approach to policy assessment, she generally does not regard the objective as unattainable: the constraints are not viewed as permanent.

4 to arrive at an overall assessment of the relative attractions of the different policy instruments.

2. Carbon Taxes and Cap-and-Trade Systems: Essential Functions and Attractions – and Interactions with Existing Regulations

The world already has experience with both carbon taxes and cap and trade. Carbon taxes were introduced in the Netherlands and Finland introduced carbon taxes in 1990, in Norway and Sweden 1991, and in Finland in 1992. New Zealand enacted a carbon tax in 2005. Quebec introduced the tax in 2007, and British Columbia did so this past July. While the stated objective of each of these efforts was to confront climate change, the potential for yielding public revenue also motivated these actions.

Cap and trade was first introduced in the U.S. At the federal level, it was implemented under Title IV of the 1990 Clean Air Act Amendments to reduce sulfur dioxide (SO_2) emissions from fossil-fuel burning power plants located in the continental United States. It was also introduced at the federal level in 1995 under the "NOx Budget Program" to control NOx emissions from electric utilities and large industrial borders. Los Angeles introduced cap and trade in 1994 to control local emissions of SO_2 and nitrogen oxides. In January 2009 eleven states in the Northeastern U.S. are launching the Regional Greenhouse Gas Initiative, a cap-and-trade system covering emissions of carbon dioxide from the electric power sector. California is poised to introduce in 2011 a cap-and-trade program as part of Assembly Bill 32, the California Global Warming Solutions Act of 2006. A group of seven Western States, along with four Canadian provinces are aiming to introduce a cap-and-trade program under the Western Climate Initiative. Similarly, ten midwestern U.S. states are organizing a Midwestern Regional Climate Initiative, to include cap and trade. At the international level, a number of cap-and-trade programs have recently been introduced relatively recently to control greenhouse gas emissions. These include the European Union's Emissions Trading Scheme, which began in 2005. Several programs are underway in individual countries.

a. Basic Functioning of the Two Instruments

Carbon taxes and cap-and-trade systems (as well as the hybrid) share a basic function: they each establish a price for emissions of greenhouse gases. In doing so, they encourage firms to alter their production processes so as to reduce these emissions. These policies cause the prices of carbon-intensive goods (for example, electricity, aluminum, and gasoline) to rise relative to those of other goods. They thereby encourage shifts in consumption patterns toward less carbon-intensive goods, which further contributes to emissions reductions.

The different instruments establish the prices in different ways, however. Under a carbon tax, the price of carbon (or of CO_2 emissions) – is set directly by the regulatory authority – this is the tax rate. In contrast, under a (pure) cap-and-trade system, the price of carbon or CO_2 emissions is established indirectly: the regulatory authority stipulates the allowable overall quantity of emissions; this then yields a price of carbon or CO_2 emissions through the market for allowances.

The base of a typical carbon tax is the carbon content of fossil fuels. In nearly all industrial processes, carbon dioxide (CO_2) emissions are proportional to this carbon content.[4] Thus, a carbon tax is effectively a tax on CO_2 emissions. A close cousin to the carbon tax is a CO_2 emissions tax; here the tax base is emissions at the point of combustion. We concentrate on carbon taxes here; we will contrast carbon taxes and CO_2 emissions taxes in later sections of the paper. In the dimensions discussed in the current section, the two taxes are equivalent.

The stringency of a cap-and trade system depends on the level of the cap, or overall allowable emissions. A cap-and-trade system also involves emissions allowances or permits. The allowances entitle the holder to emit a specified amount of emissions in a given time period. The total number of allowances issued for a given period matches the cap for that period. Sources covered by the cap-and-trade system can buy or sell allowances from other

[4] The key exception is the use of fossil fuels as petrochemical feedstocks (for example, the use of petroleum in the production of plastics). In these uses, the carbon content does not lead to CO_2 emissions. Feedstock uses account for only three percent of the carbon used in the U.S.

sources. To the extent that a cap-and-trade system restricts overall emissions, it will generate positive market prices for allowances.

Generally, a source or facility will buy additional allowances (entitling it to additional emissions) if the market price of allowances is less than what it would cost the facility, at the margin, to bring emissions down to the level implied by its initial allowance holdings. Likewise, a facility will sell allowances if the allowance price is higher than what it would cost to achieve the additional reductions made necessary by the sale of allowances. Every allowance purchase by one entity corresponds to an equal reduction in the allowances held by the selling entity. Thus, allowance trades do not affect total allowable emissions because they do not alter the total number of allowances in circulation.[5]

Figure 1 suggests the fundamental similarities and differences between the carbon tax and cap and trade. The dark curved line represents the marginal abatement cost schedule for the region in question. This indicates that marginal abatement costs rise as emissions are reduced from the business-as-usual level E_0 to some lower level. The carbon tax directly establishes a price p for emissions. Given this price, emitters will minimize their overall costs – costs of abatement plus the tax payment – by reducing emissions to E_1. At E_1, the cost of achieving the last unit of emissions reduction just equals the avoided tax payment that results from achieving that last unit.[6]

As mentioned, under a cap-and-trade system, the regulator sets the cap -- the total allowable quantity of emissions. Suppose that the cap is set at E_1. In this case, individual firms or facilities with marginal abatement costs above p would purchase allowances, and firms or facilities with marginal abatement costs below p would sell them. The market would generate a price of allowances equal to p.

Thus, the connections between price (or tax) and quantity (or emissions) are the very similar under the two types of policy. The differences are in what gets set by the regulator and what gets established by the market.

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[5] If a private party decided to retire the allowances it purchased or held, the total number of allowances in circulation would be reduced, implying further reductions in overall emissions.

[6] Any further reduction would imply an abatement cost in excess of the tax payment. Likewise, if the reduction in emissions did not extend all the way from E_0 (the starting point) to E_1, then emitters could reduce their overall costs through additional reductions, since the added abatement cost would fall short of the savings in terms of the additional avoided taxes.

b. The Cost-Effectiveness Attraction

A main potential virtue of each of these instruments is the ability to promote given emissions-reduction targets most cost-effectively. The cost of achieving a given abatement target is minimized when marginal abatement costs for all facilities generating emissions are the same. If this condition were not met, then costs could be lowered further if the emitters with higher abatement costs were to undertake less abatement and the emitters with lower abatement costs were to undertake more abatement so as to keep aggregate emissions unchanged. This would lower the overall abatement costs because the cost-savings from the first group of emitters would exceed the added costs from the second group.

Under a carbon tax, each facility will have an incentive to reduce its emissions up to the point that, at the margin, the cost of abatement equals the avoided tax (given by the emissions price or tax rate). Since all facilities equate their abatement costs to the same price, the marginal abatement costs are brought to equality. Hence the condition for maximal cost-effectiveness is achieved.

A smooth-functioning cap-and-trade system also yields the minimum-cost condition. Suppose that regulating authority gives out a total of E_1 allowances to a large number of facilities or emitters. If the facilities did not trade allowances, each facility's emissions would be restricted to the amount received from the regulator. It is extremely unlikely that each facility's marginal cost of abatement would be identical after this initial allocation. Thus, in the absence of trades, the total costs of reducing emissions to E_1 would not be minimized.

With trades, costs can be minimized. Facilities with especially high marginal abatement costs will find it advantageous to purchase additional emissions allowances rather than suffer the high abatement costs. For these facilities, it will be cheaper to purchase additional emissions allowances (and thus avoid some abatement costs) than to reduce emissions all the way to the level implied by the initial endowment of allowances. Symmetrically, facilities with exceptionally low marginal abatement costs will find it profitable to sell some of their allowances. For these facilities, the revenues from the sale of allowances will exceed the additional abatement costs that are taken on by virtue of having given up some allowances.

