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COST CONTAINMENT IN CLIMATE CHANGE POLICY: ALTERNATIVE APPROACHES TO MITIGATING PRICE VOLATILITY

Gilbert E. Metcalf

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ABSTRACT

Cap and trade systems are emerging as the front-running policy choice to address climate change concerns in many countries. One of the apparent attractions of this approach is the ability to achieve hard limits on emissions over a control period. The cost of achieving this certainty on emission limits is price volatility. I discuss and evaluate various approaches within cap and trade systems to reduce price volatility. A fundamental trade-off exists between certainty of emission limits and price volatility. A pure carbon tax sacrifices certainty of emission limits in favor of price stability. I discuss how a hybrid carbon tax can be designed to achieve a balance between price stability and emissions certainty. This hybrid, dubbed the Responsive Emissions Autonomous Carbon Tax (REACT), combines the short-run price stability of a carbon tax with the long-run certainty of emission reductions over a control period.

Gilbert E. Metcalf
Department of Economics
Tufts University
Medford, MA 02155
and NBER
gilbert.metcalf@tufts.edu

I. Introduction

Cap and trade systems have emerged as a front-running policy choice to address climate change in many countries. One of the apparent attractions of this approach is the ability to achieve hard limits on emissions over a control period. The American Clean Energy and Security Act of 2009 (H.R. 2454) reported out of the US House Committee on Energy and Commerce last month, for example, limits emissions among the controlled sectors to 132 billion metric tons of carbon dioxide equivalent (CO_2e) between 2012 and 2050.

The cost of achieving certainty on emission limits is the risk of price volatility. Responding to the experience with previous cap and trade systems a number of proposals have emerged to dampen price volatility with cap and trade systems (often referred to in the policy debate as "cost containment" measures). In the limit proposals to dampen price volatility become, effectively, carbon taxes. Hybrid cap and trade systems take on some of the attributes of a carbon tax while maintaining the core features of a cap and trade system. In this paper I discuss and evaluate various approaches within cap and trade systems to reduce price volatility focusing on this fundamental trade-off between certainty of emission limits and price volatility.

Most discussion has focused on how hybrid cap and trade systems can be designed to take on some of the desirable characteristics of carbon taxes. In contrast I discuss how a hybrid carbon tax can be designed to achieve a balance between price stability and emissions certainty. This hybrid, dubbed the Responsive Emissions Autonomous Carbon Tax (REACT), combines the short-run price stability of a carbon tax with the long-run certainty of emission reductions over a control period.

In the next section I review the experience of previous cap and trade systems with price volatility. The following section surveys approaches within cap and trade systems to address this issue. Here I focus on the tension between reducing price volatility and providing certainty over emission caps. Section 4 describes how this tension can be addressed within a carbon tax framework. Here I describe a hybrid carbon tax that provides a balance between price certainty and emission limits. Section 5 provides some preliminary results for a particular specification of a hybrid carbon tax. Section 6 concludes.

II. Tradeoffs Between Price Certainty and Emission Limits

A. Optimal Instrument Choice

Market based responses to environmental externalities fall broadly into one of two categories: price or quantity instruments. An emissions tax is a price based instrument while a cap and trade system is a quantity based instrument. In the absence of uncertainty either approach can be used to achieve a given environmental goal. If a tax is set on emissions, firms adjust emissions until the emission fee is set equal to the marginal cost of abatement on emissions. Conversely if a cap and trade system is utilized firms buy and sell permits. The price of the permits is set by demand and supply conditions. Demand follows from individual firms' marginal cost of abatement functions while supply is set by the aggregate cap. In equilibrium each firm sets its marginal cost of abatement equal to the price of permits. A tax set at rate s that leads to cumulative emissions equal to Q is observationally equivalent to a cap and trade system that sets an aggregate cap of Q. Equilibrium permit prices will equal s.

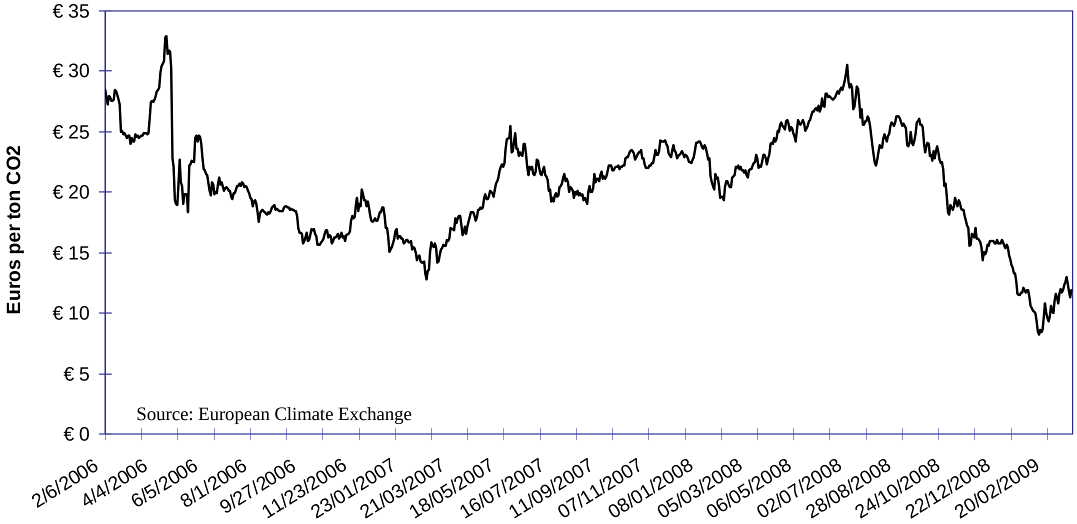
The two systems differ in the presence of uncertainty. Weitzman (1974) analyzed price and quantity instruments and showed 1) that the two approaches were ex ante equivalent when the only uncertainty is over the marginal damages of the externality; and 2) that either the price or quantity approach could dominate ex ante depending on the relative slope of the marginal damage and abatement curves. Price (quantity) approaches provided higher expected net benefits if the marginal damage curve was less (more) steeply sloped than the marginal abatement cost curve.

