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Mixing It Up

*Power Sector Energy and Regional
and Regulatory Climate Policies in
the Presence of a Carbon Tax*

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Abstract

A carbon tax will interact with other policies that are intended to reduce carbon dioxide emissions and encourage clean sources of energy and energy efficiency. This paper examines these policy interactions. A well-designed carbon tax can be an efficient instrument for reducing emissions, yet whether it will be implemented in an efficient manner is uncertain. A legislatively determined tax may not fully reflect up-to-date scientific and economic information. Behavioral and institutional factors suggest that a tax may not have its fully intended effect. These considerations suggest that climate policy should and will continue to be a complex mix of regulations at various levels of government, even with a carbon price. Nonetheless, the possibility of unintended interactions among policies remains. The role for policies to encourage renewables and energy efficiency depends on the stringency of the carbon tax and presence of externalities related to technological learning and the energy efficiency gap.

Key Words: externalities, regulation, federalism, Clean Air Act

JEL Classification Numbers: Q58, H23, H77

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Introduction

The United States is in the midst of an ongoing debate about how to address persistent budget deficits and rationalize the federal tax system. During the recession, the federal deficit spiked to \$1.1 trillion in fiscal year 2012, roughly 30 percent of total government spending. Despite the Federal Reserve's low interest rate policy, interest payments on the existing federal debt still topped \$200 billion in 2012, contributing a non-trivial fraction of total spending. As policy analysts and policymakers search for ways to substantially reduce the size of the deficit, one of the options under discussion is a carbon tax. Unlike taxes on labor and capital income, a carbon tax has the virtue of taxing something society wishes to discourage. According to recent estimates, a carbon tax of \$25 per ton of carbon dioxide (CO₂) could contribute as much as \$125 billion per year in additional revenue.

A carbon tax also has many virtues as an environmental policy. A tax that is applied economy-wide would address emissions from all sectors and enable producers and consumers to make efficient choices across fuels and technologies for energy production and use. Unlike a cap-and-trade program, a carbon tax also provides cost certainty to regulated sectors of the economy.¹ If the revenues from a tax are used efficiently, that is, to reduce the need for distortionary taxes on other sectors (through either deficit reduction or tax swaps), a carbon tax is an efficient instrument for reducing CO₂ emissions.

Yet, while it can be an efficient instrument, is a carbon tax necessarily an efficient policy? Perhaps a prerequisite for this to be the case is that the tax be set to equal the marginal damages of CO₂ emissions, although this is likely to be challenging because estimates of the social cost of carbon are much disputed (US Government 2010; Johnson and Hope 2012).

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¹ Cap and trade can be designed to limit the variation in cost through mechanisms such as a price collar (e.g., Fell et al. 2012; Krupnick and Parry 2012).

Further, as suggested in our opening paragraph, the current political relevance of a carbon tax comes from its potential contribution to revenue and broader tax reform. One can hope that the tax level would be set efficiently, but that is uncertain. Moreover, the advice of many economists on whether the tax should be set equal to the social cost of carbon will depend on how the tax revenue is used. Some have argued that if the country enacts a carbon tax, then other policies to help mitigate greenhouse gas emissions and encourage the deployment of renewable energy and other clean technologies are unnecessary.² Some observers have suggested policy swaps with the withdrawal of current and preclusion of future regulations of carbon emissions as a way to gain political support within the Congress for establishing a carbon tax (Gayer 2012; Fraas and Richardson 2013). For our purposes, the relevant question is whether the interactions between a carbon tax and preexisting policies to reduce emissions of CO₂ and encourage clean sources of energy and greater energy efficiency are likely to raise costs or lower the attainable level of emissions reductions compared to the use of either of these approaches alone. We are also interested in ways the policies can be adjusted to improve efficiency.

In this paper we sort out these arguments and offer a way to think about when it makes sense for other regulations to coexist with a carbon tax. A well-designed and well-implemented carbon tax is likely to generate the lion's share of economic gains from environmental improvement. We emphasize that the introduction of a price on carbon is imperative for creating long-run incentives for innovation and efficiency. Nevertheless, we expect limitations in the practical implementation of a carbon tax, leaving room for the coexistence of other policies at the state and local levels and regulations at the national level. Ultimately, each of these policies and their interactions with a carbon tax deserves its own analysis on a case-by-case basis.

We begin in the next section by reviewing the conceptual economic approach to analyzing the efficiency of environmental regulations. We next discuss three institutional constraints on the introduction of a price on carbon that may lead its effectiveness to differ from that anticipated in the conventional economic model. We then discuss the interaction of a carbon price with other energy policies at the national level and offer a conclusion.

² "To a first approximation, raising the price of carbon is a necessary and sufficient step for tackling global warming. The rest is at best rhetoric and may actually be harmful in inducing economic inefficiencies" (Nordhaus 2006).

The Conceptual Context for a National Carbon Tax Policy

Economic advice about the design of climate policy typically builds on the suggestion that a single policy objective (e.g., reducing an externality) requires a single policy instrument. This idea is used to assert that well-designed climate policy would therefore use *only one* policy instrument and that the use of more than one policy would likely be inefficient. The reasoning is that after using one policy in an efficient manner, the use of an additional policy to address the same objective cannot reduce and might increase costs. For example, if the climate problem is due to society's overconsumption of energy because CO₂ emissions from fossil fuel combustion are not priced, then it follows that the solution should be to introduce a price on emissions. Coupling this policy with another one that constrains consumer choices would raise the cost of reducing emissions if consumers were denied choices that might be highly valued in some situations or if it would direct consumers to choices that reduce emissions at a higher cost than would result if they were to make decisions based on the carbon tax alone.