As trades continue, facilities with initially high marginal abatement costs move down their abatement cost curves (as they engage in less abatement), and those with initially low marginal abatement costs move up their abatement cost curves. In a perfectly functioning cap-and-trade system, trades continue until the marginal abatement costs of all emitting facilities equal the (common) market price of allowances – which implies that marginal abatement costs are the same across facilities. Thus the condition for cost-minimization is achieved.

c. Connections with Direct Regulation

The ability to bring marginal abatement costs to equality is the central advantage of the two market-based approaches over direct regulations such as mandated technologies or plant- or firm-level emissions quotas. In general, regulators do not have sufficient information about individual firms' marginal abatement cost schedules to specify a set of emissions quotas or technologies that lead to equality of marginal abatement costs. Prior studies indicate that under direct regulation, marginal abatement cost can differ substantially, so that market approaches can have a large cost advantage. The South Coast Air Quality Management District estimated, for example, that the RECLAIM cap-and-trade program in Los Angeles would reduce costs by 46 percent relative to the costs of achieving the same aggregate reductions under the prior air quality management program, which involved fixed emissions caps (no trades). Carlson *et al.* (2000) estimated that the allowance trading under Title IV of the Clean Air Act offered potential cost savings of $700-$800 million per year compared to an "enlightened" command-and-control program characterized by a uniform emissions rate standard.

Still, direct regulation sometimes can have advantages. In situations where emissions are difficult to monitor, for example, it may be less costly to control emissions by requiring the installation of a particular type of equipment and monitoring its use than by aiming to monitor emissions directly.

While some regulatory bodies have viewed market approaches as a threat to direct regulation, the two approaches are not mutually exclusive. The two can be combined in the same sectors and even can apply to the same facilities. When direct regulation is in place, it contributes to the emissions reductions required under a cap and trade system or generated through a carbon tax. By putting a price on emissions, the market instruments produce the needed reductions that are not achieved through direct regulation.[7] The California Air Resources Board proposes to employ cap and trade for this purpose – to augment the reductions that direct regulation might accomplish.[8] Moreover, market instruments can cause certain direct regulations to give rise to larger reductions than they would in the absence of a price on emissions.[9] Thus, market instruments and direct regulations may work synergistically.

3. Significance of Policy Design (Rather Than Choice of Instrument) to Administrative Costs, Distributional Impacts, and International Competitiveness

Policy evaluation criteria include the ability to keep administrative costs low, the potential to achieve a desirable distribution of the policy burden, and the capacity to preserve international competitiveness of domestic industry. These are clearly very important

[7] For a cap and trade system, this point can be illustrated through the following example. Suppose: (1) direct regulations such as certain performance standards and technology restrictions apply to the electricity and manufacturing sectors; (2) a cap-and-trade system also embraces these sectors; and (3) in the absence of cap and trade, the direct regulations would accomplish a reduction of 10 million tons of CO_2 emissions. Now if the cap and trade system requires reductions beyond 10 million tons, the price of allowances will rise enough to produce the additional needed reductions. Thus, the cap-and-trade system helps bring about the needed reductions not already accomplished through direct regulation. Similarly, a carbon tax can induce additional reductions to the extent that it applies to facilities that do not face direct regulation. If the tax rate is sufficiently high, it can also induce further reductions by the facilities that do face direct regulation.

[8] See California Air Resources Board (2008).

[9] Market instruments could increase the reductions achieved by renewable fuel standards or renewable portfolio standards. Renewable fuel standards impose a floor on the ratio of renewable-based (or low-carbon) fuels to carbon-based (or high-carbon) fuels in the mix used by refiners to generate automobile fuel. Similarly, renewable portfolio standards establish a floor on the ratio of renewable-sourced electricity to conventionally-generated (fossil-based) electricity purchased by utilities. Importantly, these are *intensity* standards – they put limits on the ratios of dirty to clean fuels or of emissions to miles traveled. These standards establish appropriate relative prices for clean and dirty fuels, but do not bring about efficient prices of these fuels relative to other goods and services. Introducing market instruments raises the prices of fuels relative to other goods. As a result, they can prompt cause renewable fuel standards and renewable portfolio standards to achieve required ratios of fuels at lower absolute levels of each fuel.

considerations. However, this paper argues that with careful policy design, a carbon tax policy and cap-and-trade system have equal prospects for success along each of these dimensions. Thus, if one compares well-designed carbon taxes and cap-and-trade systems, there will be no important differences in their performance along these dimensions.

a. Administrative Ease

Consider first the costs of administration. These costs depend importantly on the number of sources that must be evaluated and monitored. This depends fundamentally on whether the policy is introduced upstream, midstream, or downstream – not on the choice between a carbon tax and cap and trade.

The issue is most relevant for the control of CO_2 emissions.[10] A purely upstream system would tax or limit quantities of the underlying source of CO_2 in the economy, that is, to the carbon content of fossil fuels. A fully downstream system would impose a tax or a cap on the ultimate emitters of CO_2. [11]

Under a fully upstream tax or cap-and-trade system, the point of regulation would be the minemouth for coal, and the wellhead for oil and natural gas. Under an upstream carbon tax, in particular, a tax would be applied to these three fuels in proportion to their carbon content. Since coal has by far the highest carbon content (per Btu or per dollar of fuel[12]), it would face the highest carbon tax rate. Under an upstream cap-and-trade system, a cap would be imposed on the total amount of carbon to enter the economy via use of these fuels. Carbon allowances would be allocated to firms that supply these fuels, with each allowance entitling the holder to supply a given amount of carbon.

A fully downstream system would apply a tax or allowances to the ultimate emitters of carbon dioxide: the facilities that combust fossil fuels or the fuels refined from the fossil

[10] As discussed below, most of the other greenhouse gases cannot be controlled upstream.

[11] For non-CO_2 greenhouse gases, downstream approaches mainly apply, since for these gases there is no simple proportionality between the chemical composition of the fuel and ultimate emissions. For these gases the ratio of emissions per unit of fuel depends on the production process involved. Metcalf and Weisbach (2008) discuss potential methods for incorporating some of these other gases in a U.S. carbon tax system.

[12] Compared with crude petroleum or natural gas, coal (bituminous or anthracite) has slightly more carbon content per Btu and four to six times more carbon content per dollar of fuel (at 2007 prices).

fuels. These include electric power plants, various industrial boilers across manufacturing industries, commercial and residential furnaces, and commercial and residential furnaces.

The upstream approach involves far fewer entities or sources than the downstream approach. Table 1, adapted from Cambridge Energy Research Associates (2006) and Stavins (2007), indicates that an upstream system might involve some 2000 energy supply companies as points of regulation. In contrast, a fully downstream system – one that considered only the ultimate emitters of CO_2 – would involve millions of points of regulation since it would need to include furnaces and automobile emissions of every household.

In light of the large number of regulated entities and the huge administrative costs implied, no serious analyst endorses the pure downstream approach. Many analysts support what might be called a "practical downstream" approach, which includes midstream elements for emissions related to the carbon in oil and natural gas. This approach would capture emissions from automobile use by addressing, at the refinery level, the carbon content of gasoline and diesel fuel. And it would address emissions from household fuel use by accounting for the carbon content in natural gas pipelines. Relative to a fully downstream approach, it thus reduces by orders of magnitude the number of points of regulation. As seen from Table 1, the practical downstream approach still involves considerably more points of regulation than the upstream approach. Thus it is likely to entail significantly higher administrative costs.

The Lieberman-Warner bill voted on by the Senate in the last (110th) session of Congress employed a midstream approach: for natural gas, the points of regulation are processing plants; for oil, they are the refiners; and for coal, they are the large coal-consuming facilities (mainly electric utilities).