Greenhouse gases are a stock pollutant and the analysis is a bit more complicated but the intuition carries over to a large extent. Because this is a stock pollutant that persists in the atmosphere for a very long time, marginal damages from emissions in any given year are essentially constant. A flat marginal damage curve favors the tax. This is borne out by a number of analyses that have found that taxes dominate cap-and-trade systems for a broad range of parameter values consistent with scientific understanding of the global warming problem (for example, Hoel and Karp (2002); Karp and Zhang (2005, Newell and Pizer (2003)).

The analysis above assumes a linear tax system. Kaplow and Shavell (2002) argue that the potential superiority of the quantity instrument over the price instrument only holds under the restriction of linear tax systems. If non-linear taxes are allowed then the tax is uniformly superior. This follows from the insight of Roberts and Spence (1976) that a mixture of price and quantity instruments can be more efficient than either alone since it allows the price schedule to more closely match the marginal damage function. The superiority of the non-linear tax, argues Kaplow and Shavell, is that firms' responses to the tax reveals information about their marginal abatement cost functions, information that is not revealed by quantity controls.[1]

B. Price Volatility with Pure Cap and Trade Systems

Carbon taxes ensure a given price for carbon emissions while permit prices in a cap-and-trade system are uncertain. Price volatility for cap-and-trade systems is well known. The EU ETS illustrated this dramatically in April 2006 when CO_2 permit prices fell sharply on the release of information indicating that the ETS Phase I permit allocations were overly generous. The December 2009 futures price fell from a peak of €32.90 on April 20 to €18.90 on May 3. Prices rebounded briefly but drifted downward for much of the rest of the year (Figure 1). They then gradually rose during 2007 and reached a peak of €30.53 on July 1, 2008. Since then the price collapsed to a low of €8.20 on Feb. 12, 2009. Currently they are hovering in the range of €12 per ton.



Source: European Climate Exchange

Figure 1. ECX Futures Contract Settlement Price

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[1] The quantity control reveals information about the marginal abatement cost functions in the neighborhood of the price determined by the aggregate cap. A non-linear tax constructed to approximate the marginal damage function (ex ante) reveals information about firm abatement costs globally.

The permit price volatility experienced in the Europe's cap-and-trade program is not unique. NO_x prices in the Northeast states' Ozone Transport Commission jumped to nearly $8,000 per ton in early 1999 before falling back to more typical levels between $1,000 and $2,000 per ton. They spiked again to similar levels in 2003 before falling back to roughly $2,000 per ton. Permit prices for the California Regional Clean Air Incentives Market (RECLAIM) rose abruptly from under $5,000 per ton of NO_x to roughly $90,000 per ton in 2000. Permit prices in EPA's Acid Rain Program rose to nearly $1,600 per ton SO_2 in late 2005 from a price of roughly $900 at the beginning of the year (see Pizer (2005) for discussions of price spikes in all of these markets).

Unexpectedly high permit prices have the potential to erode political support for the program. Regulators in the RECLAIM market, for example, relaxed the permit cap in response to the high prices. The response in the RECLAIM market should provide a cautionary note for policy makers. Highly volatile permit prices are likely to create dissatisfaction with a cap-and-trade program and make business long run investment planning difficult.

III. Mechanisms to Address Price Volatility in Cap and Trade Systems

Price uncertainty is a significant concern with cap-and-trade programs. At the outset, it is important to distinguish between short-run and long-run price uncertainty. Short-run price uncertainty (or volatility) can reflect short-term weather conditions, equipment outages and other temporary phenomena. It is not desirable for firms to face fluctuating prices on a daily (or perhaps hourly) basis due to these sorts of phenomena.

Long-run price uncertainty reflects our inability to predict whether and when various technologies to reduce greenhouse gas emissions come on line. Considerable uncertainty exists, for example, over the feasibility of carbon capture and storage at scale. Similarly political and technological constraints on nuclear power could significantly affect long-run permit prices.

Provisions to limit short run volatility are viewed as essential to build political and popular support for any climate change legislation. The first point to make here is that cost containment provisions are entirely unnecessary under a carbon tax. Second, while various approaches exist for reducing short run volatility in a cap-and-trade system, all such approaches come with some degree of complexity and uncertainty over their ultimate ability to dampen price volatility.

A. Cost Containment Under Cap and Trade

One approach to limiting volatility is to include a “safety-valve” provision –This allows firms to purchase an unlimited number of permits at a set price and thus sets a ceiling on the price of permits. If the market price for permits is below the safety valve price, then firms will simply purchase permits in the open market. Once permit prices reach the value of the safety valve, firms will purchase any needed permits directly from the government. Safety valve provisions protect against upside price risk at the cost of loosening the emissions cap. Pizer (2002) provides an early analysis of a hybrid cap and trade system that relies on a safety valve. Stavins (2007) recently proposed a cap and trade system with a safety valve set at "twice to ten times the expected level of allowance prices" (p. 22) with the revenues to be used to finance emission reductions from uncapped sources. Safety valve proposals are often combined with banking and borrowing provisions for permits. Banking allows firms to save permits issued on a particular year for use in later years. Borrowing allows firms to use future allowances to cover current emissions.

One possible problem with the traditional safety valve approach is that anticipation of future government policy to reduce emissions creates an arbitrage opportunity. If a cap-and-trade program with unlimited banking is designed, then incentives will exist to bank low price permits in anticipation of future tightening of the cap. While one can require that any permits purchased through a safety valve be used in the year they are purchased, they can still free up other permits to be banked for the future thereby achieving the result of substituting low price permits for future higher price permits.