A corollary is that the only justification for multiple policies (that is, policies in addition to a carbon tax) is the existence of multiple problems. For instance, if the benefits of private research and development accrue to other parties, then a firm might invest as much in research as would be socially efficient. In this case climate policy might involve a price on carbon aimed at reducing emissions combined with other regulation to promote research and development. Or, for example, if consumers cannot anticipate the energy savings associated with using a new appliance, then an information program that reports the efficiency of appliances might be justified.

The idea that a policy problem should be addressed with only one policy instrument is often associated with Tinbergen (1952), but actually he did not make that point. "Tinbergen's rule" prescribes that the number of policy instruments cannot be *less* than the number of policy goals. For example, a single monetary policy rule cannot achieve simultaneous targets with respect to employment and inflation. In energy or environmental policy, the implication of Tinbergen's rule would be that *at least one* policy would be required to address climate-related objectives; that is, "both energy and environmental goals need to be broken down into actionable targets, and there must be at least one policy instrument for each target" (Knudson 2009).

In the climate context, one might observe that consumers exhibit myopic decision making that places too much emphasis on the short-term cost, forgoing options that save energy and money in the long run (Allcott and Wozny 2012). In this case a carbon price by itself might not invoke the consumption and investment behavior that would reduce emissions at the least cost.

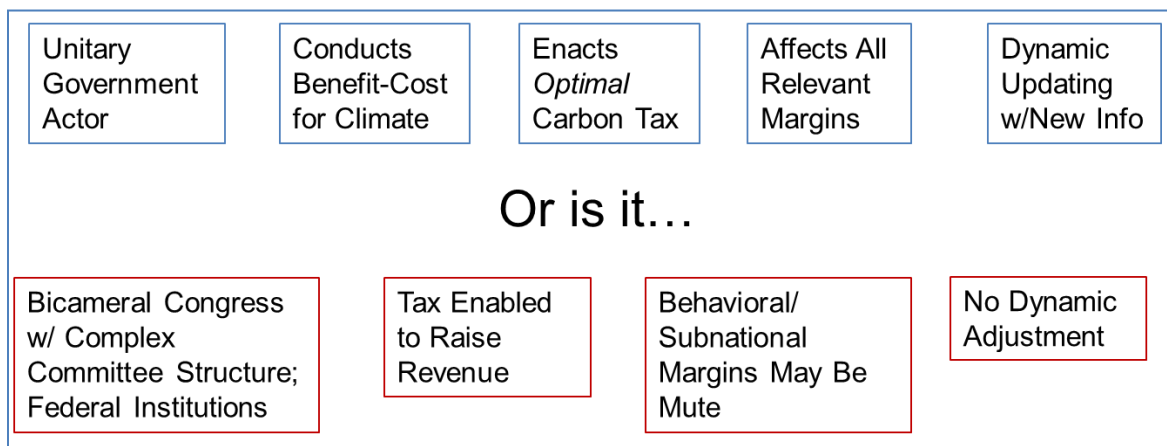
This myopic decision making might provide justification for additional policy such as performance standards that restricted the set of choices for consumers or nudged their behavior toward cost-minimizing choices (Gillingham and Palmer 2013).

We are especially interested in a different potential reason one policy might not achieve its intended policy outcome—the role of institutions. Three institutional settings are relevant: (i) the apparatus that would implement a carbon price, (ii) the federalist structure of government in the US under which a price-based policy or other regulatory approaches would take effect, and (iii) existing EPA regulatory authority under the Clean Air Act. Finally we turn to the interaction of climate policy with other energy policies. In these settings we find some justification for a combination of a carbon price with additional policies.

Imagining the Implementation of a Price on Carbon

With rare exceptions, economic models implicitly ascribe the governance of a price on carbon to a unitary government actor. As illustrated in Figure 1, that actor would balance benefits and costs to identify and implement an optimal (efficient) carbon tax. Presumably the tax affects emissions throughout the economy, and consumption and investment adjust accordingly (myopic decision making mentioned above notwithstanding). When new scientific or economic information becomes available, the model assumes the optimal carbon tax is adjusted in a timely way.

Figure 1. Mental Models of Implementation of a Carbon Tax



Realistic expectations about how a carbon price would be implemented depart importantly from this view. The level and structure of a carbon price would be decided in a bicameral congress with a complex committee structure and with the overhang of required

presidential approval. The primary function of the relevant committees is to raise revenue, not determine a level of taxation that achieves an environmental goal with respect to determination of the level of carbon emissions. Typically revenue measures are complicated, with provisions to protect national and special interests. There also tend to be many exemptions, suggesting the implementation may not be uniform throughout the economy and a price signal may not equate the marginal cost of emissions reduction opportunities. The possibility for exemptions might be reduced with an upstream carbon charge levied on fuel suppliers—coal processors, refineries, and so on.

How would the overall level of a tax be determined? Legislative staff on budget and revenue committees will lack the expertise to evaluate the link between a carbon price and associated emissions. The committee might base the level of a tax on technical information such as the social cost of carbon (US Government 2010). However, this expectation is not fully consistent with the perspective of contemporary advocates for a carbon tax, who generally suggest it is politically possible because of its ability to raise revenue. With this as the enabling justification for a carbon tax, it may be unlikely that it also would be optimized to satisfy a specific social goal that is generally not the domain of the relevant congressional committees.