If introduced at the same points in the economy, a carbon tax and cap-and-trade system are likely to have very similar administrative costs. The main costs involved are monitoring the fuel sales or emissions (depending on where the policy is implemented), and enforcing the tax or penalties for non-compliance. These are similar under both policies. Under cap and trade, costs also include the expense of running the market and the transactions costs of the trades themselves, but studies of existing cap-and-trade systems indicate that these costs are very small.

Some analysts have criticized the cap and trade system as being far more costly to administer than a carbon tax. But these analysts have in fact compared an upstream carbon tax with a midstream cap-and-trade policy. This is not a valid comparison.

Given that administrative costs are smallest under an upstream approach, one might expect wide support for such an approach, regardless of whether the policy involved is a carbon tax or cap and trade. This is not the case. Many proponents of cap and trade favor the (practical) downstream approach on the grounds that this approach gives downstream entities such as large industrial emitters greater incentive to reduce emissions than would an upstream approach. Under an upstream approach, these entities would not have to hold and submit allowances: they are not the points of regulation. In this case, what encourages these entities to reduce emissions (or fuel use) are the price increases of the oil, natural gas, coal, or refined fuels brought about from the upstream taxes or quantity limits on the fossil fuels. Proponents of the downstream approach argue that these price increases do not provide as clear or strong an incentive to reduce emissions as would the obligation, under a downstream approach, to hold and submit emissions allowances (and face penalties if insufficient allowances are submitted).

Most economists are not persuaded by this argument. They maintain that, for any cap-and-trade system involving a given aggregate cap on carbon, the cost from an additional unit of emissions is likely to be the same no matter whether the system involves upstream or downstream regulation.[13] As a result, the reward from reducing emissions (whether through the adoption of an alternative production process or the installation of equipment to capture emissions) is the same under the two approaches and thus the response of emitting firms should be the same.[14]

[13] However, if there are serious non-competitive elements or information problems in the supply chain from fuel extraction to end-use good or service, the downstream cost of emissions under upstream and downstream systems could differ.

[14] There is much debate on this issue as it applies to a possible cap-and-trade system for California. In 2006 the California EPA set up a 14-member Market Advisory Committee of outside experts to arrive at recommendations for the design of a cap-and-trade system for the state. Most members of the Committee favored the downstream approach, claiming it would more effectively lead to emissions-reductions. All of the economists on the committee, however, favored an upstream approach.

Thus, the administrative costs of a carbon tax and cap-and-trade system are likely to be similar assuming they involve similar points of regulation.[15] Table 2 includes this conclusion.

b. Distributional Impacts and Compensation

The distribution of the regulatory burden is an important policy consideration, for reasons of fairness and political feasibility. Here again, however, it is the case that the two instruments have equal potential.

Consider first the impacts of a cap-and-trade system. Figure illustrates changes in producer and consumer surplus from such a system imposed on a competitive polluting industry. With no emissions policy, price and output would be p_0 and Q_0, respectively. With the introduction of a cap-and-trade system in which emissions generated by this industry are capped, firms incur costs of *c* per unit of output from induced changes in their input mix and/or adoption of end-of-pipe treatment. And the cost per unit of remaining emissions—the allowance price multiplied by emissions per unit of output—is *r*. Thus, the policy drives a wedge of $c+r$ between the resulting consumer price p_1^C and producer price p_1^P, and reduces output to Q_1.

The distribution of the burden on polluting firms depends on how the allowances are introduced. If they are introduced through a competitive auction, the policy will generate no rents: rents are bid away through competitive bidding for allowances. In this case, the loss of producer surplus is trapezoid *fgih*, while the loss of consumer surplus is *abgf*. The rectangular area *abed* represents the revenue that the government would receive from the allowance auction. These revenues can benefit taxpayers to the extent that they reduce the government's reliance on other taxes. Alternatively, the revenues could be used to pay for additional public spending, in which case the individuals would benefit from the goods or services provided. If instead the allowances are introduced through free allocation, the distribution of impacts between producers and taxpayers is fundamentally different. In this

[15] Metcalf (2007) contends, however, that the administrative costs of a U.S. carbon tax might be lower than those of a U.S. cap-and-trade program with the same points of regulation. He suggests that a carbon tax has a cost-advantage because the U.S. has a well-established federal level tax infrastructure, whereas there is no comparable institutional system for cap and trade.

case the rectangle *abed* represents rents to producers rather than revenues to the government.

Studies of NOx allowance trading under the U.S. Clean Air Act (Bovenberg *et al.* (2005)) and of potential carbon dioxide allowance trading in the United States (Bovenberg and Goulder (2001), Smith *et al.* (2002)), suggest that the rents from 100 percent free allocation would more than compensate firms for the costs they would otherwise face under these programs. In fact, these studies show that a fairly small share of the allowances – generally less than 30 percent – need to be freely allocated in order to provide sufficient rents to prevent an overall decline in firm equity values.[16] In the first phase of the European Union's emissions trading program, over 95 percent of the allowances were given away for free. In keeping with the analysis above, this generated windfall profits to many of the regulated firms. Partly in reaction to this result, there has been a distinct shift towards greater emphasis on the auctioning of allowances in the recently established Regional Greenhouse Gas Initiative in the northeast U.S. and in various climate bills recently introduced in the U.S. Congress. It should be noted, however, that both cases involve relatively modest emission reductions.

How do these impacts compare with those under a carbon tax? When allowances are auctioned, a cap-and-trade system leading to allowance price v has the same distributional impact as a carbon tax with tax rate equal to v. Again the burden to polluting firms is the loss of producer surplus given by the trapezoid *fgih* in Figure 2. The impacts are the same since under both policies, as sources of emissions (or carbon) again need to pay v for every unit of pollution generated (or carbon supplied). In contrast, when allowances are given out free, there is a smaller burden on the polluting firms than under the carbon tax just described.

One might be tempted to conclude that a carbon tax imposes burdens on polluters at least as large as, and sometimes larger than, the burdens under a comparably scaled cap-and-trade system. But this is not the case, for two reasons. First, it is possible to design a carbon

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[16] Whether these rents are sufficient to compensate firms for the costs of complying with the program depends critically on two factors. The first is the elasticity of supply relative to the elasticity of demand: the greater the relative elasticity of supply, the greater the pass through of compliance costs into producer prices, or the smaller the initial loss of producer surplus. The second is the extent of required abatement: at low levels of abatement, permit rents *abed* are large relative to compliance costs *deih*, and therefore rents are more likely to exceed the loss of producer surplus.

tax system that functions just like a cap-and-trade system with freely allocated allowances. This is a carbon tax system which grants a tax exemption for a certain amount of emissions – that is, the tax applies only to emissions in excess of a certain quantity, *x*. For a given emitting firm, this carbon tax policy has an impact identical to a cap-and-trade system in which the firm is freely granted emissions allowances authorizing emissions of *x*.

Second, the overall distribution of impacts between polluting firms and other parties depends on how revenues from a cap-and-trade system (with auctioned allowances) or a carbon tax are returned or "recycled" to the economy. In theory, by appropriately targeting the revenues, a cap-and-trade system with auctioned allowances, or a carbon tax without tax exemptions, can duplicate the distributional impact of a cap-and-trade system with freely allocated allowances, or of a carbon tax with tax-exemptions.[17] Free allocation of emissions allowances, or exemptions to a carbon tax, are not necessary to avoid firm-level adverse impacts. Some potential adverse impacts can be neutralized by recycling the revenues generated by the policy. These revenues can be recycled in the form of tax credits to firms.[18]

Hence the choice between cap and trade and a carbon tax does not determine the distribution of the regulatory burden between the polluting firms and other parties. This distribution depends on specific design features, such as the extent to which firms enjoy some emissions without charge (either by receiving free allowances under a cap-and-trade system, or by having some emissions tax-exempt under a carbon tax) and the way revenues from the policy are recycled. Clearly the distribution of regulatory burdens is a crucial policy consideration – but distributional concerns do not argue in favor or against cap and trade as compared with a carbon tax. This conclusion is recorded in Table 2.