Another problem with traditional safety valve approaches is that they remove the certainty over emission limits provided by pure cap and trade programs. This has made them unpopular with environmental groups. A straight safety valve has also raised concerns with some that the expected price of permits is driven down by the safety valve thereby undercutting incentives for investments in carbon-free technologies.   One response to this concern is to combine a safety valve with a floor price on emissions.[2] This combination creates a band within which permit prices may fluctuate and if constructed appropriately can ensure the same expected price for permits as occurs in a cap and trade system with no cost containment mechanism.

The safety valve approach has been modified to address the concern that overall emission limits may be exceeded with a traditional safety valve. One simple way to do this is to cap the annual amount of permits that may be purchased at the safety valve

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[2] See, for example, Dallas Burtraw's testimony to the Committee on Ways and Means on Sept. 18, 2008.

price. This is the idea of a strategic allowance reserve.[3] In addition, one can require that any permits sold for cost containment reasons are simply borrowed from allowance allocations in future time periods. This is the approach taken under the Waxman-Markey bill (HR 2454).

Putting constraints on the number of safety valve permits that may be purchased may address the arbitrage opportunity raised by the anticipation of future policy tightening. But it also raises its own issues. Many of the cap-and-trade policies currently under consideration call for extremely sharp reductions in emissions (more precisely allowance allocations) by the middle of the century. Various analyses of these policies suggest that allowance banking will be sizable in the early phase of the program.[4] Making more permits available in the present through an allowance reserve that borrows against future allocations may simply lead to further banking to offset anticipated higher future prices due to a tightening of the future cap. In other words the reserve may be ineffective at damping price volatility.[5]

B. How Sure are Emission Caps Under a Pure Cap and Trade System?

A central argument put forward by many environmental groups for favoring a cap and trade system over a carbon tax is the certainty of emission limits under a cap and trade system and the lack of hard limits on emissions under a tax-based approach. A cap and trade system, so the argument goes, provides certainty over the emission limits while the tax does not.[6] There are three flaws in this argument. First, every cap and trade

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[3] See Murray, Newell and Pizer (2009).

[4] See, for example, Appendix D in Paltsev et al. (2007).

[5] This is an environmental analogue to the Ricardian Equivalence Proposition posited by Barro (1974).

[6] See, for example, the posting by Gernot Wagner and Nathaniel Keohane, "The case for cap-and-trade: There's certainty in the environmental outcome" posted on the Bulletin of the Atomic Scientists Roundtable

proposal under serious consideration has some form of price relief mechanism. A straight safety valve approach (such as proposed by Stavins (2007) among others) relaxes the cap if the price exceeds the designated upper limit on prices. HR 2454 provides limited relief with the allowance reserve program. Permits may be moved forward in time to address near-term high prices.

The strategic allowance reserve proposal is designed to address this first concern. But there is a second flaw in the argument. Even in cap and trade proposals with no explicit safety valve, Congress serves as the ultimate safety valve. If permit prices rise too high – perhaps because of a shortfall in permits as permits are shifted forward in time through the allowance reserve – Congress can relax the cap and so bring the price down. Above I argued that the allowance reserve may be ineffective because the desire of firms to bank permits for future use could more than offset any effort of the allowance reserve to shift permits forward in time to reduce price. But there is another possibility. Firms may use exceptionally high discount rates to value carbon trading permits. If so prices might rise even higher than is projected by most analysts.

To understand why this might happen we need to digress a bit on how permit prices are expected to change over time. Permits are financial assets. With no binding limits on banking or borrowing the decision by firms of when to utilize permits depends on the trade-off between receiving the value of the permit today or in the future. Consider a permit with a current price of $20. The firm can use it this period or use it in a future period. If it uses it in this period it foregoes the opportunity to sell the permit and receive the cash (holding other behavior constant). If it holds on to the permit it has the

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on Carbon tax versus cap and trade at http://www.thebulletin.org/web-edition/roundtables/carbon-tax-vs-cap-and-trade accessed on May 5, 2009.

opportunity to sell the permit in the future (or use it and obtain the value of avoided emission abatement). An optimizing firm will hold the permit if the permit price appreciation exceeds the potential return on the $20 it can invest from the proceeds of selling the permit today. Conversely the firm will sell the permit if the permit price appreciation falls short of the potential return on the sale proceeds. In equilibrium the firm will demand the same return on permits as on other financial assets. Since the return on permits is entirely driven by the change in price over time we can predict that the price path of permits will rise exponentially at the firm's discount rate (controlling for any shocks to the economy). This logic has been used by numerous modelers to predict the price path for permits over time based on real discount rates on the order of 4 to 6 percent.

All of these models assume a single type of financial asset to which the return on permits is compared. In actuality firms hold a wide range of assets with varying degrees of riskiness. Holding all other things constant firms demand a higher return for holding riskier assets. A basic tenet in financial economics is that two assets that provide the same stream of returns over time should be valued equivalently. An implication of this is that equally risky assets should be discounted at the same rate with the discount rate rising with the riskiness of the asset.

Let's return to the proposition that Congress serves as the ultimate safety valve in a cap and trade system. This creates political risk for holders of permits. If permit prices rise too high Congress may release more permits thereby subjecting holders of permits to capital losses.[7] This risk leads to the use of a higher discount rate which suggests a price profile that starts out lower and rises more rapidly than is suggested by models that ignore political risk. In other words firms are less likely to bank permits for fear that their value will be eroded by unexpected permit creation in the future by Congress. But this very behavior raises the likelihood that Congress will relax the allowance cap in the future thereby justifying the use of higher discount rates by firms for permits.