On which side of the technically efficient level might a carbon tax fall? The absence heretofore of a price on carbon (or any price on most other environmental externalities) indeed suggests that pricing would likely understate the efficient level. Olson's (1965) *logic of collective action* predicts that the costs of externality policy would likely be concentrated on a small number of interests, thereby focusing political opposition to the tax, while the benefits would likely be diffuse (accruing mostly to future citizens, who are not part of the contemporary political economy). This logic predicts that in general one should expect the tax to be set at a level below the optimal target based on a comprehensive balancing of social benefits and costs. However, the converse might occur; for example, interest groups supporting alternative uses of revenues were to coalesce with environmental groups to achieve a carbon tax set at a higher than efficient level.

Distributional considerations are yet another concern. Public finance economists typically relegate the remediation of distributional effects directly to distributional policies and seek to design a tax system that is as efficient as possible; however, in practice policy coalitions form to balance multiple objectives using portfolio approaches. Hirth and Ueckerdt (2012) explain that a price on carbon has distributional outcomes that can be offset by other energy policies such as renewable energy targets, which tend to lower market prices of power. These types of

distributional effects provide one explanation for the coexistence of a price on carbon (below its optimal level) and other energy policies even when those policies are less efficient.

There also may be technical reasons why the tax would be set below Pigouvian levels or applied unevenly across the economy. One reason might be to lessen the loss of economic activity associated with introducing a new tax on top of already existing taxes. That loss is expected to result even if revenues are used to reduce other taxes, such as the labor income tax, because the carbon tax would be levied on a narrower tax base. Another reason might be to protect energy-intensive trade-exposed industries from unregulated competition. In this case a mix of policies might lessen unintended distortions in the economy. In sum, there are several reasons why a carbon tax might not be set at the Pigouvian level.

Finally, the mental model illustrated in Figure 1 also assumes that the carbon price would automatically be adjusted to assimilate new information. However, it is hard to imagine how this would occur, since the tax level is established by congressional action and revisiting the technical basis for this legislative decision might be just as fraught or flawed as the initial implementation of a tax. The inability of Congress to update the emissions cap in the sulfur dioxide (SO₂) cap-and-trade program initiated by 1990 legislation amending the Clean Air Act provides an instructive example. When the legislation was passed economists anticipated the marginal benefits of the emissions levels established under the cap would about equal the marginal costs (Portney 1990). Five years later economists found the marginal benefits likely to be ten times marginal cost, and soon the estimate rose to thirty times costs (Burtraw et al. 1998; Chestnut and Mills 2005). However, in spite of this new information, Congress was unable to revise the level of the cap. Fortunately, from an efficiency perspective, the Clean Air Act preserved the authority of the US Environmental Protection Agency (EPA) to regulate SO₂. Policies based on this regulatory authority will reduce emissions by 2015 by more than the amount resulting from the implementation of the SO₂ emissions trading program. These regulatory actions pursued concurrently with the price on SO₂ introduced by the cap-and-trade program have already led to tens of billions of dollars in net benefits (Burtraw 2013).

This experience with SO₂ does not provide confidence that a carbon tax would be dynamically updated by Congress to reflect the latest scientific information. One approach to assimilating new information might be to delegate authority to adjust the carbon tax to an expert agency such as EPA (Fraas and Richardson 2013; Burtraw 2013). However, the authority to tax is the exclusive domain of Congress, and this is one power the legislative branch guards jealously and rarely delegates.

In sum, economic theory tells us that a carbon tax is a relatively efficient instrument. However, an efficient instrument does not guarantee an efficient policy. The outcome depends on how the instrument is used, and that depends importantly on the institutional context for policymaking. The implementation of a carbon price seems likely to be imperfect. This suggests a potential role of multiple instruments to achieve the goal of mitigating carbon emissions.

Subnational Climate Policies to Address Greenhouse Gas Emissions

Subnational levels of government have a vital role to play in the societal response to climate change because decisions about the infrastructure that will define social opportunities for the next century reside not primarily at the federal level, where a tax policy might take shape, but at the state and local levels (Shobe and Burtraw 2012). This is where decisions are made that govern industrial operations, siting and permitting, residential land use, building codes, and transit modes and patterns.

In a unitary model of government, the introduction of a price signal is assumed to be transmitted instantly to decision makers at all levels of government so that permitting, land use planning, and other functions of government adjust accordingly. If the introduction of a price signal would be transmitted effectively to all levels of the society, then additional efforts by subnational levels of government would be expected to be redundant at best and inefficient in general because they would lead to different effective marginal costs of emissions reductions across the economy (Goulder and Stavins 2011).

But in fact there is little research to indicate how well this would occur. There are many reasons to think that price signals *may not be* transmitted efficiently through levels of government. Local levels of government do not respond to short-run price signals. Their decisions are accountable to incumbent landowners who value consistency of new construction with the existing architecture, an interest that heavily influences local zoning decisions. In anticipation of this incongruity, the Waxman-Markey proposal included specific incentives to motivate state and local government actions to develop more energy-efficient transportation and land use policies.

Without addressing the potential inconsistency, one might also observe that while there may be a tendency for local jurisdictions to respond slowly to price signals, state governments have often been leaders in the introduction of policies to reduce carbon emissions. These jurisdictions have initiated energy efficiency standards for household appliances and vehicles and emissions standards for vehicles, which subsequently were taken up at the national level, and

they have unique purview in the development of building standards. Currently 29 states have renewable portfolio standards, and over half the states have energy efficiency programs. Ten states have adopted emissions cap-and-trade programs for CO₂.