Yet carbon taxes are generally perceived to be more burdensome to such firms – most likely because there is little consideration of the possibility of using tax exemptions under a carbon tax policy much in the same way free allowances could be used under cap and trade.

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[17] Work by Dinan and Rogers (2002), Parry (2004), and Metcalf (2007) indicates that a U.S. cap-and-trade system with freely allocated allowances would impose a disproportionately large economic burden on low-income individuals. For this reason a number of citizens' groups are highly critical of cap and trade with free allocation. Hoerner and Robinson (2008) argue that more equitable alternatives include a "cap and dividend" policy involving auctioned allowances, with all auction revenues recycled to households on a per capita basis, and a "climate asset plan," in which revenues are targeted for relief to low and moderate income households, the financing of investments in energy efficiency and renewable energy, and other tax reductions.

[18] Although individual firms can be compensated either by being awarded free allowances or by receiving firm-specific tax cuts, there has been much more focus on the former than the latter as a compensation method.

This misperception partly explains why carbon taxes are less popular politically than cap and trade.

c. Border Adjustments and Competitiveness

A major concern is the potential impact of climate policy on industry competitiveness. Not all nations (or all states) impose similar climate policies; thus a nation or state that introduces a climate policy can potentially put its own firms at a disadvantage in the broader marketplace. California policy makers contemplate how its own climate policies will affect the ability of in-state firms to compete with competitors elsewhere. Likewise, decision makers at the federal level are concerned with the impact of a national policy on the international competitiveness of U.S. firms.

Both cap and trade and carbon tax policies can offset these potential adverse impacts through adjustments at the border. Such adjustments would serve to offset the price advantage that goods imported to the U.S. might otherwise enjoy, or the price handicap that U.S. exports would otherwise suffer. Border adjustments might include taxes or allowance requirements applied to imports of fuels and carbon-intensive products, and exemptions for exported fuels or goods.[19]

Border adjustments introduce enormous practical problems, however. Consider in particular the difficulties of determining the needed border adjustments related to U.S. imports. To prevent any adverse competitiveness effect, border adjustments would need to undo the price advantages that imported goods would otherwise enjoy as a result of a domestic climate policy. It is impossible to eliminate this advantage perfectly. Nations that export goods to the U.S. differ dramatically in the stringency of their climate policies. Moreover, the technologies employed to produce goods for export to the U.S. differ across countries and differ from U.S. production methods. To discern the price advantage, one

[19] The instrument chosen for the border adjustment need not match the instrument applied to domestic firms. That is, one could accompany a domestic carbon tax with either a tax on carbon-intensive imports or limits on the quantities of such imports, based on their carbon content. Similarly, if an upstream cap-and-trade system were introduced, one could address imports either by including imported carbon within the system (that is, requiring importers to submit allowances in keeping with the carbon content of the imports) or by taxing imports.

would need to know the production technologies employed at each stage of production, since these technologies affect the ultimate direct and indirect carbon associated with production. No U.S. regulator will have the information to determine the necessary adjustment applicable to each good arriving at the U.S. border. Moreover, beyond the information problem, any "perfect" border adjustments would be extremely complex, distinguishing imports by type of good and country of origin. Recognizing these administrative constraints, proposed policies have involved far simpler border adjustment schemes that involve imposing border taxes or applying emissions allowances only for imported fossil fuels and, in some cases, for some refined fuels and highly carbon-intensive products like steel and aluminum.[20]

The border-adjustment issues have great importance – but they are largely orthogonal to choice between carbon tax and cap and trade system. In the absence of border adjustments, both policies would negatively affect the competitiveness of U.S. firms, but neither one is clearly worse than the other along this dimension. And the administrative challenges and information requirements involved in introducing border tax adjustments are largely the same under both policies. This conclusion is recorded in Table 2.

4. Where Instrument Choice Makes a Difference

We now consider dimensions along which the carbon tax and cap and trade produce different outcomes, even when comparably designed. Here we will contrast the two instruments according to their ability to: control volatility of emissions prices, address uncertainties about damages from emissions and costs of emissions abatement, achieve broad sector coverage (and related cost-effectiveness), harmonize with emissions reduction systems in other countries, address uncertainty, and overcome political barriers.

[20] The required border adjustments differ depending on whether the climate policy is instituted upstream or downstream. If an upstream policy is implemented, then in the absence of border adjustments all imports would experience a price-advantage relative to U.S. produced goods. Hence to preserve competitiveness a broad set of border adjustments would be called for. In contrast, to the extent that climate policy is applied at the point of final goods consumption, domestic final goods are put at no disadvantage relative to imported final goods. Hence fewer border adjustments are necessary. See Morris and Hill (2007) and Metcalf and Weisbach (2008) for further discussion of border tax adjustment issues.

a. Volatility of Emissions Prices

Emissions price volatility is not a problem for a carbon tax. Under that policy, the emissions price is the tax rate, and presumably the rates change smoothly through time, if they change at all. But this is a major issue for a cap-and-trade system, where the emissions price is the allowance price. Under cap and trade, the supply of allowances is perfectly inelastic – fixed at any given period of time. When the supply is perfectly inelastic, shifts in demand can cause significant price changes.

Some existing cap-and-trade systems have in fact displayed considerable allowance price volatility. The energy supply crisis in California in summer of 2000 gave power companies incentives to bring online some older power generators in the Los Angeles region. This led to a significant increase in the demand for NOx emissions allowances under the Regional Clean Air Incentives Market (RECLAIM) program, since allowances were needed to validate the emissions produced by these generators. As a consequence, NOx allowance prices rose from about $400 per ton to over $20,000 per ton between May and August 2000[21].

There was significant price volatility as well in the first phase of cap and trade under the European Union's Emissions Trading Scheme (EU ETS). As described in Metcalf (2007), about a year after its implementation, emissions allowance prices dropped dramatically with the release of information that indicated that the ETS Phase I permit allocations were very generous in the sense that they did not much constrain the covered sources. The December 2008 futures prices fell from 32.25 euros to 17.80 euros between April 19 and May 12, 2006. There was even greater volatility for the Phase I permit prices contained in December 2007 contracts. These prices dropped from 31.65 euros on April 19, 2006 to 11.95 euros on May 3. In the year 2008, the December 2009 futures prices have ranged from 13 euros per ton (January) to 30 euros per ton (June).

One way to reduce potential price volatility is to allow for intertemporal banking and borrowing of allowances. With intertemporal borrowing, firms can apply toward present

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[21] Stavins (2007) argues that some of the allowance price volatility experienced by RECLAIM was due to weaknesses in the design of RECLAIM's cap-and-trade system – in particular, the absence of provisions for banking and borrowing of allowances.

emissions the allowances allocated to them for future time periods. Similarly, with intertemporal banking, firms can apply to future periods the allowances they do not use in the current period. Such intertemporal flexibility makes the current supply of allowances more elastic and thus can dampen price volatility. With this in mind, several senators have proposed the creation of a Carbon Market Efficiency Board whose purpose would be to alleviate price volatility of a federal cap-and-trade system by expanding, as necessary, provisions for intertemporal borrowing and banking.[22] Metcalf (2007) points out that introducing such a system would raise uncertainties as to when and how the Board would act.

Another way to address volatility is to add a "safety valve" component to a cap-and-trade system (Pizer (2002), Jacoby and Ellerman (2004), Burtraw and Palmer (2006)). The safety valve establishes a price ceiling for allowances: if the allowance price reaches the ceiling price, the safety valve is triggered – that is, the regulator is authorized to sell whatever additional allowances must be introduced into the market to prevent allowance prices from rising further. Two of the most significant climate policy bills introduced in the 110th Congress – Senate Bill 1766, sponsored by Jeff Bingaman (D-NM) and Arlen Specter (R-PA), and Senate Bill 2191, sponsored by Joseph Lieberman (I-CT) and John Warner (R-VA) – contained a safety valve.