Finally let me address the argument that cap and trade systems provide greater certainty over emissions than do price based systems. Just as hybrid cap and trade systems can be constructed to mimic desirable attributes of price-based systems (e.g. reduced price volatility), hybrid price systems can be designed to mimic desirable attributes of quantity-based systems (e.g. certainty over emission limits). I demonstrate one such hybrid price approach in the next section.

IV. Price Certainty and Emission Limits Under a Carbon Tax

A carbon tax provides the greatest degree of certainty over carbon prices as the price is set by the tax rate. This certainty is one of the attractions of the tax approach to many. But it provides the least certainty over the policy's ability to keep emissions below a given target over some control period. Again this is simply the inherent tension between price and quantity based instruments discussed in section II above. One way to read the public debate over climate policy in the United States is that a compromise is developing among different interest groups that addresses environmental concerns for certainty over emission targets with the business community's interest in stability in

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[7] This is analogous to the risk of expropriation of energy reserves by government. Weiner and Click (2007) find that the discount rate used to value purchases of energy properties varies across countries depending on the political risk of that country.

carbon prices to assist them in their long-range capital planning. If this is correct, any carbon tax approach needs to address the desire for greater certainty over long-run emissions. I turn next to demonstrate how this could be done.

A hybrid carbon tax could be constructed to ensure that cumulative emission targets are met over some long-run (e.g. 40 year) control period. I will describe such a hybrid, dubbed the Responsive Emissions Autonomous Carbon Tax (REACT). REACT eliminates short-run price volatility while ensuring that long-run emission limits are met.

The profile of tax rates over time is an essential design provision of any carbon tax. REACT takes the following approach:

- An initial tax and standard growth rate for the tax is set for the first year of a control period.
- Benchmark targets for cumulative emissions are set for the control period. The law could require that the targets be met at annual, five-year, ten-year or some other time interval.
- If cumulative emissions exceed the target in the given years, the growth rate of the tax would increase from its standard growth rate to a higher catch-up rate until cumulative emissions fall below the target again.

With a high enough catch-up rate, we can be reasonably sure that we will meet emission caps by mid-century in a similar fashion to current cap-and-trade proposals.[8] This suggested approach ensures that long-run targets are met while price stability is achieved in the short run. Given the ability to predict emissions in the short run and the transparent nature of the tax, firms would be able to predict with considerable certainty

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[8] In those instances where marginal abatement costs are sufficiently steep that very high carbon prices are ineffective at meeting specific emission caps, a cap and trade system with those caps is also likely to fail. Permit prices will have risen to such a high rate that Congress is likely to relax the cap to reduce permit prices.

what the growth rate of the tax will be in the near term thereby providing greater clarity for their planning purposes.

One could, if desired, couple REACT with additional design considerations. In particular it might contain the following additional elements:

- A refundable tax credit for permanently sequestered greenhouse gas emissions. This would provide the appropriate incentives to develop carbon capture and sequestration technologies as well as to avoid penalizing users of fossil fuels as feedstock in applications that permanently sequester carbon dioxide.
- A border tax on the embedded CO_2 in imported fossil fuels and select carbon intensive inputs.[9]
- A rebate of some or all of the revenues from the tax to address distributional concerns.[10]

B. Additional Considerations

The previous subsection describes the essential elements of REACT. Next I turn to a more detailed discussion of key design issues.[11] There are two principles, one physical and one economic, which allow us to substantially reduce the collection and enforcement costs for a tax on emissions from fossil fuels. The first is that a unit of fossil fuel will emit the same amount of carbon regardless of when or where it is burned. For carbon emissions from fossil fuel combustion, there is a perfect correspondence between input and output. Therefore, we can tax the input – the fossil fuel – rather than the output – the emission. The exception to this rule is for fossil fuel permanently sequestered, such

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[9] See Metcalf and Weisbach (forthcoming) for more on this point.

[10] Metcalf (2007b) describes one rebate approach that is both revenue and distributionally neutral.

[11] This section draws in part from Metcalf and Weisbach (forthcoming).

as fuel used for tar or carbon that is captured and stored. As discussed above, a credit should be given for carbon that is permanently captured and stored.

The second principle is that the incidence of a tax (and its efficiency effects) is unrelated to the statutory obligation to remit the tax. This means that we can impose the tax (choose the remitting entity) to minimize collection and monitoring costs and to ensure maximum coverage. In general, imposing the tax upstream (i.e., at the earliest point in the production process) will achieve these goals as there are (1) far fewer upstream producers than there are downstream consumers and (2) because of economies of scale in tax administration, the cost will be lower per unit of tax.

These two principles lead to the conclusion that the administrative costs a carbon tax can be reduced through upstream implementation on fuel producers rather than downstream on fuel users. The tax could be applied at the mine mouth for domestic coal, and at the border for imported coal. There were 1,438 operating mines in the U.S. in 2006.[12] Almost all coal used in the U.S. is produced here and there are very few exports. Taxing at the mine would capture virtually 100 percent of U.S. coal production. Moreover coal mines are potential sources of methane, either captured and put into the pipeline system or released into the air. If it is captured, this source of methane may not need to be processed Therefore, having mines as taxpayers may create synergy – they can pay the tax on this source of natural gas or methane as well. If it is not captured, coal mines should pay a tax on any release. Coal-bed methane emissions were around 58.5 million metric tons of CO_2 equivalents, so imposing this tax will be important.

Natural gas could be taxed at the operator level or on import. Operators already pay state severance taxes, which means that they have the administrative capacity to pay

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[12] Energy Information Administration, Annual Coal Report (2007)

the tax and states are already collecting the necessary data. Although there are many small operators, taxing the top 500 would capture almost all the natural gas produced in the United States. Imported gas could be taxed at one of fifty-five locations where natural gas (or liquefied natural gas) can be imported or exported, consisting of six liquefied natural gas facilities and forty-nine pipeline border points.