The introduction of a national price on CO₂ interacts with these existing activities in sometimes unavoidable ways. The introduction of an emissions cap and trade program would effectively and automatically preempt these efforts because marginal efforts in one locale (or by one individual) to reduce emissions would free up allowances under the cap that could be used in other jurisdictions (Burtraw and Shobe 2009). Goulder and Stavins (2011) refer to this as 100 percent leakage. In contrast, the introduction of a price on carbon through a carbon tax would preserve the additionality of emissions reduction measures by subnational levels of governments or individuals. Emissions reductions achieved through various means will not affect the level of the tax. Consequently, the marginal incentives to reduce emissions as a result of the carbon price would not be diluted.

Incentive-based policies interact in another unavoidable way. Each policy introduces an implicit price, and for multiple policies, those prices interact. There are many possibilities, but one example would be the existence of a cap-and-trade program at the state level interacting with a carbon tax at the national level. In this case the introduction of a national tax would lead the state allowance price to fall. (The marginal cost to reduce emissions would equal the sum of the state allowance price and the national carbon price.) This would affect the availability of revenue generated at the state level. Perversely, even the anticipation of a tax at the national level would affect decisions about mitigation and banking at the state level in anticipation that the value of banked allowances would be reduced after a national tax was adopted (Stavins 2007). Firms that are holding emissions allowances would suffer a loss of value associated with that asset. To arrest this problem, national policymakers might consider compensation for the loss in value of banked allowances under state programs.

In summary, it may be beneficial from a national perspective to have subnational governments and individuals taking measures to reduce emissions beyond what would be incentivized by a price on carbon alone. Subnational initiatives might provide additional incentives for investments and behavior where the transmission of market price signals is incomplete. Inevitably policies at the national and subnational level will interact, and consideration should be given to how that will unfold.

However, occasionally attention is given to the question of preempting policies at the state and local level. The answer hinges on whether in any circumstance there is a *national*

interest in preventing state and local governments from doing more than national policy requires of them to reduce their contributions to a global externality. If subnational policies yield innovative outcomes, those innovations can be expected to spread to other jurisdictions. If subnational efforts are redundant or inefficient, they impose costs on those jurisdictions while they would lower costs or yield benefits for citizens elsewhere. It is hard to construct a justification for preemption of subnational policies.

EPA Authority to Address Greenhouse Gas Emissions under the CAA

What should become of EPA's regulatory authority if a carbon price is introduced? There are two aspects to this question. First is the role of EPA in the administration of the carbon price, and second is EPA's independent development of regulations affecting emissions from specific sets of sources.

EPA's Role in the Administration of a Carbon Price

Does EPA have a role in the administration of a carbon price? An important lesson from the flagship SO₂ trading program is the need to preserve a role for an expert agency in updating the program. As mentioned above, Congress proved unable to update the level of the SO₂ emissions cap based on new technical information. This might not be surprising, given the specific knowledge necessary to evaluate and remain current with new economic and scientific information. On the other hand, executive branch agencies are organized with the purpose of maintaining technical expertise; for environmental matters this responsibility falls to EPA.

Resolving the dilemma of the SO₂ trading program points to a two-part strategy to guide the design of a policy that introduces a price on carbon. First, there is the possibility that costs change in unanticipated ways. The economics literature has suggested price-based environmental regulation should encourage innovation that would change costs over time. A revolutionary feature of market-based policies compared to traditional, prescriptive approaches is the ability to discern the change in costs because information about changes in marginal costs of emissions reductions is instantaneously summarized in the market price of an emissions allowance.

If the initial level of an emissions cap were set to reflect the judgment of policymakers based on expected benefits, then if costs were to fall, policymakers should want to purchase more of those benefits. In a cap-and-trade program an automatic way to do so would be the introduction of a price floor, implemented as a reserve price in an auction for allowances (Burtraw et al. 2010). Bids below the reserve price would not be accepted. If the quantity of

accepted bids were less than the number of allowances for sale, the supply of allowances in circulation would automatically contract, yielding additional environmental benefits. Under a carbon tax the price level would automatically accomplish what a price floor would do in a cap-and-trade setting. On the other hand, the cost of emissions reductions could rise unexpectedly. One reason this might occur is a change in the relative cost of fuels, making substitution to relatively clean fuel more expensive or a failure for technology innovation to emerge in anticipated ways. In this case an alternative compliance payment that essentially caps the price of an emission allowance could reduce the costs of achieving the environmental goal and facilitate policy acceptability (Patino Echeverri et al. 2013; Fell et al. 2012).

A second possibility is that new scientific information might reveal that benefits of emissions reductions are greater or less than initially thought. Such a finding would not be reached quickly; it involves a scientific assessment of the expected damages from emissions, which would be incorporated into estimates of the social cost of carbon and which would take time to assess. To accomplish this assessment and translate findings into an updated regulation requires a role for an expert agency, a role that is built into regulation under the Clean Air Act and is needed also under a carbon tax. Guidelines for this process are not obvious because Congress is protective of its ability to set taxes. If the objective is to set the tax efficiently from an environmental perspective (leaving aside the reasons—noted above—why this may not be the case in practice), then an ongoing oversight role for an expert agency would appear crucial to the efficient implementation of a carbon price.