It is also possible to enforce a price *floor* by authorizing the regulator to purchase (withdraw from the market) allowances once the allowance price falls to the pre-established floor price.

While the safety valve reduces price uncertainty by establishing a ceiling price, like the carbon tax it introduces emissions uncertainty.[23] In effect, a cap-and-trade system becomes a carbon tax when the safety valve is triggered. Some proponents of a carbon tax tend to see little reason to have a "hybrid" policy of cap and trade with a safety valve. On the other hand, many analysts like the hybrid, believing that it combines nicely the attractions of cap and trade (in particular, establishing a clear emissions reduction target when the trigger price is not activated) with that of a ceiling price.

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[22] Metcalf (2007) describes the specific ways the Carbon Market Efficiency Board would address volatility.

[23] A recent paper by Murray, Newell, and Pizer (2008) proposes an "allowance reserve, a new mechanism for a cap-and-trade system that addresses both price and emissions uncertainty.

In sum, the carbon tax and the hybrid (cap and trade with safety valve) have an advantage over the simple cap-and-trade policy in avoiding price volatility. Table 3 records this advantage.

b. Addressing Uncertainty

As indicated by the discussion above and Figure 1, the two instruments address uncertainty differently. The carbon tax stipulates the price of emissions, while leaving uncertain the aggregate emissions level. Cap and trade stipulates aggregate emissions, leaving the price uncertain.

For many environmental groups, the fact that a carbon tax does not guarantee that emissions will be kept within a given limit is a crucial liability. These groups indicate that uncertainty about emissions quantities (under a carbon tax) raises the possibility that emissions will significantly exceed desired levels. At the same time, some business groups abhor the fact that cap and trade leaves prices uncertain. They emphasize that uncertainty about emissions prices (under cap and trade) constrains the business community's ability to respond to climate policy: changing the input mix (for, example, engaging in fuel substitution) and investing in research toward new technologies is more risky when future allowance prices are uncertain.

At least two arguments underlie environmental groups' opposition to emissions uncertainty and their support of fixed quantity limits under cap and trade. One is that specifying a given quantity limit on emissions is consistent with the intent of many types of climate legislation, which stipulate given emissions targets. Imposing cap and trade promotes adherence to this goal. California's Global Climate Solutions Act of 2006 (AB 32), commits the state to reducing greenhouse gases to 1990 levels by the year 2020. Environmental groups argue that a cap and trade system best assures that this target is not exceeded. Here it is worth noting that a California cap-and-trade system would not embrace all emitting sources in the state. Hence the state's adoption of cap and trade would not guarantee that statewide emissions stay within the stipulated target: it would only assure that, with proper enforcement, emissions from sources covered by the system are constrained to the level given by the system's aggregate cap.

A second underlying argument is that leaving the emissions level uncertain risks greater harm to society than allowing uncertainty about emissions prices. If the relationship between emissions and environmental damage is highly nonlinear, then allowing emissions to exceed given levels might pose significant risks. This tends to favor setting a limit on emissions quantities. On the other hand, setting such a limit would compel firms to reduce emissions to a given level no matter what their costs of abatement turn out to be. If abatement costs are highly nonlinear, rising sharply with the amount of abatement, there's a risk that abatement costs could become very large.

Which of these two risks – high environmental damages or high abatement costs – is more important? This is an empirical matter. On this issue some analysts refer to the significant contribution of Weitzman (1974), which compared the expected efficiency losses from inaccurate price-based (as with carbon taxes) with those from quantity-based (as with cap and trade) regulation in the presence of uncertainty about costs and damages. His analysis indicates that when the marginal damage function is relatively steep (as a function of emissions), then a quantity-based instrument (like cap and trade) is superior to a price-based instrument (like a carbon tax) in the sense that it yields a larger expected value of efficiency gains. In contrast, when the marginal abatement cost function is relatively steep (as a function of emissions reductions), a price-based instrument yields larger expected efficiency gains.

Several recent studies modify or extend the Weitzman framework to gear it more closely to climate policy.[24] These analyses tend to suggest that a carbon tax (or the hybrid) would generate larger expected gains in efficiency on the grounds that, in the climate change context, the relevant marginal abatement cost function is steeper than the relevant abatement cost function.

Stavins <cite> further dismisses concerns about the emissions uncertainty that arises under the hybrid or carbon tax. He notes that the uncertainty about emissions quantities under the hybrid can be reduced or eliminated if policy makers pledge to invest in other,

[24] See Hoel and Karp (2002), Newell and Pizer (2003), and Karp and Zhang (2005). Weitzman's analysis considered the case where damages are a function of the flow of output (or emissions). Global climate change is mainly a function of the stock of greenhouse gases, not the flow. These recent studies have considered the issue of price versus quantity instruments when damages depend on the stock. The results from these studies are broadly similar to Weitzman's findings.

offset projects to compensate for whatever increase in emissions would otherwise occur as a result of including the safety valve (price ceiling mechanism) in climate policy. Revenues from emissions allowances sold could be used to finance some or all of these offset projects.[25]

These arguments tend to favor the carbon tax or hybrid over pure cap and trade. However, the arguments are not air tight. First, there remains some disagreement on the empirical issue of relative steepness. Second, the Weitzman framework is not relevant in some policy contexts. It is most relevant to situations where the policy objective is *net benefit maximization*: achieving the level of emissions reductions that maximize the benefits from the reductions minus the costs of achieving those reductions. For many climate policy efforts – particularly those at the state or regional levels – the objective is instead *cost-effectiveness*: the achievement of some previously established level of emissions reductions at minimum cost. By establishing a statewide or regional emissions target, the policy maker is implicitly attaching great weight to achieving this target – more weight than implied by marginal damages schedule in the Weitzman framework. This tends to favor pure cap and trade. Thus, although considerations of the relative costs of emissions and price uncertainty seem to weigh against pure cap and trade, there remains some uncertainty about the implications of these uncertainties.

A recent paper by Murray, Newell, and Pizer (2008) brings in a different aspect of the uncertainty issue. It argues that a cap and trade system (or the hybrid) with intertemporal banking of allowances has more ability to adjust to new information in the presence of uncertainty than does the carbon tax. Their argument relies on the fact that under a carbon tax, current marginal abatement costs are largely determined by the carbon tax rate in place today. In contrast, under a cap-and-trade system (or the hybrid) with intertemporal borrowing and banking, the current cap on allowances does not fully determine current marginal abatement costs: changes in expectations about future policy will lead to adjustments in current abatement decisions. This greater ability to respond to changing expectations gives cap and trade and advantage over the carbon tax.

[25] Stavins makes this point in reference to the hybrid, but it applies equally to concerns about uncertain emissions from a carbon tax.

Overall, the uncertainty dimension does not seem to clearly favor any single policy alternative. On the one hand, the carbon tax or hybrid seems to have an advantage along the "Weitzman" uncertainty dimension – avoiding large policy errors in the face of uncertainties about environmental damages and abatement costs. On the other hand, the hybrid or pure cap and trade program could have an edge over the carbon tax along the lines considered by Murray, Newell and Pizer – attaining flexibility to adjust to new information. These points are recorded in Table 3.

c. Wealth Transfers to Oil Exporting Countries

Recently, Judd (2008) has shown that a cap-and-trade system can lead to wealth transfers from oil-consuming to oil-exporting nations that would not occur under a carbon tax.