Petroleum products could be taxed on the crude as it enters the refinery or on the various products produced from crude oil along with refinery process emissions. Again, the administrative burden is not particularly cumbersome because there are roughly 150 refineries in the United States. In all cases above, the taxed firms are already reporting data to the IRS and paying taxes. A carbon tax would likely create less of an administrative burden than creating an entirely new accounting scheme for carbon allowances.

Non-energy carbon emissions come from a variety of sources, predominantly iron, steel, and cement production. These CO_2 emissions, along with many other GHGs, could be taxed either at the point of production or at the point of consumption. Metcalf and Weisbach (forthcoming) estimate that roughly 90 percent of U.S. GHGs could be brought into the tax base at relatively low cost.

With the carbon tax applied at upstream points, it is important to provide tax credits for carbon capture and storage (CCS) at downstream levels and for fossil fuels used as feedstocks in manufacturing activities where the carbon is permanently stored. CCS refers to technologies that remove carbon from the exhaust streams of fossil fuel burning plants and store it underground – either locally or after transportation to a storage site – for many centuries. Electric utilities that burn coal in an advanced boiler with CCS, for example, should be allowed a tax credit equal to the tax paid on the carbon that is sequestered. Since firms that engage in sequestration activities (e.g. coal-fired electric power plants) may not be the firms subject to the carbon tax (e.g. coal mines), allowing the permits to be traded would ensure that the credits for sequestration would have full value. Thus coal companies with carbon tax liability could purchase carbon tax credits from downstream firms that earn the credits for sequestering CO_2.[13] Credits for certain land-use activities, including forestry sequestration, should also be considered for credit eligibility. This would be a way of allowing sectors not covered by the carbon tax to opt in to the system and receive payments for approved carbon reducing activities.

IV. Tax Rate Scenarios Under REACT

REACT is a hybrid carbon tax that combines short-run price stability (feature of a carbon tax) with long-run certainty of emission limits over the control horizon (feature of a hard cap-and-trade system). By adjusting the growth rate of the tax between a standard growth rate and a higher "catch-up" rate, it can meet long-run emission targets while providing price predictability. Given the ability to predict emissions in the short run and the transparent nature of the tax, firms would be able to predict with considerable certainty what the growth rate of the tax will be in the near term thereby providing greater clarity for their planning purposes.

As an example of how REACT could be designed, assume benchmark targets based on the permit allocations in the American Clean Energy and Security Act of 2009 (H.R. 2454). Assume that the tax goes into effect in 2012 with a control period running

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[13] Alternatively, firms with carbon tax credits could receive a refund from the IRS directly, thereby obviating the need for tradability. This would be similar to the treatment of zero-rated firms who receive a credit for a Value Added Tax (VAT) paid at earlier stages of production but pay no gross VAT on their value added.

through 2050. The standard growth rate for the tax is 4 percent (plus inflation) and a higher catch-up rate of 10 percent (plus inflation). The catch-up rate is triggered when cumulative emissions in any year exceed cumulative target emissions.

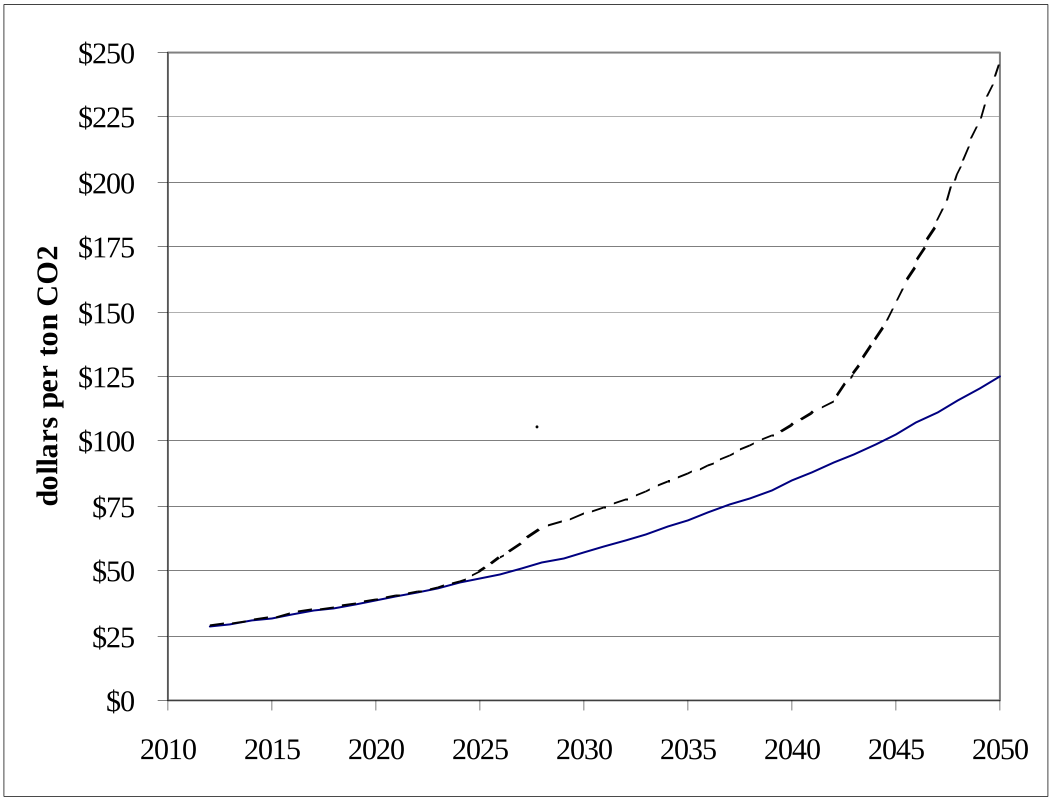

Figure 2. Representative Carbon Tax Paths

Figure 2 above illustrates two possible paths for the carbon tax between the 2012 and 2050. The smooth path shows a carbon tax that starts at $28 and rises at 4 percent (real) each year to 2050. The tax rate in the final control year is $125. The less smooth line illustrates a REACT tax rate that is designed to achieve the cumulative emission reductions called for in the Waxman-Markey bill. There are a number of years in which the tax grows at a 10 percent annual growth rate reverting to the 4 percent rate in those years in which the cumulative emission targets are met.[14] The tax rate in 2050 is $245 in this particular realization. The higher tax rate assures that the cumulative emission cap over the control period is met.