Greenhouse Gas Regulations under the Clean Air Act

In 2007 the US Supreme Court affirmed the authority of EPA to regulate greenhouse gases under the Clean Air Act.³ Subsequently EPA made a formal, science-based determination that greenhouse gases are dangerous to human health and the environment, which compels the agency to develop regulations to mitigate that harm. Important regulations have already been finalized in the mobile source sector and for the construction permitting of new and modified stationary emissions sources (new source review). Draft new source performance standards have been proposed for new fossil-steam electricity generators, and regulations for other sectors are expected to follow. Most importantly, the Obama administration has signaled its intent to move

³ *Massachusetts v. EPA*, 549 US 497 (2007).

forward with performance standards for existing stationary sources. With the introduction of a price on carbon, should these regulations and EPA's authority to regulate be withdrawn?

We have argued already that a carbon price is not guaranteed to affect decisions at every margin in the economy, potentially leaving cost-effective emissions reduction efforts untouched. And we argued that the carbon price might not be set at a level that is fully efficient. These possibilities would appear to provide justification for continuation of EPA's authority to regulate.

However, *if* a carbon price is accomplishing its intended environmental goal, then what would be the consequence of coincident regulation under the Clean Air Act? This is a bit of a tautology, because if one policy is defined to be successful it would seem that only bad things could happen by adding to it, that is, fixing something that is not broken. To be sure, Clean Air Act regulation will likely be less efficient than a price-based policy because it is likely to miss many opportunities for cost-effective emissions reductions where regulators lack specific information about technological heterogeneity among the regulated sources. In principle, a price on carbon would be expected to invoke cost-effective differences in investment among these sources. Further, regulations are likely to emerge slowly; and when regulations overlap precisely with a carbon price and are calibrated to the same outcome they are likely to be irrelevant. However, one might compare the price-based and regulatory approaches to regulating emissions to the parable of the hare and the tortoise. If the price-based policy stagnates, the regulatory approaches might become relevant. In other words, regulation could be structured such that it would be relevant only if a price-based policy fails to perform. As we discuss below, this was the observed sequence of events in the first grand experiment introducing a price on SO₂ emissions. From this perspective one might conclude that the regulatory authority under the Clean Air Act might do no harm and might provide important benefits.

There is a nagging concern that redundancy could impose anachronistic measures that would accomplish few emissions reductions but perhaps impose high costs. In some cases, regulation may be counterproductive. For example, technology standards that are differentiated by vintage may require higher efficiency and raise the cost of new investment, resulting in the delayed retirement of older, dirtier facilities (Gruenspecht 1982; Maloney and Brady 1988; Stavins 2006). Patino Echeverri et al. (2013) examine such regulation in the context of a CO₂ performance standard for new power plants and find that an inflexible standard could result in greater cumulative emissions due to the delay in new investment in more efficient generators that would otherwise occur. In its proposed performance standard for new fossil-steam power plants, EPA has attempted to address this problem by introducing a 30-year averaging rule, which

would allow new generators to exceed the performance standard as long as retrofits were made by the tenth year of operation allowing the standard to be achieved in the long run. Nonetheless, this illustrates that regulations may impose compliance requirements that are less efficient than if firms were left to respond to the price signal. In this eventuality, redundant regulation might introduce unnecessary costs that undermine efforts to address climate change.

The concern about wasteful redundant regulation might be allayed somewhat by the language of the Clean Air Act that is relevant to the regulation of CO₂ from existing stationary sources. EPA has decided to use Section 111 for this purpose. Unlike other portions of the act that regulate human health effects of pollution, this section has a cost test that requires the agency to take into consideration the effect of regulation on the remaining useful life of a facility. The technical preparation of a regulation is required to address this criterion, providing some protection against regulation that would not achieve meaningful emissions reductions or would do so at high costs. In addition, although the schedule often has not been met, this section of the act calls for the regular review of performance standards, which provides a forum to address the efficiency of existing regulations.

National Energy Policy with a Carbon Tax

In addition to policies that focus specifically on emissions of CO₂ and climate and energy policies implemented at other levels of government, there are numerous other national policies directed at the electricity sector that are motivated in part by a desire to reduce greenhouse gas emissions. Chief among these are policies to encourage the adoption of energy efficient appliances and equipment and policies to encourage the use of renewables and other non- or low-CO₂-emitting sources of electricity generation. If there were a carbon tax in place, should these policies be continued, and if so, in what form and to what extent?

The answers to these questions depend on several considerations. The first is whether the carbon tax is set in a way that fully internalizes the externalities associated with CO₂ emissions, or if encouraging investments and behavior that yield additional reductions in emissions is welfare enhancing. The second is whether there are other market failures resulting in suboptimal deployment of renewables or inefficiently low consumer investments in energy efficiency that these policies could address. The third consideration is how these policies promoting renewables and efficiency interact with each other and with the carbon tax. A fourth consideration is distributional concerns, which, as discussed above, can explain the coexistence of a suboptimal carbon price and other energy policies.

Given the possibility (discussed above) that the carbon tax might not be set aggressively enough from an environmental perspective, additional federal policies to promote clean technologies or to reduce electricity consumption may be warranted on the basis of addressing the CO₂ externality alone. However, this is true only to the extent that a policy reduces emissions of CO₂ at an incremental cost that does not exceed the environmental benefits of those further emissions reductions.

Other justifications for energy policies, including issues with technology spillovers and consumer failures to value future energy savings when purchasing durable equipment, also play an important role in determining what energy policies may be warranted and how they should be specified in a world with a carbon tax. We discuss these issues in the contexts of renewables policies and then energy efficiency.