Judd implicitly considers a simplified setting where the only carbon-based fuel is oil. Suppose that in the absence of cap and trade, the equilibrium price of oil on the world market, given by the (fixed) world supply and the world demand is p_0. Suppose a cap-and-trade program is introduced. The price of oil now rises to consumers, since oil users must now face an allowance price. Let z represent the cost of allowances needed per unit of oil.[26] The new equilibrium is established where the quantity of oil demanded is Q1 and the price of oil inclusive of the allowance cost is $p0 + z$, as in the left-hand portion of Figure 3. The rectangular area between p_0 and $p0 + z$ and extending up to the quantity Q_1 is the value of the allowances. This value accrues either as rents to domestic firms or as revenue to the Treasury and the public (see Section 3 above).

Judd notes that, under these conditions, oil exporters could exploit this situation: they could reduce supply and cause world oil prices to rise to p_1 (or the original $p_0 + z$) without suffering any loss of revenue. In fact, the exporters would *gain* revenue from doing so! How is this possible? If the oil exporters reduced supply to *S'* while the cap and trade system was in place, as long as the allowance price z remained positive the quantity of oil demanded would be less than Q_1 . For in this case the price to consumers would be $p_1 + z$, above the

[26] This cost is positive whether or not the firm obtains the allowances free, since there is an opportunity cost from using an allowance rather than selling it.

price that yields a quantity demanded of Q_1. This would not be a sustainable equilibrium, however. So long as the quantity of oil consumed fell short of Q_1, emissions would be below the amount "targeted" by the supply of allowances. (Recall that the supply of allowances was such as to bring oil demand down to Q_1 when the oil supply was *S*.) So now the demand for allowances would fall short of the supply, and the price of allowances would fall. Indeed, the price of allowances would continue to fall until the overall price of oil to consumers (including the component due to the allowance price) was p_1. But given that the oil exporters have reduced the supply to *S'*, this requires that the allowance price z fall to zero. Any positive price of allowances would imply a price of oil to consumers above p_1, a quantity demand of oil below Q_1, and a demand for allowances below supply. Hence the reduction in the world supply of oil brings oil demand (and emissions) down by exactly the amount otherwise reduced through scarce allowances. Hence the new equilibrium is as on the right-hand portion of Figure 3. The allowances are no longer necessary: their price goes to zero. Importantly, what was rent or revenue to domestic firms or the domestic Treasury now becomes revenue to the oil exporters. The cap-and-trade program becomes considerably more costly than the comparable carbon tax, whose revenues are retained domestically.

A qualification to Judd's analysis is in order. The result is muted once one accounts for the fact that oil is not the only fuel that would be covered by cap and trade. The CO_2 allowance price is determined not simply by the demand for oil but by the demands for other carbon-based fuels (coal and natural gas) as well.[27] As a result, if oil exporters raised the world price, CO_2 emissions would fall less than in proportion to the reduction in oil quantity demanded, since higher oil prices would induce substitutions to other carbon based fuels and associated increases in emissions from these other fuels. This means that the allowance price would not fall one-for-one with the increase in the world oil price. This in turn reduces the extent of the international wealth transfer. In this more realistic setting, by increasing world oil prices the oil exporting countries transfer wealth to owners of competing fuels as well as to themselves.[28]

[27] In 2003, oil accounted for about 43 percent of the carbon in U.S. fossil fuels consumed. It might account for a roughly similar percentage of emissions under a climate policy.

[28] A minor comment might be worth noting. Judd suggests that the main result from his analysis is that cap and trade makes consumer demand for oil inelastic. The present paper suggests that the crucial finding is that cap and trade gives oil exporters the ability to convert allowance revenues or rents into revenues for the oil-exporting countries.

Still, Judd's argument indicates a valid disadvantage of cap and trade. This is recorded in Table 3.

d. Budget Discipline

Metcalf (2007) identifies an institutional issue that could affect the relative success of the two policy alternatives in terms of the disbursement of any revenues that may be collected. He points out that revenues from a carbon tax would fall under the domain of the House Ways and Means Committee and Senate Finance Committee, and points out that coordination across these two tax committees has a long history. He indicates that, in contrast, disbursement of revenues from auctioned allowances under a cap-and-trade system would likely involvement not only of these committees but also of the House Energy and Commerce and Senate Energy and Natural Resources committees. He suggests that the latter committees might be predisposed toward using the revenues to finance environmental projects less inclined toward recycling the revenues so that the overall policies remain revenue-neutral. To the extent that revenue-neutrality is considered a critical feature of climate policy, this can be seen as a potential disadvantage of a cap-and-trade program (and a hybrid program as well). Table 3 records this idea.

e. Potential for Broad Coverage

Stavins (2007) points out that the political dynamics surrounding a carbon tax and cap and trade are likely to be very different, and that this will have important implications for cost-effectiveness. Pointing to historical experience, he argues that as a carbon tax moves from initial proposal toward implementation, various industries will seek, and some will win, exclusions from the tax. This would make the carbon tax less cost-effective: any given target for emissions reductions will be reached at a higher cost, the narrower the set covered pollution sources.

Stavins contrasts this result with what has occurred historically as the details of a cap and trade system get defined prior to implementation. He points out that stakeholders struggle less for outright exclusions than for a larger share of the stock of freely allocated emissions allowances. This has distributional consequences, but has little impact on cost-effectiveness because, as indicated earlier, the free allocation of allowances does not affect marginal prices or the overall sectoral coverage of the program. This implies an advantage of cap and trade.

Thus there are potentially important differences in stakeholder activities as these two types of policies get worked out, and these differences have implications for cost-effectiveness. Table 3 acknowledges that consideration of these differences tends to weigh in favor of cap and trade (or the hybrid).

Some policy oriented economists might dismiss these considerations, claiming that "these are political matters" and therefore outside the domain of economic analysis. But others would argue that since economic outcomes depend importantly on these phenomena, they should be given close consideration. We will return to the distinction between these two approaches to policy evaluation in the conclusion to this paper. It will turn out that the choice between the two approaches fundamentally affects which of the two policy options one is likely to regard as superior.

f. Potential for Linkages across Jurisdictions

Initially separate cap-and-trade systems can be linked, and previously distinct carbon tax systems can be harmonized (that is, the rates can be set equal). Linkage and harmonization can yield cost savings.

The cost-effectiveness attraction of allowance trading applies to any single cap-and-trade system. But linking once-separate cap-and-trade programs allows for further (cross-jurisdictional) reallocations of abatement effort and thereby yields further cost reductions. Thus, when the separate cap-and-trade programs of individual U.S. states are linked, or when a U.S. program is linked with a European one, there is the potential for additional cost reductions.

Consider, for example, the impacts of linking a U.S. federal cap-and-trade system with the European Union's Emissions Trading Scheme. Suppose that, before linkage, the emissions allowance price is $15 per ton in the EU ETS and $25 per ton in the U.S. If the two systems were linked, U.S. entities would be net purchasers of the (cheaper) EU ETS allowances, and the prices of U.S. and ETS allowances would equate somewhere between $15 and $25 per ton. Linkage would induce greater abatement effort in the EU, leading to global cost savings.

Linking individual cap-and-trade systems only works when the two systems have structural similarities: while it may make sense to link two upstream programs or two downstream programs, linking an upstream with a downstream program is problematic. This can lead to double-counting: the carbon content constrained under the upstream program of one region will again be constrained by the downstream program in another.

The analog to linkage of cap-and-trade systems is the harmonization of carbon tax systems – that is, the use of a common tax rate across jurisdictions. Suppose that the EU initially had a carbon tax of $15 per ton, and that the U.S. originally instituted a carbon tax of $25 per ton. Harmonizing the two taxes at an intermediate level would generate the same economic outcomes and cost savings as linking two cap-and-trade systems in the example above.[29]

How do these considerations affect the choice between carbon taxes and cap-and-trade? History matters here. The fact that other nations have already committed to cap and trades seems to weigh in favor of a U.S. cap-and-trade system over a U.S. carbon tax, since opportunities exist for linking a U.S. cap-and-trade program with such programs elsewhere, whereas there seems to be less room, at present at least, for tax harmonization. While advocates of cap and trade point out this advantage, carbon tax proponents argue that current (and possibly transitory) international commitments toward cap and trade should not carry great weight in a U.S. decision about a long-term climate policy. (We return to this issue in the final section of this paper.)