To show how the tax might operate in an uncertain economic environment, I ran simulations of the REACT tax assuming that emissions follow the following stochastic process:

$$\ln E_t = \beta_0 + \beta_1 t + \beta_2 \ln(P_t) + \beta_3 \ln(P_t)t + u_t \tag{1}$$

where u_t is a AR(1) process with autoregressive parameter 0.2 and standard deviation of the independent shock equal to 0.5. The regression in equation (1) was fitted to the data from various runs of the carbon tax in Metcalf et al. (2008). Observations from all carbon tax runs in that paper were included in a single regression.[15] Regression results are shown in Table 1.

Table 1. Emissions Response to Carbon Prices

ln(Carbon Price)	16.742 (3.91)
Year	0.046 (.0007)
ln(Price)*Year	-0.0084 (0.0019)
Intercept	-83.47 (13.75)
Adjusted R^2	0.905

Source: Author's computations based on data in Metcalf, et al. (2008).

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[14] This simulated price path checks emissions against the targets in each year. The tax could be modified to check the targets every five years or some other interval.

[15] Strictly speaking, such a regression is not a valid representation of the emission process given the differential technology responses that can occur in different tax simulations of the EPPA model. For my purposes I simply need a reduced form relationship between emissions and price to illustrate how the REACT tax might operate.

The elasticity of emissions with respect to the carbon price in 2012 is -.159 and declines to -.478 by 2050. This regression is not meant to precisely reflect the response of greenhouse gas emissions to carbon prices but is suggestive for the purposes of illustrating the price trajectory of the REACT tax. Based on the response of emissions to a carbon price as given in Table 1, I simulate 1,000 runs of the REACT tax to provide a sense of how we might meet the cumulative emission targets described above given different realizations of emissions. Over the 1,000 runs, the average number of years that the tax is growing at the higher catch-up rate is 16.1 ranging from a low of 10 years out of the 38 control years to a high of 22. Figure 3 displays information on the range of tax rates between 2012 and 2050 based on the stochastic nature of emissions as modeled above.

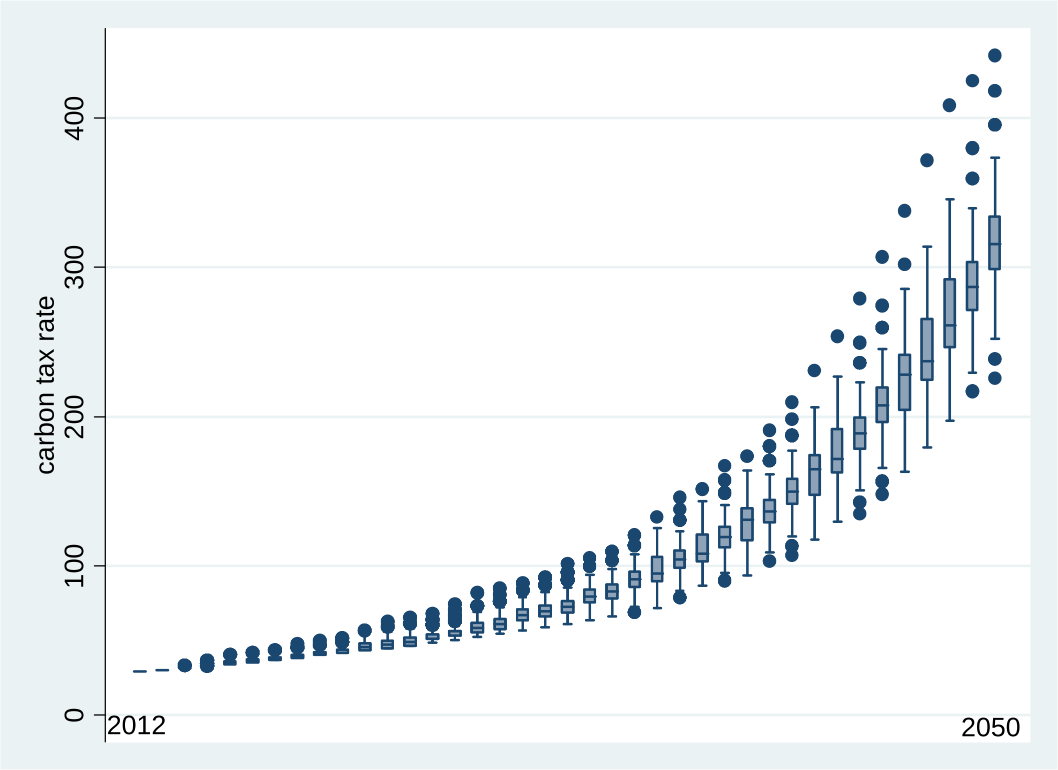

Figure 3. Simulated Monte Carlo Price Paths

In each year the box and whiskers graph shows the distribution of tax rates across the 1,000 simulation runs. The box provides the interquartile range (25th percentile at the lower end of the box and 75th percentile at the upper end of the box) along with the median value (line inside of box). The "whiskers" show the range of adjacent values and the dots show any outlying values.[16] The lower end of the whisker (or outlying value) in each year is the value of the carbon tax if no adjustment is made to allow cumulative emissions to catch up to the targets in each year. The simulation indicates that a "bad" state of the world (in which emissions were especially high – say due to unexpected and persistent outages of nuclear power plants or especially hot weather) could lead to a carbon tax rate as high as $442 based on the responsiveness of emissions to the tax and the stochastic nature of emissions posited for this example. In the Monte Carlo simulation, this occurs less than one percent of the time.