Renewables Policies and Motivations

In addition to the possible failure of a carbon tax to fully capture the externalities associated with CO₂ emissions, knowledge spillovers provide another reason why markets alone may not lead to the efficient level of deployment of renewable electricity technologies. These spillovers can occur at both the research and development stages of creating or further developing a renewable technology and also at the deployment stage through learning by doing. Policies that provide incentives for renewables investment and generation directly encourage learning and indirectly provide incentives for R&D by increasing the returns to deployment of renewables technologies resulting from successful R&D. After reviewing the main existing and proposed federal renewables policies, we come back to the questions of how well they mesh with these other policy motivations and how they mesh with a carbon tax.

The main federal policy mechanisms used to promote investment in and generation by renewable energy sources are tax incentives. For a number of renewable technologies, including wind, geothermal, and biomass, these incentives take the form of a production tax credit that is applied to each kWh generated by the facility for the first 10 years of operation. In early January 2013, Congress extended the 2.2 cent per kWh production tax credit for wind generators to apply to all generators that have begun construction by the end of 2013.⁴ For other technologies, the tax credit, which varies between 2.2 cents per kWh for wind, geothermal, and closed-loop biomass

⁴ Prior incarnations of the law required that a facility be operational before the expiration date of the tax credit in order to be eligible for the credit.

and 1.1 cents per kWh for others including small hydro, wave, and tidal energy and landfill gas, also expires at the end of 2013. (The sizes of these credits are roughly comparable to the 1.4 cent and 2.8 cent per kWh relative cost advantage that renewables would have to natural gas and coal respectively under a \$25 per ton carbon tax.) Notably the production tax credit is lower for the more nascent technologies such as wave and tidal energy than it is for the more mature technologies such as wind power, which seems a poor match to where the greater benefits from technological learning might reside. In addition to the production tax credit, there is also an investment tax credit that applies to solar and small wind facilities. Since 2009 it has also been possible for a facility that is eligible for the production tax credit to opt for using the investment tax credit instead. Overall the fiscal costs of this program are relatively modest; according to the Congressional Budget Office, the total cost to the government of the renewable production and investment tax credits is estimated to be about \$2.5 billion in fiscal year 2013 and another \$2.6 billion for the grants to renewables in lieu of tax credits (Dinan 2013), which totals to roughly 4 percent of the revenue expected from a \$25 per ton carbon tax.

A renewable portfolio standard (RPS) focuses on mandating renewables production instead of on reducing their costs. An RPS specifies the minimum share of electricity sales that must be produced using qualified renewables. RPS policies typically are accompanied by a credit trading provision that allows retail electric utilities that do not generate enough renewable electricity themselves to comply with the standard by purchasing credits. As mentioned, currently 29 states and the District of Columbia have state-level RPS policies in place, and a federal RPS was proposed as a part of the Waxman-Markey climate cap-and-trade legislation passed by the US House in 2009. An RPS is a less cost-effective approach to reducing CO₂ emissions compared to a policy that prices CO₂ emissions directly (Palmer et al. 2010; Palmer et al. 2011), for several reasons. First, the RPS does not reduce emissions outside the power sector. Second, the RPS does not raise electricity price the way a tax would and thus does little to encourage conservation and in some instances can actually lead to lower electricity prices than with no policy (Fischer 2010). Third, an RPS does not differentially disadvantage fossil technologies in relation to their emissions intensity. Palmer et al. (2010) show that a Clean Energy Standard, an alternative policy that seeks to encourage a wider array of non- and low-emitting generation technologies such as nuclear and natural gas, could be a more effective and more cost-effective approach to reducing CO₂ emissions than an RPS. President Obama and former Senator Jeff Bingaman have both proposed Clean Energy Standards (CES) that are targeted to provide substantial reductions in CO₂ emissions (Mignone et al. 2012).

Do these renewable or clean energy technology policies make sense in a world with a tax on carbon emissions? Research (Böhringer and Rosendal 2010; Fischer and Preonas 2010) has shown that an RPS in combination with a cap on CO₂ emissions will tend to lower the costs of CO₂ emissions allowances and thus lower the cost of generating with emitting sources relative to a cap by itself. However, as noted above, this price-lowering effect does not occur with a carbon tax, so marginal incentives to reduce emissions are not diluted. The role for policy depends importantly on the size of other externalities related to innovation. Fischer et al. (2012) find that given current estimates of learning-by-doing externalities for renewables technologies (as represented in the EIA's NEMS model), the level of an RPS or a renewables subsidy justified by learning by doing is much lower than levels specified in current policies. Their work suggests that a substantial gap between the adopted carbon tax and the optimal carbon tax would be necessary to motivate even modestly ambitious renewables tax credits or RPS targets, and that in the presence of a meaningful carbon tax, some adjustments in these policies or even a phaseout is likely warranted. Increased certainty about the future course of the renewable tax credit will help to prevent large fluctuations in renewables investment that have occurred to get benefits from a policy that has lapsed and been reinstated more than once. If a national RPS is instituted alongside a carbon tax, an alternative compliance payment that effectively limits the cost of tradable renewable energy credits could help to contain the cost of such a policy.

One aspect of learning that has not been considered in the literature and that could be very important is learning about better ways to integrate intermittent renewables into the grid as they increase their share of the generation mix. Policies that provide incentives to expand transmission capacity between locations with substantial renewable resources and locations with high demand for electricity should help to facilitate integration, as would increasing the ability of energy conservation and load management programs to be more responsive to price fluctuations in wholesale electricity markets.