Further considerations complicate the ranking of carbon taxes and cap and trade as regards the potential for linkage. One potential difficulty associated with international linking cap-and-trade programs is the potential for very large revenue flows from the nations

[29] For comparability, the harmonized carbon tax would need to yield the same overall emissions reductions as under the linked cap-and-trade systems. The harmonized tax rate that achieves the same reductions is the same as the allowance price that results when the two cap-and-trade systems are linked. This is the price that equates marginal abatement costs across regions while leading to the same emissions reductions as when the two cap-and-trade systems are linked.

purchasing allowances to those selling them. In contrast, an internationally harmonized carbon tax does not directly produce any international revenue flows. The potential for large international revenue flows under cap and trade raises concerns about exchange rate and other macroeconomic effects.[30] However, experience to date with the European Union's Emissions Trading Scheme yields no evidence of adverse exchange rate or macroeconomic consequences from trade-induced revenue flows.

The potential for large international revenue flows is especially pronounced when one of the nations involved utilizes a (relatively low) safety valve. Under these conditions, no matter how many allowances other countries purchase from this country, the allowance price will remain the same (assuming the safety valve is triggered). As pointed out by Stavins (2007), other nations may be unwilling to link with a nation that utilizes a safety valve, given the possibility of very significant revenue outflows. This suggests a tension between the goals of price stability (addressed through a safety valve) and cost-effectiveness (addressed through international linkages).

At the same time, arriving at a uniform international carbon tax raises practical difficulties. Various nations may claim that they already tax carbon through existing taxes on individual fossil fuels or on refined fuels (gasoline, home heating oil, etc.). Arriving at a uniform international tax on carbon would in theory require knowledge of the incidence of a wide range of existing energy taxes – in practice this can only be approximated. Individual nations might well manipulate the calculations so as to suggest they are already paying significant taxes on carbon and thereby avoid much of an increase as part of an international effort to obtain a uniform international tax rate.

Thus there are significant challenges to the international linkage of carbon taxes or cap-and-trade systems. However, the most important consideration might be the first – that other nations already have cap and trade in place. This favors cap and trade. This advantage is acknowledged in Table 3.

g. Perceptions and Political Feasibility

[30] See, for example, McKibbin and Wilcoxen (1997).

Currently, cap and trade has more political support than a carbon tax. The general public dislikes taxes, and cap and trade seems to benefit from the fact that it is viewed as something different from a tax. In fact, as discussed above, cap and trade can be designed to produce the same distributional impact as any carbon tax, and vice versa. More specifically, a cap-and-trade policy involving auctioned allowances has the same impact as a carbon tax, assuming the revenues from the two policies are used in the same way. And a cap-and-trade system with freely allocated allowances has the same distributional consequences as a carbon tax with similar inframarginal exemptions. Thus the relative political popularity of cap and trade is partly due to misperception. Table 3 indicates that cap and trade has the advantage of greater current political support. In the next section we discuss whether this constitutes a valid criterion for policy choice.

5. How It Adds Up

A few decades ago, there was much debate about whether to adopt market-based instruments for environmental policy. The present-day discussions about the relative merits of cap and trade and carbon taxes seem to mark a new era for environmental policy. The main focus of recent national-level climate policy debates is no longer whether to introduce a market-based instrument, but which type to employ.

This paper claims that some of the issues raised in the current debates have little real bearing on the relative merits of the options. It emphasizes that a carbon tax, cap and trade, the hybrid have similar administrative costs when implemented at the same point in the economy (upstream, midstream, or downstream). Similarly, there is no inherent difference in how policy costs (or windfall gains) would be distributed across households or firms. The distribution of these costs depends principally on two design features: the extent to which firms are allowed inframarginal emissions without charge, and the way that revenues from auctioned emissions allowances or a carbon tax are spent. Carbon taxes and cap and trade have the same range of options along these two design dimensions, and any distributional impact generated by one of the instruments can be matched by the other. The two instruments also have similar implications for the international competitiveness of domestic firms. This depends on border adjustments, and the potential for and nature of such adjustments is largely independent of whether cap and trade or a carbon tax is introduced.

On some other important dimensions the two alternatives perform quite differently, however. A look at Table 3 indicates that the "hybrid" extension of a pure cap-and-trade system – that is, a cap-and-trade program with an allowance price ceiling – performs at least as well as pure cap and trade along all the dimensions listed, and in contrast with pure cap and trade is able to avoid emissions price volatility. To prefer pure cap and trade over the hybrid, one might need to adopt the view that having certainty over emissions quantities is more important than having certainty over emissions prices. Empirical applications of the Weitzman-type analysis cast doubt on this view. Moreover, as discussed earlier, the uncertainty about emissions quantities under the hybrid can be reduced or eliminated if policy makers pledge to invest in other, offset projects to compensate for whatever increase in emissions would otherwise occur as a result of including the safety valve (price ceiling mechanism) in climate policy.

The choice between the hybrid and carbon tax alternatives is less clear cut. Table 3 reveals that each alternative has advantages along certain dimensions. Importantly, however, how one ranks these two policies connects closely with how one regards some "political" factors – political dynamics, existing climate policies in other nations, and current domestic policy sentiment. These factors affect the issues listed at the bottom of Table 3. Along the dimensions in the *top* two thirds of the table and less closely connected to these political issues, the carbon tax seems to have an advantage. It performs equally well in dealing with price volatility and uncertainty, while avoiding possible problems that the hybrid could encounter in terms of international wealth transfers and domestic budget discipline.

However, as discussed in the preceding section, the carbon tax seems handicapped along the dimensions more closely connected with the political factors. First, political-economy considerations might imply that a carbon tax will be less broad in its sector coverage (and therefore less cost-effective) than the hybrid. Second, given the existence of other cap-and-trade systems overseas, it might be easier to achieve international harmonization through a U.S. cap-and-trade program (such as the hybrid) than with a U.S.

carbon tax. Third, cap and trade and the hybrid are more popular (currently) than the carbon tax alternative, in part because their tax-like functions are not fully recognized. If one gives great weight to these issues, the hybrid emerges as the best choice.

How much weight should one give to these factors? Much depends on one's view of the whether, within the policy-relevant time frame, these factors – political dynamics, existing climate policies in other nations, and current domestic policy sentiment – can be muted or eliminated. A "constrained" policy analysis would regard these factors as fixed within the relevant time frame. An adherent to this approach would claim that one should accept and work within these constraints rather than disregard them or assume they can be overcome in order to seek some more "ideal" policy. In terms of the dimensions at the bottom of Table 3, this constrained view is that *within the relevant time frame*: (1) it will not be possible to change the political dynamics that cause a carbon tax to span a narrower range of economic sectors (and be less cost-effective) than the hybrid; (2) other countries are not going to discard the cap-and-trade systems they have, and this makes a U.S. cap-and-trade or hybrid system attractive in terms of international linkages; and (3) cap and trade and the hybrid's greater current popularity relative to the carbon tax is an important consideration. We may refer to this as the "constrained' policy view.

The "unconstrained" policy approach gives less weight to these factors, and consequently tends to regard the carbon tax as most attractive. One is more likely to adopt the unconstrained approach to the extent that one believes that, though public policy and other actions, the various constraints discussed can be modified or eliminated. This belief finds support to the degree that one feels that there is relatively little urgency to adopting climate policy, so that there is considerable time to address and modify these constraints. Thus, in particular, an adherent to the unconstrained approach might assert that: (1) public policy ultimately can confront and overcome the political dynamics that work toward a narrow base under the carbon tax; (2) eventually other countries can be persuaded to move to carbon tax systems, which could be harmonized with a U.S. carbon tax or consolidated into a single international carbon tax; and (3) over time the public's unfounded preference for cap and trade (or the hybrid) can be eliminated through information programs and other measures. To the extent that this view is correct, the carbon tax emerges as most attractive.