This modeling has not taken into account an important behavioral effect that may occur. Firms may anticipate cumulative emissions rising to the point where they may trigger a shift to the high growth rate in the tax and undertake additional abatement activities to avoid this outcome. Further modeling is needed to understand whether this is a potentially significant response or not.

The REACT hybrid tax shares similarities with other carbon pricing systems that have recently been put forward. Douglas Elmendorf, Director of the Congressional Budget Office, recently described a managed price approach for a cap and trade system. Permit prices would be set not by the market but by regulators annually to achieve a given emissions path over time (see Elmendorf (2009)). Similarly the Clean

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[16] Adjacent values are those that are no more than 1.5 times the interquartile range (IQR) away from the 25th or 75th percentiles. Outliers are more than 3 times the IQR in distance from the 25th or 75th percentiles.

Environment and Stable Energy Market Act of 2009 (H.R. 1683) introduced by Cong. Jim McDermott (D-WA). H.R. 1683 establishes federal emission permits that are sold by the federal government with the price established by the Secretary of the Treasury and adjusted over time to match a federal emissions allocation over time. The essential difference between these approaches and the REACT hybrid tax is that the price adjustment mechanism is built into the law rather than delegated to regulators or the Treasury Secretary.

The REACT approach addresses the objection that a carbon tax does not ensure a hard cap on greenhouse gas emissions over the control period. An overall cap can be maintained while insulating consumers and businesses from short-run fluctuations in carbon prices that add volatility to energy prices and undermine support for climate change legislation. It does this with a transparent mechanism for adjusting the price of emissions over the control period.

V. Further Thoughts on Policy Choice

A hybrid carbon tax has several attractive properties. First, it provides a clear price signal while committing to cumulative caps over a control period. Setting a clear price on emissions provides the impetus for emitters to begin to reduce emissions through process changes and investment. And the commitment to strong cumulative emission caps provides the assurance many want that the United States will take strong and decisive action on greenhouse gas emissions. This is important domestically as well as internationally as major greenhouse gas emitting countries join to construct a new international agreement for the post-Kyoto era. Finally, administrative considerations suggest a carbon tax can be put in place more rapidly than a cap and trade system. But why take a hybrid tax approach when the cap and trade approach seems so well accepted? I discuss a few features of the tax based approach that offset many if not all of the advantages of the cap and trade approach.

A. Revenue

A cap and trade system is built around the instrument of tradable permits. Permits are valuable assets. They can be auctioned by the government, thus raising revenue. But historically they have been given away to industry as part of a process of obtaining support for the system. To be fair, prior domestic cap and trade programs were an order of magnitude smaller than any potential carbon cap and trade program. Thus, given the revenues involved, auctioning permits in those programs was simply not that important.

The stakes are higher with a carbon cap and trade bill and the need for fiscal discipline that much greater. The debate last year over the Boxer Amendment to the Lieberman-Warner Bill is instructive. The bill set very specific uses for the freely allocated permits as well as for spending from auctioning. In effect the bill implemented a large-scale set of revenue and spending programs that circumvented the normal committee process.

The Waxman Markey bill reported out of committee also sets very specific uses for most of the permits. Table 2 provides an estimate of the allocation over the 2012 – 2030 period. Nearly half of the permits are allocated to offset the higher price impacts on consumers (allocations to low and moderate income households as well as to local distribution companies). Energy producers receive just over seven percent of the allowances and trade affected industries receive nearly twelve percent. Thirteen percent of the permits are used for technology funding (including carbon capture and storage, clean vehicles, renewable energy and efficiency) and nearly twelve percent for adaptation. The unallocated permits (roughly seven percent) are used for deficit reduction through 2025 and for consumer rebates after 2025.

Table 2. Permit Allocations in HR 2454

Use of Allowances	2012-2030
Allocation to mitigate economic impacts	**67.9%**
Electricity local distribution companies	27.4%
Merchant coal generators	3.2%
Long-term contract generators	1.4%
Natural gas local distribution companies	5.9%
Home heating oil/propane	1.4%
Protection for low- and moderate-income households	15.0%
Worker assistance and job training	0.7%
Allocation to energy-intensive, trade-exposed industries	11.6%
Oil refiners	1.4%
Technology funding	**13.1%**
International and domestic adaptation	**11.6%**

Source: Author's estimate

The Congressional Budget Office recognized these indirect revenue implications of cap and trade bills with its decision in late 2007 to begin counting freely allocated permits as revenue and offsetting spending (see the CBO cost estimate of S. 2191 released on April 10, 2008). One could push this point further and argue that any new major revenue source – such as arises from a tradable permit system whether the permits are auctioned or freely allocated – should go through the usual Congressional budget process. This ensures that Congress weighs the best use of funds from the initiative against all the pressing budget needs. This is precisely the process that would occur with a carbon tax.

This is not to suggest that proponents of carbon pricing couldn't propose fiscal constraints on the use of carbon revenue. On the contrary, the constraint to be revenue and distributionally neutral could be imposed and might provide appropriate fiscal discipline that would contribute to support for the passage of a climate change bill. Note though that the incentives for this sort of discipline may be stronger for a tax than a cap and trade bill. Any tax bill, including a carbon tax, would emerge from the House Committee on Ways and Means, which initiates all tax legislation in the House, and the Senate Finance Committee, which controls tax legislation in the upper chamber. Members of these committees may be able to more easily impose the revenue and distributional neutrality constraint than can members of the House Committee on Energy and Commerce or the Senate Committee on Environment and Public Works, which are responsible for cap and trade legislation.   These committees have a narrower fiscal focus and the natural incentive for committee members is to spend revenues on programs under their purview.