Energy Efficiency Policies and Motivations

Historically policies to promote energy efficiency have been motivated by the apparent *energy efficiency gap*—that is, the empirical observation that consumers fail to adopt energy efficient technologies that appear to more than pay for the upfront investment costs in terms of expected energy savings over the life of the technology (Jaffe and Stavins 1994). Some have suggested that closing the gap through widespread adoption of more efficient technologies could produce substantial reductions in CO₂ emissions essentially for free (McKinsey & Company 2009). Explanations for the gap are wide ranging and have differing implications for policy.

Some explanations point to mismeasured underestimates of costs due to a failure to account for opportunity costs in the assessment of technology costs; for example, some consumers' reluctance to switch to compact fluorescent lighting may be partly due to a reduction in the perceived quality of lighting when compared with incandescent bulbs. Other factors, including heterogeneity in consumer energy use and opportunities for savings and the option value of waiting to make investments in light of uncertainty about future energy prices, also suggest that the efficiency gap has been overstated (Murphy and Jaccard 2011). These arguments indicate that the role for energy efficiency enhancing policy may be more circumscribed than studies based on engineering costs have suggested (Allcott and Greenstone 2012). However, other explanations, such as informational asymmetries, nonalignment of incentives for energy use and investment between tenants and building owners, the opportunity costs for energy consumers of attention to choices within perceived complex choice sets, and consumer failure to value future energy savings in investment decisions, suggest that there may be a role for policy to encourage greater adoption of energy efficient durable goods. For example, consumers may be reluctant to make investments in enhancing the energy efficiency of their homes if they don't believe they can recover that investment upon sale of their house. Which explanations are most relevant likely varies across energy users and energy uses, and sorting them out continues to be a topic in need of research.

Motivated by both climate and energy efficiency gap considerations, there are numerous federal policies currently in place to promote energy efficiency, including mandatory standards, mandatory and voluntary information programs, and financial incentives. Federal appliance standards currently apply to more than 50 categories of appliances and equipment, ranging from air conditioners to lightbulbs, and Parry et al. (2010) estimate that 60 percent of total electricity consumption is associated with durables that are or are potentially subject to minimum efficiency standards. Federal rules also require Energy Guide labels that display expected annual energy use and costs for consumer durables including refrigerators, freezers, water heaters, dishwashers, washing machines, room air conditioners, central air conditioners, heat pumps, furnaces, and boilers. To encourage manufacturers to make products that are more energy efficient, EPA runs a voluntary product certification program known as Energy Star, which allows products that are in the top 25 percent of the most efficient products within their category to receive the Energy Star label, indicating to consumers that the product is among the most energy efficient available. The US Department of Energy also offers free energy use assessments through its Industrial Assessment Centers program to small and medium-sized manufacturing firms. For many years the federal government acting through the states has offered weatherization assistance to low-

income families, and there are tax incentives for certain types of efficiency enhancing upgrades to homes.

Recently proposed policies would increase the number of appliances subject to efficiency standards and upgrade those standards for certain appliances. In addition, the proposed SAVE Act would mandate disclosure of modeled energy efficiency evaluations for a home as a precondition for getting a federally insured mortgage. Because annual energy costs can be quite high, this policy will help lenders assess the effect of differences in expected energy costs across properties on a homeowner's ability to pay a mortgage.

In addition to federal policies, there are numerous state and local policies and utility programs to promote energy efficiency investments. These prolific policies are outside the purview of national government; the question of their continuation, we have argued, rests with state and local governments.

Should policies to promote energy efficiency be continued in the presence of a carbon tax, and if so, which ones? Again, the answer depends in part on whether there is an important difference between the marginal damages from carbon emissions and the carbon tax that is in effect. It also depends on the size and causes of the energy efficiency gap. Information programs can help address lack of information or asymmetric information problems; efficiency standards may be more effective and even more cost-effective than a carbon tax if consumers are systematically failing to account for future savings in their actions. Targeting of policies toward affected populations and particular market failures will tend to raise overall cost-effectiveness relative to less targeted policies.

Assuming that carbon taxes are effective at reducing CO₂ emissions, research suggests that efficiency policies designed to address underinvestment in energy efficiency should be less stringent than efficiency policies that aim to achieve substantial reductions in CO₂ emissions. Fischer et al. (2012) show that an energy efficiency subsidy alone set to achieve a 20 percent reduction in CO₂ emissions from the electricity sector is roughly three times as stringent as an energy efficiency policy designed to offset an assumed 10 percent efficiency undervaluation by consumers in the presence of an optimal carbon tax and other policies to address renewables. Higher rates of undervaluation would suggest a greater role for efficiency policy to deal with undervaluation alone. Parry et al. (2010) find the literature on implicit discount rates suggests an undervaluation anywhere between 0 and 65 percent. Imposing a tax on carbon will likely lead to higher electricity prices (due to the pass-through of carbon tax costs) and therefore stronger incentives for conservation.

Fischer and coauthors also show that interactions between renewables policies and energy efficiency policies will matter for the prescribed level of each type of policy necessary to fully address the relevant issues. By introducing renewables that have low or zero operating costs, the RPS tends to shift out the electricity supply curve and lower the market price of electricity in competitive markets, which in turn raises consumption levels. For example, in the presence of an RPS, the optimal subsidy to energy efficiency necessary to counteract a 10 percent undervaluation of energy efficiency benefits will be higher than in the absence of an RPS. The flip side is that subsidizing energy efficiency if there is no undervaluation by consumers will result in less adoption of renewables and thus exacerbate the learning externality. Careful consideration of these interactions is an important part of energy policy design with or without a carbon tax in place.