Which view is correct requires an assessment of political opportunities and of the extent of urgency of implementing a domestic policy. Such an assessment is beyond the scope of this paper. Still, by revealing the potential merits and shortcomings of the carbon tax, hybrid, and pure cap-and-trade alternatives, and by showing how the overall assessment of these policies connects with two very different approaches to policy analysis, the paper aims to advance the policy debates. Policy makers should not lose sight of the fact that each of the options – the carbon tax, the hybrid, and pure cap and trade – has significant attractions and the potential to improve social welfare substantially relative to the status quo. Much is to be gained by avoiding great delay in adopting one of these options, irrespective of what the particular choice should turn out to be.

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Figure 1

Emissions and Prices under Carbon Tax and Cap and Trade

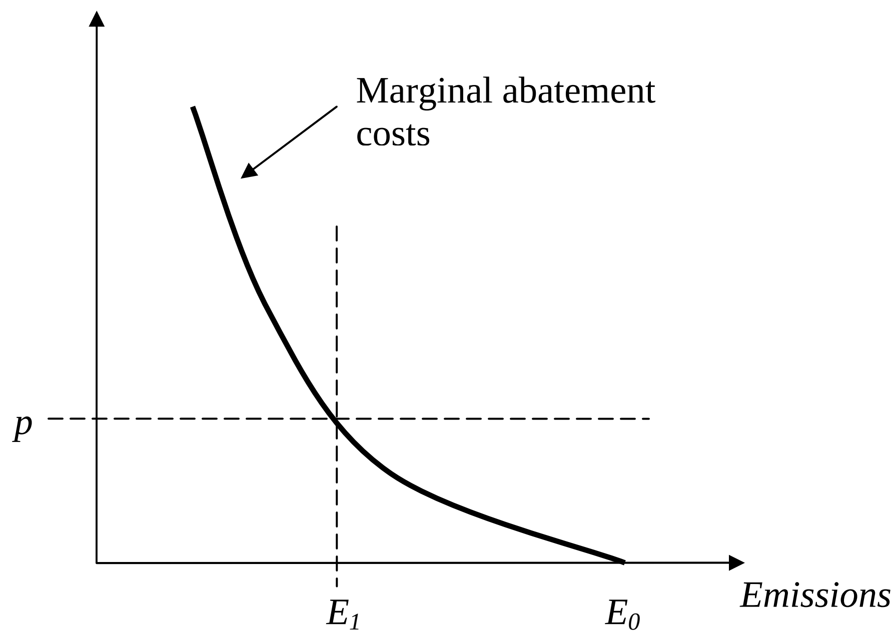

Table 1

Alternative Points of Regulation
For a U.S. Carbon Tax or Cap and Trade System

	----- Fossil Fuel Category -----		
Point of Regulation	**Coal**	**Oil**	**Natural Gas**
Upstream	Mining and imports (500 companies	Production wells and imports (750 companies)	Production wells and imports (750 companies)
Midstream	Rail, barge, and trucking operations (numbers not estimated)	Refining (200 refineries)	Pipelines and processing (200 pipelines, or 1,250 local distribution companies and 500 liquified natural gas plants)
Downstream	Electric power plants (500 plants)	Mobile sources, industrial boilers, and electric power plants (millions of sources)	Industrial boilers, commercial and residential furnaces, and electric power plants (millions of sources)

Source: Adopted from Cambridge Energy Research Associates (2006).

Table 2

The Importance of Policy Design (Rather Than Choice of Instrument) to Administrative Costs, Distribution, and International Competitiveness

Issue		**Comment**
Administrative Cost		Depends largely on point of regulation (upstream, midstrem, or downstream), not choice of instrument Cap and trade and carbon tax have equivalent options for point of regulation.
Distribution of Burden across Industries and across Household Groups		Depends on: (1) extent of free emissions (2) disposition of policy revenues Cap and trade and carbon tax have equivalent options along these dimensions.
International Competitiveness		Depends on border adjustments. Cap and trade and carbon tax have similar opportunities for border adjustments.

Table 3

Relative Advantages of Carbon Tax, Hybrid*, and Cap and Trade

(check marks indicate relative advantage)

Issue	**Carbon Tax**	**Hybrid**	**(Pure) Cap and Trade**
Issues Less Closely Connected to "Political" Factors			
Avoiding Emissions Price Volatility	✓	✓	
Addressing Uncertainty			
Weitzman (price vs. emissions uncertainty)	✓	✓	
Murray-Newell-Pizer (flexibiity to respond to new information)		✓	✓
Avoiding Wealth Transfers to Oil Exporting Nations	✓		
Achieving Budget Discipline	✓		
Issues More Closely Related to "Political" Factors			
Gaining Broad Coverage		✓	✓
Harmonizing with Emissions Reduction Systems in Other Countries		✓	✓
Gaining Political Approval		✓	✓

* The hybrid is a cap-and-trade system with a safety valve (provision for a price ceiling).

Figure 2

Impacts of Cap & Trade and Carbon Tax
On Producer and Consumer Surplus

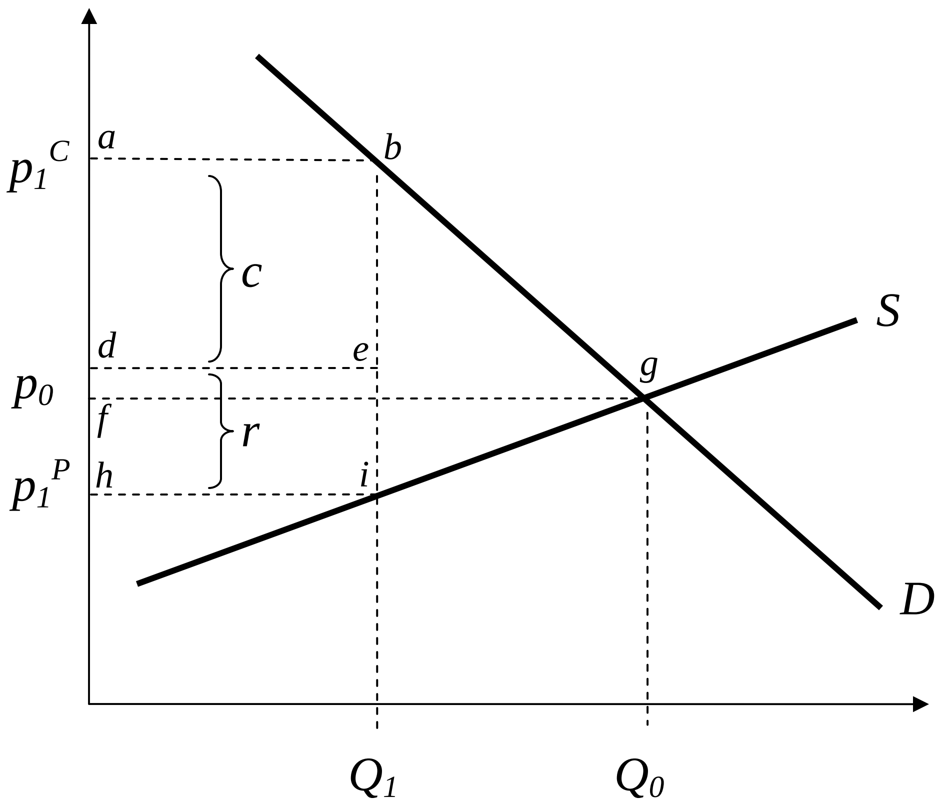

Figure 3

Potential for Wealth Transfers to Oil Exporting Countries
Under Cap and Trade