B. Administration

We have a time-tested administrative structure for collecting taxes that can ramp up a carbon tax in relatively short order. Firms that would be subject to a carbon tax are already registered with the IRS and have whole departments within their firms that carry out the record keeping and reporting for tax payments. Coal producers already pay an excise tax to fund the Black Lung Trust Fund and oil producers pay a tax to fund the Oil Spill Trust Fund (see Metcalf (2007a) for a description of these funds). We also have precedents for refundable credits for sequestration activities in federal fuels tax credits. In contrast, we have no administrative structure for running an upstream carbon cap-and-trade program. A report by the Congressional Budget Office (2008) details the lead-time required to establish allocations. All this suggests that we can implement carbon pricing through a tax more quickly than through a cap and trade system.

C. Carbon Tax Concerns Don't Apply to Hybrid Tax

Many of the traditional concerns with a carbon tax are directly addressed with the hybrid tax described above.

1. No Binding Cap on Emissions

A common criticism of carbon taxes is that they do not provide any binding cap on emissions. The REACT proposal squarely addresses this criticism by building into the tax code predictable and automatic rate adjustments that keep emissions on target to significant reductions. The mechanism is transparent and provides firms with clarity for planning purposes.

2. Tipping Points

Tipping points provide an important qualification to the efficiency argument for taxes that was discussed above. Tipping points are discontinuities in marginal damages that may arise if critical concentrations of GHGs lead to temperature increases that are sufficiently high to cause large-scale and abrupt climate change. The existence of a tipping point, it is argued, favors cap and trade type programs to ensure that we avoid crossing such a threshold.

The problem with this argument is that we do not know where the tipping point is or whether we are close to it. Setting a fixed cap at an inappropriately low level could lead to unnecessarily large welfare losses. Until our knowledge about climate processes and threshold effects improves we are likely better off setting a gradually increasing price on GHG emissions and providing clear market signals to firms to reduce emissions.

3. Efficiency and Political Expediency

A political realist might argue that it is inevitable that concessions will have to be made to the energy industry as part of a grand deal on U.S. carbon policy. Proponents of a cap-and-trade system argue that concessions in a cap and trade system will not bring about an efficiency loss whereas concessions in a carbon tax regime would be distortionary. Concessions in a cap and trade system would be given in the form of a free distribution of permits, which is a lump-sum transfer. The argument goes that with a carbon tax, the only way to make concessions is to exempt entire sectors or segments of sectors. This clearly would be distortionary. But nothing precludes a carbon tax from providing lump-sum transfers similar in impact to lump-sum distributions of free permits. A carbon tax, for example, could levy the tax on emissions above some threshold. The similarity between lump-sum distributions made under cap and trade systems and those made under tax systems has been pointed out by Pezzey (1992) among others.

4. Interactions with International Systems

A final argument against a U.S. carbon tax is that it is incompatible with efforts to bring the developing world into an international agreement. The argument is that we will need to use monetary transfers and technology transfer programs such as the Clean Development Mechanism (CDM) to engage the large developing countries in setting limits on GHG emissions, and that such mechanisms are only compatible with cap and trade programs, where they can be used as offsets to domestic caps.[17] However, nothing about a carbon tax precludes the use of CDM-type projects as offsets. If the United States so desires it could allow certain offsets like CDM projects to be taken as credits against the carbon tax. To reduce the administrative burden for firms, the offsets could be made tradable, in which case brokers would likely emerge to serve as a clearing house for firms with carbon tax liability to purchase offsets.

On a related matter, nothing precludes the United States from employing a carbon tax while other countries rely on cap and trade systems. In the end what matters is that the international community coordinate on harmonizing carbon prices. Some countries may choose to do this through a carbon tax while others through cap and trade systems. So long as the prices are broadly in line across countries, concerns about leakage (i.e. movements of economic activity from high carbon price to low or no carbon price countries) should be minimized.[18]

VI. Conclusion

Carbon pricing is widely accepted as a necessary step for addressing the challenge of global climate change in the United States. One of the main objections to a carbon tax has been the uncertainty over emissions over the control period. This paper describes an approach that could be used to ensure cumulative emission caps are achieved over the control period. The REACT tax ties the change in the tax rate to progress over meeting cumulative targets. The targets could be met on an annual or less frequent basis. While

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[17] The Clean Development Mechanism was developed under the Kyoto Protocol as a way to allow GHG reducing projects in developing countries that are not subject to emissions limits to count towards the targets for countries that are subject to such limits. See Lecocq and Ambrosi (2007) for a history and analysis of CDMs.

[18] Nordhaus (2007) discusses the advantages of a tax-based approach in the context of global systems. I take a more modest position here, arguing that a domestic tax-based approach can be made compatible with whatever international system evolves elsewhere.

this paper provides results from simulations using annual benchmarks, five year benchmarks might be more appropriate.

Hybrid cap and trade schemes have been proposed to achieve the right balance between certainty over emission limits during a control period and minimizing price volatility for firms and individuals who will face higher costs of energy and other products due to carbon pricing. A hybrid carbon tax such as the REACT model sketched out in this paper can achieve the appropriate balance between price and emission certainty in a tax-based framework. This provides a number of advantages over the hybrid cap and trade approach. First it avoids the need for a new administrative structure to oversee this major new program. Second it avoids the creation of financial assets and the resultant and costly rent seeking activity to obtain these assets.

Policy choices inevitably involve trade-offs among competing goals. The key competing goals in climate change policy are price certainty and emissions certainty. To date efforts to strike the appropriate balance between these competing goals have focused on hybrid cap and trade systems. This paper suggests that focusing on hybrid cap and trade schemes is needlessly limiting. A hybrid tax system can achieve whatever appropriate balance between price and emission certainty is deemed socially desirable while building on the administrative and political benefits of a tax-based system.

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