Environmental Policies and Nuclear Power

Historically, the electricity sector has been a major source of emissions of criteria air pollutants such as SO₂ and nitrogen oxides (NO_x) and of air toxics such as mercury. Over the past 23 years, as a consequence of the SO₂ cap-and-trade program under Title IV of the Clean Air Act Amendments of 1990 and subsequent regulations including the NO_x Budget Program, the Clean Air Interstate Rule, and the recently adopted Mercury and Air Toxics Standard (MATS), substantial reductions in these emissions have been achieved. For example, when MATS is fully implemented, emissions of SO₂ are expected to be reduced to roughly 2.3 million tons per year by 2015–2016, well below the 8.95 million ton annual cap introduced by the 1990 amendments. Because the SO₂ cap is no longer binding, imposing a carbon tax would result in further reductions in SO₂ emissions as electricity generation shifts away from coal to greater reliance on natural gas and renewables. Estimates of the marginal health and environmental benefits of reducing SO₂ emissions are varied, ranging from \$1640 per ton (Muller and Mendelsohn 2012, 2000 year dollars), to \$1,800–4,700 (Banzhaf et al. 2004, 1999 dollars). The EPA recently used an estimate of \$29,000 in the Eastern states and \$8,300 in the Western states (US EPA 2011, 2007 dollars). All of these estimates suggest that any ancillary SO₂ reductions that result from a carbon tax will have a positive net benefit to society. The observation that taxing carbon has ancillary air pollution benefits, coupled with the fact that SO₂ emissions are not subject to a separate fee of their own to reflect their adverse impacts, suggests that the appropriate tax on electricity generators should be greater than the marginal social cost of CO₂ emissions alone. In practice such adjustments might be difficult to implement, as the adverse effects of SO₂ emissions vary substantially across locations (Muller and Mendelsohn 2012).

A carbon tax will also improve the relative cost of nuclear power compared to coal or natural gas. Whether this change in the economics would lead to more investment in nuclear plants is an open question, as the tsunami in Japan and damages to the Fukushima nuclear plant there have raised concerns about safety that will take effort to resolve. Also, the US federal government's failure to come up with a long-term solution for storage of spent nuclear fuel means that waste storage in hardened casks on the site of existing nuclear plants is the default strategy for dealing with this highly hazardous material. This suggests that the development of future nuclear power plants may be limited to available space at the sites of existing plants where there is experience in dealing with waste and an existing risk profile.

Conclusion

A carbon tax is politically plausible because of its ability to generate revenue to contribute to the substantial revenue needs of the federal government. In the face of this priority and given the institutional structure of decision making in implementing a tax, we question whether a tax is likely to be set at an efficient level with respect to climate policy goals. If it is set efficiently, it is unclear how it would adjust to assimilate new scientific and economic information. A carbon tax may be an efficient instrument, but it may not be used efficiently. To do so, we argue, requires a role for an expert agency to set the tax and adjust it to reflect new information.

Even if a tax is used efficiently, it may not work as described in the conventional economic model. In particular, it may not, and we think it most certainly will not, affect all relevant margins of decision making in the economy from consumer behavior to the decisions of state and local governments.

The preemption of state and local actions seems especially poorly advised. Climate change is a global externality that presents one of the most difficult coordination problems in the history of civil governments. It is a problem fundamentally characterized by the incentive for free riding. The notion of preempting voluntary actions by subnational jurisdictions to address the global externality would seem to lack a rationale, absent its potential interference with other constitutional protections for business. Keohane and Victor (2010) argue that at the international level, solutions to such coordination problems lie in small groups of relevant countries finding incentive-compatible commitments that align. The outcomes of such cooperation efforts are likely to be decentralized complexes of networked institutions rather than integrated, hierarchical treaties that govern a coherently defined issue area. We observe the same phenomenon in microcosm happening in domestic policy formation. This is not to say that a price on carbon is

not useful or ultimately imperative. We believe it is; however, we differ with a premise stated at the outset of this essay. A price is a necessary policy to address the challenge of climate change, but it is not sufficient.

An array of policies also may offer the advantage over a single, integrated policy regime by enabling the flexibility to address related issues such as other greenhouse gases and the ability to adapt over time (Keohane and Victor 2010). Several policies, including regulation under the Clean Air Act, renewable and clean energy technology standards, tax incentives to promote technologies, and other examples, are meaningfully within the domain of national government, even if they also exist in some form at the subnational level. In an era of budget deficits and constrained resources for federal agencies, targeting activities in an efficient manner is essential. If an effective carbon tax were in place, managers at agencies such as EPA would be likely to divert resources to other priorities and slow development of climate-driven regulations. Nonetheless, a portfolio approach offers diverse measures in the face of uncertainty about the effect of any individual policy, and for this reason it may have intuitive appeal to policymakers.

Finally, we note that public opinion appears to rest solidly in favor of a portfolio approach. Krosnick and MacInnis (2013) report that large majorities of Americans have endorsed a variety of policies to reduce greenhouse gas emissions, such as those we discuss at length, and this support has been consistent for many years. Public support for these policies is sensitive to the cost of policies; however, the public continues to prefer mandated emissions reduction policies over price-based approaches.

For these many reasons, there is no basis for automatic preemption of the many existing climate-related policies in the presence of a carbon tax, but it is nonetheless important for local, state, and national governments to consider the interactions of other policies with a carbon tax and the potential for unanticipated consequences. They will often interact in unanticipated ways that in fact may raise the cost of achieving climate policy goals. To understand how this may occur and how it should be managed requires a realistic characterization of the institutions and behaviors that shape climate policy.

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